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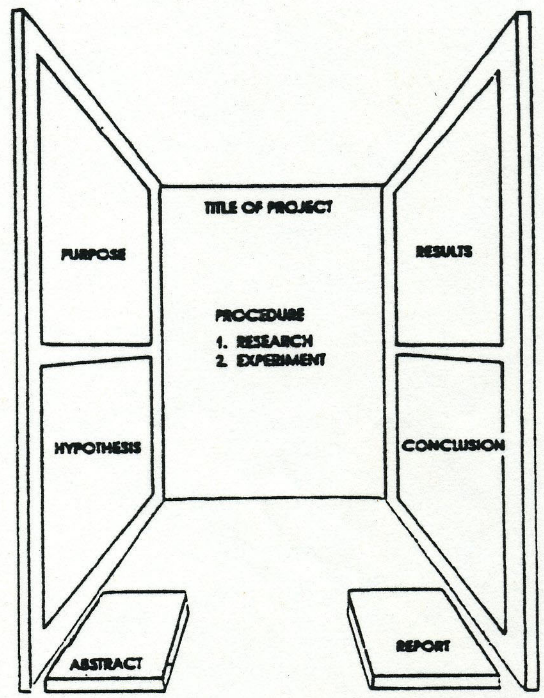
The Scientific Method



A Science Fair project should demonstrate the student's knowledge of the scientific method, which is the process scientists use to investigate nature. Simply put: wonder about something, think of a reason why it happens, and check to see if that idea is right.

Making this process work in a truly scientific project involves two concepts that need extra explanation. They are concepts that may cause more procedural problems than any others in science projects: variables and the control.

Variables are simply things that can change during an experiment (or from one repetition to another) and affect the outcome. There are two kinds of variables: experimental and controlled. The experimental variable is what the experiment examines. For instance, if the experiment is about the effect of different amounts of fertilizer on plant growth, then the experimental variable is the amount of fertilizer each group of plants receives. Everything else that might change during the experiment is a controlled variable: in this example, soil type, plant type, amount of water, temperature, amount of light, depth and time of planting, *everything*. The critical point about controlled variables is that they are not actually allowed to vary — they have to be the same for every experimental group and repetition (that's why they are called "controlled"). Clearly, if this is not done, when the experiment results are examined it will be impossible to tell which results are caused by the experimental variable and which are caused by something else; the experiment would be useless.

The control is different from a controlled variable. The control is an experiment group in which not even the experimental variable is allowed to change. In the plant example above, the control group might be a group grown under the same conditions as the others, but with no fertilizer at all. The growth of the fertilized plants could then be compared with the control group of unfertilized plants.

Be sure to understand the ideas of variables and a control, and include them in the project.

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What a Project Must Have

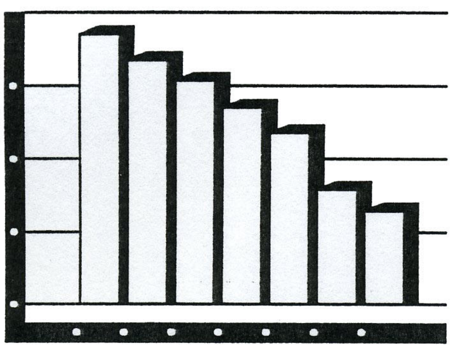
Purpose — The Purpose of the project states why the student is doing the project and tells the judge what the student hopes to learn. Don't just write that the purpose of the project is to complete an assignment; while perhaps honest, this misses the point and hurts the project's score. In stating the project's purpose, as throughout the project, write in the 3rd person; avoid the use of "I," "we," "you," and similar pronouns.

Hypothesis — This is the idea to be tested by the experiment. Whether the hypothesis turns out to be correct or not is less important than finding out by using the scientific method and a valid experiment! In place of an hypothesis, some teachers will allow a question that the experiment will answer or a problem the experiment will solve. Hypotheses can be general ("Water boils when heated enough.") or very specific ("Water boils at a temperature of 100° Celsius."); however, students should be sure their hypothesis is not so general as to be trivial. Common mistakes in writing the hypothesis include failing to use a hypothesis that really relates to the project's purpose, writing an hypothesis that includes more than one idea to be tested, and using an hypothesis that cannot realistically be tested by a student (it is unlikely, for instance, that a middle or high school student can do any meaningful experimental research about the formation of galaxies).

Title — The project title can be used to help catch a judge's eye. Good titles may be short and to the point, or may even have some humor in them. Avoid very long titles, and titles that simply restate the hypothesis. Make the title as noticeable and attractive as possible.

Procedure — The Procedure statement explains how the experiment was done. It should include all the materials needed to perform the experiment, and step-by-step instructions. Think of it as an instruction sheet; the Procedure statement is done properly if a judge could use it as directions to repeat the experiment. List all the variables and how they were controlled. Bear in mind that if the project's procedure is simply to read a book about the subject or to build an "arts and crafts" model relating to the subject, then something is wrong with the procedure (and maybe with the subject). Remember, science is a process that uses the scientific method; just reading a book is only the first step.

Bear the following hints in mind. Be sure the experimental procedure actually tests the hypothesis, and that it tests *only* the project hypothesis; testing related ideas should be reserved for another project. Remember that the more data the project generates, the more confidence a student can have in the results; for instance, results concerning the growth of plants will be more reliable if 20 plants are grown and measured than if one is. Every experimental variable except the one being tested should stay the same for every test. Finally, it's OK if reading about the subject gives a student a good idea of what the experiment's results will be; that may just allow fine-tuning of the hypothesis. Just be sure that the experimental design and results, combined with the student's own knowledge, can convince a judge that the experiment was really performed and that the data was not just copied from a book.



Results — The Results should indicate what was found out from the experiment. Data should be displayed in neat, easily understood form; tables of data work well. If data is available from many repetitions (for instance, 2 groups of ten model rocket launches each group identical except for engine power), display both the data and an average for each repetition. Graphs can be extremely effective for displaying data, but should accompany the actual data rather than replacing it; since there are many styles of graphs (such as line graphs, bar graphs, etc.), use the most appropriate one.

Conclusion — The project's conclusion states what has been learned from the experiment. It is different from the Results, being a logical conclusion based on the data. Simply concluding that the hypothesis is correct or incorrect may be trivial; try to be more specific. If the hypothesis is wrong, and the data suggests an alternative, state it.

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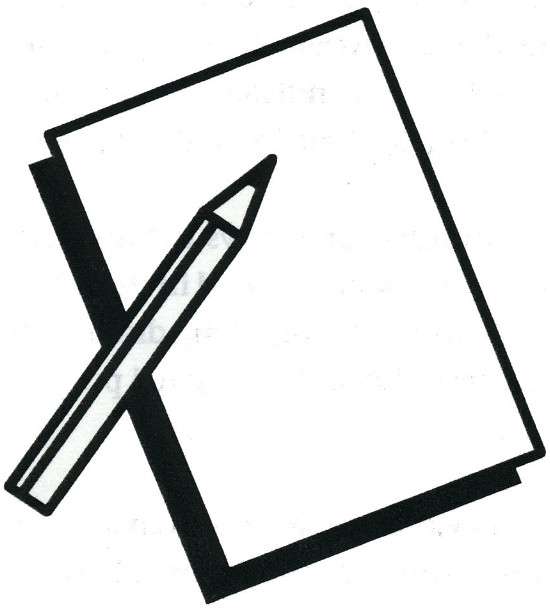
The Report and Abstract



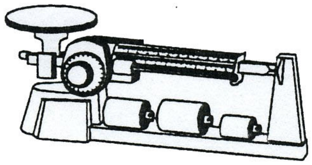
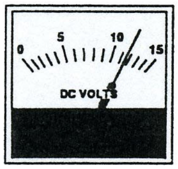
In many projects, the report is little more than a restatement of what is on the project board, and the abstract is much the same; it must seem like repetitious "make-work" to the student. That's not the way it has to be, though. Although the report should include the information from the board (remember, the person reading the report may not have the board in front of him), it should also include much more. There should be some background information about the general subject of which the project is a part and the report should include some or all of the extra touches listed below. There should be a thorough bibliography. If the project deals with humans or other animals, a great deal of paperwork is required by Science Fair officials; this should be included in the report.

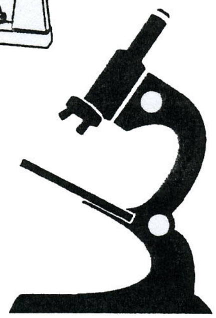
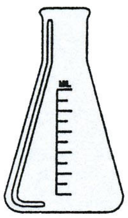
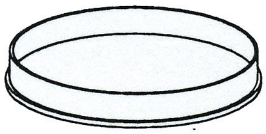
The abstract is a brief statement explaining for a judge what he or she should expect from the project. It should be based on the report, should include the basic board information, and should be written in the style of a one page report (don't just list the purpose, hypothesis, and so on).

Extra Touches for a Good Project

Raw data sheet — This is the original record of the data taken during the experiment. Most students make a neat copy of this to put on their project board and in the report; an experienced judge may give some extra points if the original is labeled and included in the report.

Acknowledgments — It is intellectually honest (and only fair) to indicate who may have helped with a project, and what those helpers did. Acknowledge people who gave interviews, typed the report, answered questions, or anything else. If a student understands the

project's subject and obviously did most of the work, this honesty will impress a judge; if a student obviously doesn't understand the project, a judge will figure someone else did the work even if no acknowledgments are made.

Error analysis — Measurements may vary in accuracy, but are never exact. Repetitions of a well designed experiment may yield results that are extremely consistent, but vary slightly. Considering and indicating why those variations occur shows a superior effort by the student.

Possible applications — Indicate some ways the information learned during the project might be used in the future by the students or others. These ways don't have to involve earth-shaking discoveries and may be useful only to the student, but will help drive home the original purpose behind the experiment.

Suggestions for further research — Even in "real life" science, as experimental research answers questions, many new questions arise. Try thinking of new questions based on the project just finished; who knows, that might suggest the subject for next year's project!

Attractive appearance — Although the actual research in a project is more fundamental, making a project attractive is time well spent. A nice-looking project will attract the attention of judges, and be evidence of attention to detail.

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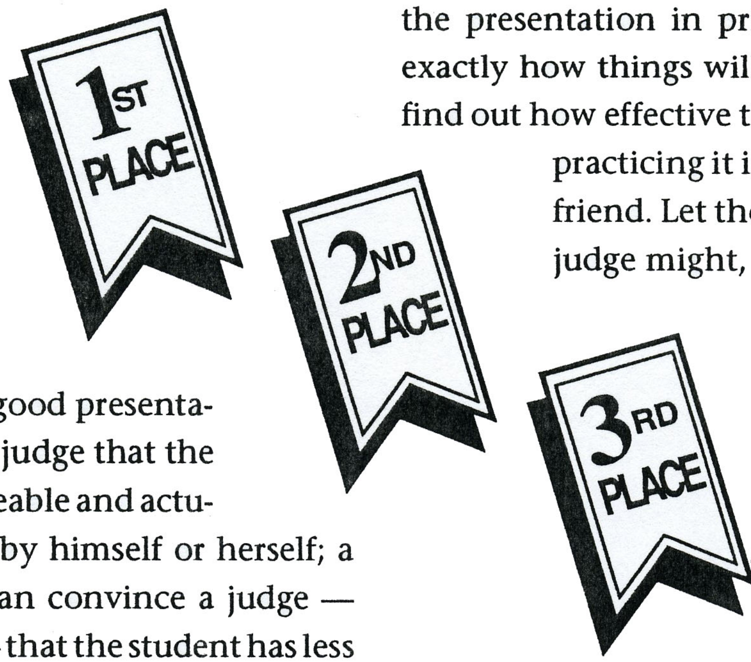
Getting through the Spoken Presentation

Many schools require students to make an oral presentation about their projects to judges. A good presentation can mean a big improvement in score, and a poor presentation can really hurt the score. For a good project, it can be the difference between doing well enough to go on to the next Science Fair level or staying home. A good presentation can convince a judge that the student is knowledgeable and actually did the project by himself or herself; a poor presentation can convince a judge — rightly or wrongly — that the student has less understanding than the project indicates and that parents did most of the work.



There are three keys to a good presentation: practice, practice, practice. Finish the project a day or so early, and put some thought into the oral presentation. What are the key points in the project? Are there important subtleties the judge needs to know? What parts seemed particularly interesting? What questions might a judge ask? Practice the presentation in private, and work out exactly how things will be said. If possible, find out how effective the presentation is by practicing it in front of a parent or friend. Let them ask questions as a judge might, and be sure they get answers. An hour spent practicing can make a student look good on Science Fair day.

Try to avoid memorizing the presentation, though. If a student loses his or her place while speaking, it's easy to become flustered and never recover. Consider using the pictures, writing, and graphs on the board as notes and reminders of what needs to be said.