

The Scientific Method

The following is a review of the Scientific Method with some key questions and directions on how to design and conduct an experiment.

Problem/Purpose

- * What is your goal?
- * What idea are you trying to test?
- * What is the scientific question you are trying to answer?

Hypothesis

- * Explain how you think your project can demonstrate your purpose.
- * Make a prediction regarding the outcome of your experiment.
- * State the results you are predicting in measurable terms.

Procedure

- * Give a detailed explanation of how you will conduct the experiment to test your hypothesis.
- * Be clear about the variables (elements of the experiment that change to test your hypothesis) versus your controls (elements of the experiment that do not change).
- * Be very specific about how you will measure results to prove or disprove your hypothesis. You should include a regular timetable for measuring results or observing the projects (for example, every hour, every day, every week).
- * Your procedure should be like a recipe - Another person should be able to perform your experiment following your procedure. Test this with a friend or parent to be sure you have not forgotten anything.

Materials

- * List all materials and equipment that were used.
- * Your list of materials should include all of the ingredients of the procedure recipe.

Observations/Data/Results

- * Keep a detailed journal of observations, data, and results. Your journal should contain data measurements and written notes about what you are sensing (hearing, seeing, or touching) about your experiment.
- * If appropriate, photograph your project results or phases of the project to help your analysis and possibly to demonstrate your experiment on your exhibit board.

Analysis

- * Explain your observations, data, and results. This is a summary of what your data has shown you.
- * List the main points that you have learned.
- * Why did the results occur? What did your experiment prove?
- * Was your hypothesis correct? Did your experiment prove or disprove your hypothesis? This should be explained thoroughly.

Conclusion

- * Answer your problem/purpose statement.
- * What does it all add up to? What is the value of your project?
- * What further study do you recommend given the results of your experiment? What would be the next question to ask?
- * If you repeated this project, what would you change?

Student Science Fair Checklist

START EARLY!

Many students begin planning their research at the end of the school year so that they can conduct research during the summer and fall.

1. Find a topic that interests you and research what is already known about the topic.
2. Narrow the topic to a specific scientific problem and develop an experiment to solve that problem. (See the [Scientific Method](#) to help plan your experiment.)
3. Discuss the project with your parents and teacher and review with them the [ISEF Rules and Regulations](#), noting the specific rules that might apply to your type of research (i.e. are you working with human subjects or animals or working with hazardous substances?).
4. Develop a hypothesis (Scientific Method) and develop a procedure.
5. Write a detailed research plan about how you will conduct the research and complete the [required Intel ISEF forms](#) and any additional local science fair forms required. You then must obtain the appropriate approvals as needed before the start of experimentation. This may involve being reviewed by your local Institutional Review Board (IRB) or Scientific Review Committee (SRC).
6. Once your approvals and forms are in order, begin your experimentation following your research plan and any revisions that those supervising or approving your research have recommended.
7. Make observations and collect data in a project journal (all participants must keep a journal)
8. Interpret the data and observations
9. Draw conclusions
10. Finalize your project for presentation.
11. Write the research paper and [abstract](#) (Intel ISEF does not require a research paper, some regional fairs do require it; check with your teacher or with your regional fair rules and handbook.)
12. Create the project exhibit board being sure to follow the [Display and Safety Regulations](#).
13. Practice your presentation and prepare to answer judges' questions.
14. Present the project at your school Science Fair, and/or your regional Intel ISEF-affiliated fair.

Why Complete a Science Fair Project?

The following statement is excerpted, with thanks, from the [Greater San Diego Science and Engineering Fair](#) Web site.

First

A science fair project is the ultimate answer to the often asked student question: "Why do I need to learn this stuff, anyway?"

It integrates, into one functional activity, virtually all of the skills and arts that are usually taught separately (sometimes not at all or without obvious "purpose") in many schools. When brought to completion, the project is an amalgamation of reading, writing, spelling, grammar, math, statistics, ethics, logic, critical thinking, computer science, graphic arts, scientific methodology, self-learning of one or more technical or specialty fields, and (if the project qualifies for formal competition) public speaking and defense in front of expert judges. It is, perhaps, the only educational activity that allows students to teach themselves, to take from the established information what they need to discover something exciting and new, and to identify and choose the tools that they need to conduct and conclude their project. When a student completes a science fair project, year after year, through junior and senior high school, the science fair process yields mature, self-confident, skilled, and competitive young leaders who have career goals and the preparation, discipline, and drive to attain them.

Second

A science fair project can be self-validating and exciting because it is not just practice. It involves real discovery of little known or even unknown information.

It develops personal power of importance in students, where perhaps none or little existed before. The project usually is based on scientific questions or interests that the students already have, and allows them to develop the questions independently into formal, testable, solvable problems. When such studies are undertaken in earnest, the students often become driven by their projects. Learning the outcome and finding the answer can be an electrifyingly powerful moment of discovery. It proves to students, and to others, that they were successful and that they did it on their own! The result? An ordinary student is motivated to become an excellent student, and an excellent student to become a scholar. Of all the programs that a school might offer a student to improve self esteem, it seems that participation in a science fair is one sure-fire way to build student

confidence, challenge potential, and instill the incredible feeling of independent achievement that the successful science fair project provides.

Finally

Science fair projects can pay off in cash and open the doors of academic opportunity.

Well-done projects generally lead to competition and awards at Intel® ISEF-affiliated regional fairs. First-place winners at regional fairs usually have the opportunity to compete for additional awards in the California State Science Fair. Top first-place winners from junior and senior divisions in many fairs are selected as sweepstakes winners and receive cash awards. Additionally, selected senior sweepstakes winners (the best of the best) go on to compete with other grand prize winners from throughout the world for substantial cash and scholarship prizes at the annual Intel International Science and Engineering Fair.

Perhaps most importantly, however, graduating high school students with records of awards for original research or engineering at the regional fair and beyond, have a distinct advantage over other college applicants in being considered and accepted by the schools of their choice. This is because science fair honors rank high among the screening factors used by admissions officers at most top universities.

Lastly, students who participate in regional fairs have their projects evaluated by top local scientists from research and industry. Participants whose projects are judged to be worthy of international competition will be judged by the top scientists of the world. Imagine your student discussing a project with a Nobel Prize winner. The exposure and self confidence such an opportunity generates cannot be quantified.

Tips and Advice

Research Science Fairs

Decide which science fairs you're going to enter. You can enter a school science fair or any of the Intel ISEF-affiliated fairs. You should also attend a science fair clinic. Many regional science fairs offer clinics in the fall; ask your teacher for information.

Pick Your Topic

Find a topic that interests you.

Advice from Alumni

Explore the areas of your interest. Look for questions within that area that might be worth exploring.

Along with interest, you should also choose a topic that can benefit your community or society in general. Look around your community and try to find something that you can discover, study, design, create or improve that will solve a troublesome problem. Why not choose a topic that will allow you to contribute to society and to make a difference?

Don't be afraid to try something even though it might not work. Let your imagination run wild and be creative. Sometimes the simplest solutions and the smallest contributions are the most important.

Read science magazines like *Science News* and *Scientific American* and research on the Internet to see what is currently being done in science. Always choose a topic that interests you and make sure whatever you choose is possible to do in time and with the equipment available.

Read. Talk to people. You'll find out there's a lot of stuff out there you don't know that you would like to know by doing these things.

Research Your Topic

Research what is already known about the topic. Narrow the topic to a specific scientific problem.

Plan Your Experiments

Develop an experiment to solve the specific scientific problem you've chosen. See the Scientific Method to help plan your experiment.

Consult Your Adult Sponsor

Discuss the project with your parents and teacher. Review with them the International Rules as well as the specific rules that might apply to your type of research. For example, if you are working with human subjects or animals or hazardous substances, specific rules apply.

Advice from Alumni

My experience with mentors has been fantastic. In addition to wonderful mentors who I found at my high school, I have been fortunate to work with researchers at several major scientific institutions. Finding these people was by no means easy, and I think that my success was probably due to persistence more than anything else. Even after I was rejected by administrators (who may view you as being too young), I continued to press my case until I was granted interviews with a few prospective mentors. Getting an interview is essential. The interview is when you and the mentor see if you are personally compatible.

Ask your science teacher for help. Don't be shy--call professors at local universities or even E-mail them.

You should try to find someone to act as your mentor for support and suggestions. Nevertheless, it is not always required to work in a large institution with a specialist in your area of interest. I spent my time working at home in my father's workshop, using parts I found around the house to build my inventions and to solve a few problems. I also spent time working at school in the workshops and labs or out on the lake. A mentor is a guide, not a solution. Don't be afraid to seek help from several sources and to use the resources that are at your disposal.

Write a Research Plan

- * Write a detailed research plan describing how you plan to conduct your research:
- * Develop a hypothesis using the Scientific Method.
- * Develop a procedure.
- * Obtain the appropriate approvals before starting your research.

Complete the Required Forms

Complete the required forms for Intel ISEF and any additional local science fairs.

Conduct Your Experiments

Begin your experimentation following your research plan and any revisions recommended by the people supervising or approving your research. Investigate to test the hypothesis. Make observations and collect data in a project journal (a project journal is required). Interpret the data and observations.

Write the Abstract

Finalize your project for presentation. Write the abstract (required by Intel ISEF). If required for a local science fair, write a research paper.

Prepare Your Presentation

Create the project exhibit board, being sure to follow the display and safety rules. Practice the presentation and prepare to answer the judge's questions. Present the project at your school science fair and/or at an Intel ISEF-affiliated fair.

Advice from Alumni

Your presentation board should be appealing to the eye and should explain both what you did and what you found. Pictures are very helpful and often say more than words. Diagrams are also very useful as they allow the public to follow your train of thought easily and without confusion. Avoid putting up your entire written report; try explaining your project visually with graphs, diagrams, pictures and subtitles. Use color to separate ideas and arrows to direct your audience. Avoid buying expensive presentation tools. Your artistic touch is much more appreciated and shows your involvement in the project.

Make sure your posters clearly outline what your project is about. You should be able to get what the project is, how it works, and how it was created from the posters.

Have your display board look professional and not too crowded. Remember that large boards do not always indicate good projects.

You will see a tremendous range of backboards at the Intel ISEF. Some will be equipped with remote controls, projection screens, fancy lights, or

even personal power supplies. Some will look like they were assembled in an hour, because in many cases they were. Remember, people come to the Intel ISEF from all around the world, and sometimes they can't ship their completed backboards, and have to build them on-site. While it may seem that being in this position puts you at a serious disadvantage, don't worry. The reality is that the judges are keen enough to recognize good science, as long as it is presented reasonably well. The most important part of your presentation is verbal, and few judges will actually read most of your backboard. My advice is to not devote too much time to making your backboard look good, and to spend that time on your research.

Rehearse Your Presentation

Advice from Alumni

Do not memorize your presentation. I repeat, do not memorize your presentation. You should target your presentation to your audience every time, and this means changing it. To do this, of course, you have to know something about your audience. I suggest you use the first minute or two of your time to ask your judge about his background. You may learn, for example, that the last time your physics judge saw anything related to your project was in college, and that he's spent the last 30 years doing an entirely different kind of research. Or, you could find out that your military judge really wants to know if your project can help build a better computer (perhaps for nuclear weapons simulations, but not necessarily so).

Relax. The judges are usually are friendly, and they aren't out to make mince meat of your project. Just tell them what it's about naturally, and answer their questions.

Practice in front of a mirror and try to eliminate "ummm" from your speech. Don't spend too much time explaining your project so that the judge will have plenty of time to ask questions. Be confident in yourself. Look professional, smile, and relax.

I've learned through experience and friends that the more enthusiastic you are about your project, the more excited the judges will be about it. Also, make your project appear wonderful, because in a lot of ways it probably is, but also remember the limitations of your project. Recognizing the limitations of data is a key to almost any scientific pursuit.

Rehearse, rehearse, rehearse. The best presentations are made by the groups most comfortable doing them. Anticipate questions that might be asked. Be prepared.

The oral presentation is also very important. Make sure you speak clearly and that you take the time to ask your audience if they have any questions. It is important to cover everything briefly, even your failed attempts, and to do so in a logical pattern. Don't spend too much time on one thing. If you are working with a partner, take your turn explaining the project and switch every five minutes or so. This way, it allows your audience to differentiate between sections and will add energy to your presentation. Teamwork is essential. Work together and help each other out.

Enjoy the Experience!

Advice from Alumni

Don't participate in science fairs for the awards. Don't do science for the recognition. Don't compare yourself to anyone else and don't force yourself to do it. Do it because you love it and because you can make a difference. Help your community and contribute to society. Learn through your experiences and discover the world around you. Such is the true reward of science.

Don't be afraid to try something even though it might not work. Things rarely work the first time. Learn from your mistakes, discover as you try different things, and never give up.

Remember that science fair is supposed to be fun and don't let it stress you out too much and good luck to everyone!

Tips for Parents

- * Give encouragement, support, and guidance.
- * Make sure your child feels it is his or her project. Make sure the work is primarily the work of the child.
- * Realize the main goal of a science fair project is to help your child use and strengthen the skills he or she has learned and develop higher-level skills. The main goal should not be the ribbon or prize.
- * Provide transportation to libraries, nature centers, or universities that can help your child find project information.
- * Locate Internet access, either at home or at a school or library.
- * Help your child design a project that is safe and properly supervised.
- * Help at your local school Science Fair. Contact your child's teacher to volunteer.
- * Help your child plan a mutually agreed upon timeline to prevent a last minute project. Some projects may take 6 to 10 months. It is suggested to allow at least 12 weeks to conduct an experiment and prepare the presentation.
- * Do not worry or get upset if your child doesn't win a prize at the science fair. The skills the child has gained are worth all of the effort.
- * Help your child begin to plan for next year.
- * Feel a sense of pride and accomplishment when the science fair is over. You and your child have earned it!

Internet Resources

The Discovery Channel

<http://school.discovery.com/sciencefaircentral/>

The Discovery Channel contains a wealth of resources for students, parents and fair organizers.

CyberFair

<http://www.isd77.k12.mn.us/resources/cf/SciProjIntro.html>

A resource provided by David Morano for 3rd-6th graders complete with example experiments. Resources for intermediate students (grades 7 & 8) are also accessible at this site.

Science Fair Primer

<http://users.rcn.com/tedrowan/primer.html>

A site to help students get started and run a science fair project.

What Makes A Good Science Fair Project

http://www.usc.edu/CSSF/Resources/Good_Project.html

A website from USC that gives a lot of good tips and ideas to think about regarding what makes a good science fair project. Advice for students as well as teachers and parents is included.