The Randall Museum

STUDENT'S GUIDE to the

SAN FRANCISCO SCIENCE FAIR

Illustrations by Curtis G. Leonardo

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Yomi Agunbiade, General Manager — Chris Boettcher, Museum Director

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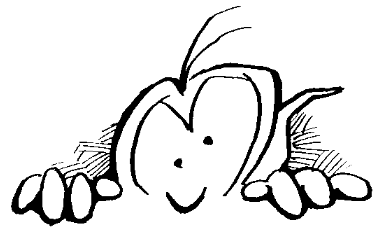
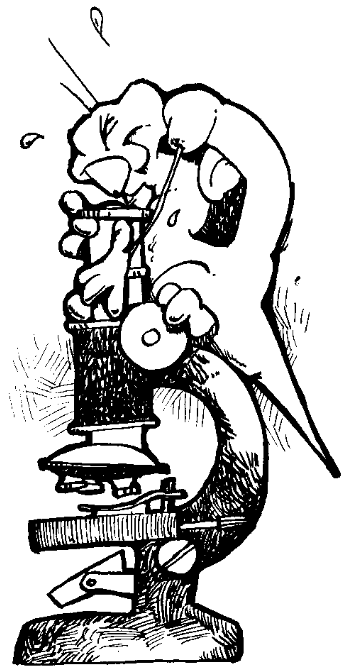
What is a science fair project?



A science fair project is a careful investigation of a small problem of scientific interest. It begins with an idea or question that needs to be tested. Your tests are called experiments and should be done in an accurate and controlled way. Finally, you will prepare a report of your results for public display. This guide will tell you how to do all this -- it's easier than you think, and fun, too!



How do you do a science fair project?

There are three things you need to do:

1. Find an interesting problem to explore,
2. Do experiments, AND
3. Communicate your results.

Let's look at each of these more closely....

1. Finding a Problem to Explore

A. What interests you?

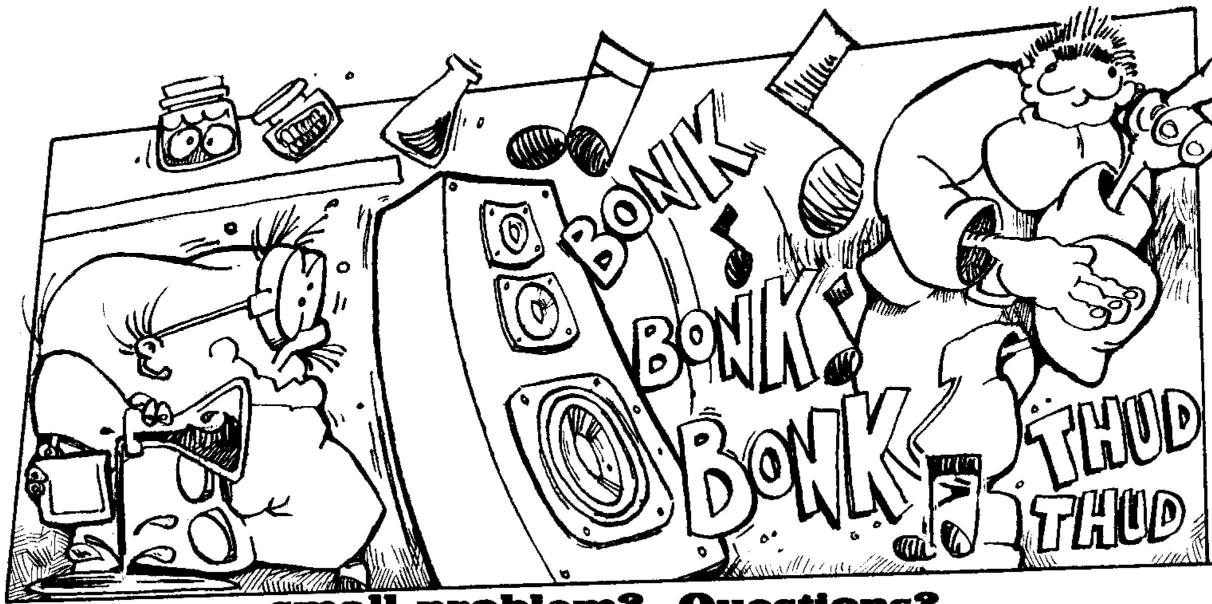
Choose some scientific area (such as animal behavior, airplanes, electricity, rockets, psychology, etc.) that you really enjoy learning about.

DO THE RESEARCH

Example: Let's say you're very interested in gardening. That's too big and broad a topic to deal with in one science fair project, so you'll need to...

B. Narrow it down.

Ask some more specific question in the area that interests you. Do some research at the library and on the Internet, and talk to your teacher, parents, and/or a professional scientist in the area that interests you. Make sure you are going to do something that is new and interesting to you. The research will tell you what is already known about your topic, and will help you avoid doing something scientifically silly or too big to tackle in the time you have to finish your project.

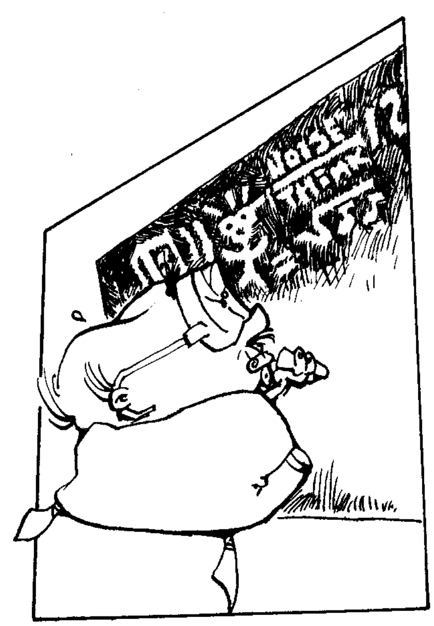


small problem? Questions? Idea for an EXPERIMENT?

Example: Perhaps you've heard that music makes plants grow better. But how would you test that? You still need to narrow it down more. What kind of music will you test? How often will you play it for your plants, and how loud? What kind of plants will you grow? How will you define growing "better?" So instead, you might ask, "Does exposure to classical music make tomato plants grow taller or produce more leaves than plants that aren't exposed to music?" NOW you've got a problem that you can handle in the time you have.

C. Write a hypothesis.

BEFORE you do any experiments, you must state what you are testing by making your best guess of what will happen in your experiments. This prediction is your HYPOTHESIS, and it should be a very simple sentence. It's important to realize that it doesn't matter if your hypothesis turns out to be incorrect. Scientists learn just as much from unexpected or disappointing results from their experiments. You won't get a bad grade from your teacher or from science fair judges if your hypothesis was wrong; what matters is how well you did your work. Just make the best guess you can from what you learned in the research you did before you started.



THE HYPOTHESIS

Example: One hypothesis for the musical plants problem could be: "Tomato plants exposed to classical music will grow taller and produce more new leaves than plants not exposed to music." The hypothesis *could just as well be that the music would have no effect, or a different effect. What do YOU think will happen, based on what you know before you start? Select ONE possible outcome as your hypothesis.*

D. Make sure your project is a discovery, not a demonstration.

Ask your teacher about this. Basically, what this means is that you should do your work on a question that you don't know the answer to already. Scientists don't spend a lot of time doing experiments in which they know what will happen ahead of time. You'll learn more, do better work, and have much more fun if you try to SOLVE A MYSTERY rather than just show something that you already know!

Example: You probably already know that if you stop watering a plant, it will eventually dry up and die. Killing a bunch of plants by demonstrating this is not a new discovery and is therefore not a good choice for a science fair project.

2. Doing Experiments

A. Design a way to test your hypothesis.

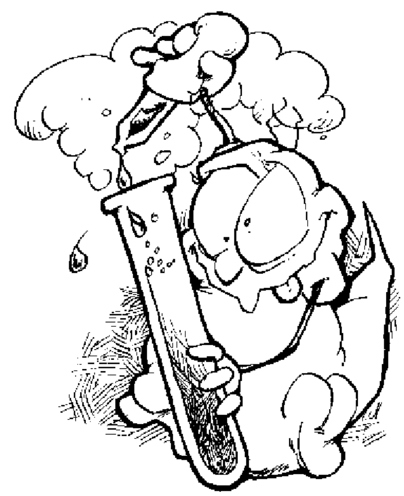
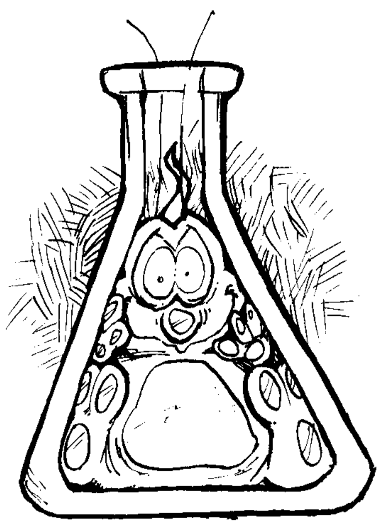


Figure out an experiment or a set of experiments to see if your hypothesis is true or false. Decide what tools and procedures you will use. Be sure that your experiment really tests what you are trying to find out and that nothing is changing your results except the thing you are testing for. This means that your experiment is WELL CONTROLLED. This is one of the easiest places to make a mistake. Try to think of everything that is likely to go wrong and design your experiment to prevent these things from happening.

Example: One way to see if music makes plants grow better would be to play a selection of recorded classical music to a group of tomato plants every day for several weeks, then measure how tall the plants have grown and how many new leaves they have sprouted. Half of your plants will be exposed to no music -- this is the CONTROL GROUP for your experiment -- and the other half will be exposed to classical music; this is the EXPERIMENTAL GROUP. In order to make sure that your experiment is well controlled, all things must be the same for all your subjects (plants) except the presence or absence of music. Be sure that they are all the same kind of plant growing in the same kind of container, that they are kept at the same temperature and receive the same amount of sunlight and water, etc. Play the same music at the same volume at the same time of day for all of your experimental plants, and make sure the control plants aren't accidentally exposed to music from another source. Make sure there is enough of a difference between what you are doing to your experimental group and to your control group that any effects will show up; that is, play the music loud enough and *long enough each day, over enough days, that you think it has a chance of making a difference. Also, instead of just comparing the heights and numbers of leaves on your plants at the end of your experiment, make note of how tall each plant was and how many leaves it had at the beginning, and only compare the changes at the end of your experiment (otherwise, you might see a false difference between the groups because the plants exposed to music started out bigger than the control group, or vice versa).*

B. Make sure your project uses good scientific methods.

Good scientific work can be repeated exactly by someone else, is well controlled, and really tests the hypothesis. Also, good scientists don't try to make their experiments turn out a certain way, they just set things up carefully and then observe what happens.



BEFORE you begin ANY experiments, check with your teacher or science fair advisor AND read the rules at the end of this guide to make sure you have planned appropriate and ethical experiments, and that you have completed any paperwork that might be necessary. It would be terribly disappointing to finish what seems like a great science fair project, only to have it disqualified for not following the rules!

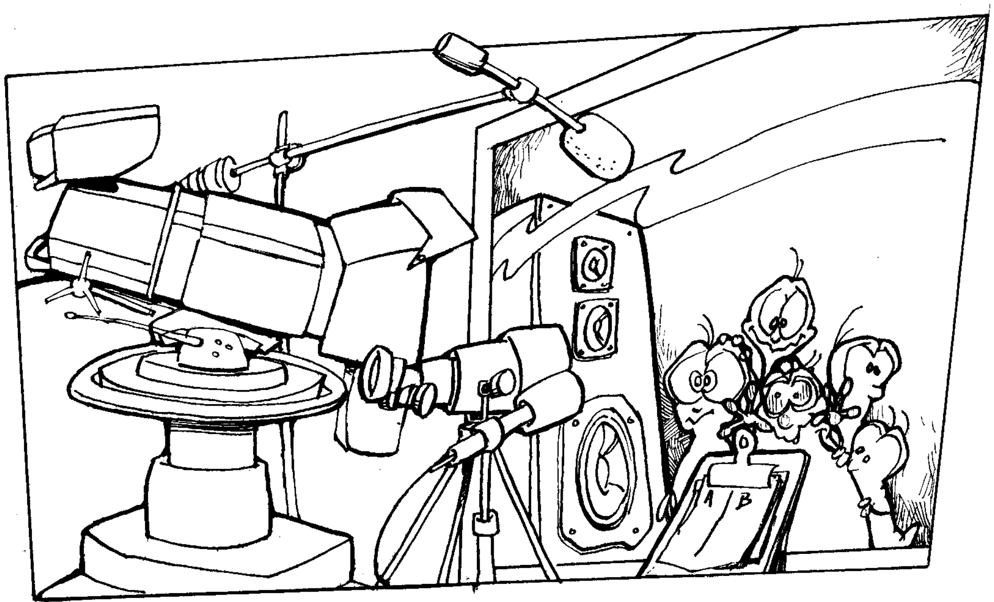
C. Do the experiment as many times as you can.

Lots of tests and results make your work more reliable. If you only did your experiment a few times and something unusual happened, it could make a big difference in your results. To make sure that what happened in your experiment was what usually happens, do it as many times as you can and write down your observations AS THINGS HAPPEN. There is no "magic number" of repetitions you need to do, but your project will be much better if you do more than if you do fewer.

Example: If you only grow four plants, and the two that are exposed to music happen to have come from inferior seeds, they could make it seem that music doesn't make any difference or even hurts plants, when in general music might actually help plants grow. This is what you are trying to find out, and the more plants you test, the less likely it is that you'll get misleading results by accidentally choosing unusual plants as experimental subjects.

D. Keep a project notebook.

In a notebook, write down your hypothesis, your procedures, and all your observations from your experiments as they happen. Don't make any guesses yet as to whether your hypothesis is correct -- just make sure you are keeping track of everything that happens. You might also want to take photographs or make sketches of your experiment in progress.



RECORD YOUR OBSERVATIONS

E. Put down your observations from experiments in a measurable form.

When writing down what is happening in your experiments, avoid just using words like "more," "taller," "better," "faster," and so on. Remember that good science is repeatable, so that someone will know exactly what you did and saw. So tell HOW MUCH more, or HOW MUCH taller, and record your observations as measurements in NUMBERS with units: in centimeters, degrees, miles per hour, whatever you are trying to measure. It may be useful to record qualitative information also (for instance, colors or shapes), but the more you can quantify (count) your observations, the better. Charts, graphs, and tables can also be very useful for organizing and communicating your information.

Example: Measure and record the height of each plant in centimeters at the beginning of your experiment, then measure each plant again in the same way every few days until the end of your experiment, recording the information each time. At the end, subtract the starting height from the final height to see how much each plant has grown. Do the same for counting the number of leaves on each plant. (If you notice differences in the color or texture of the leaves, the shape of the stems, or anything else unusual or surprising, make a note of this as well.)

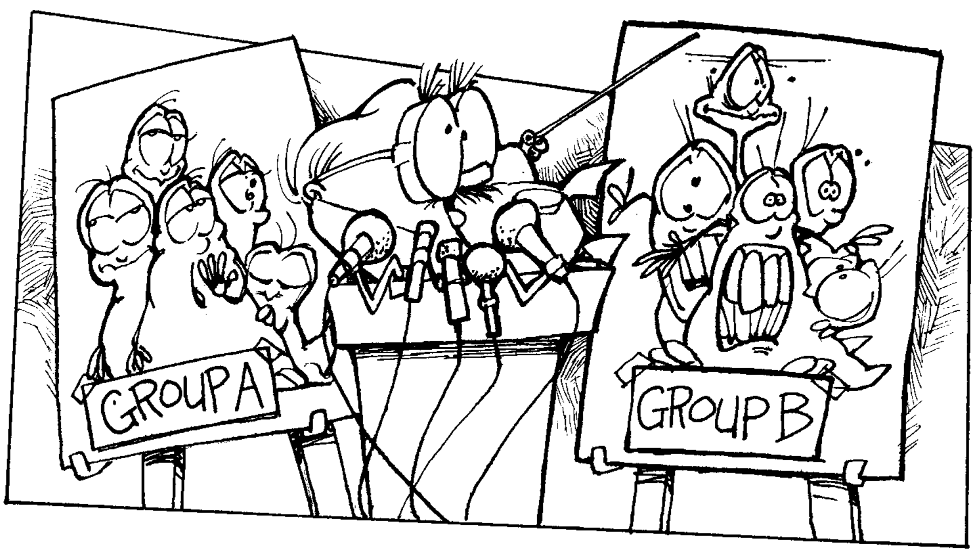
F. Look at what happened in your experiments, sum up the results, and draw your conclusions.

Did your results support or contradict your hypothesis? You should be able to say that your hypothesis ("best guess") appears to be correct or incorrect based on your experiments. Remember, it's OK if your results do not support your hypothesis; DON'T change it. If you have time, make a new hypothesis, test it with new experiments, and see what happens. Some of the best science fair projects come out when the original hypothesis was wrong or the experimental results were confusing and the student takes the next step of creating a new experiment to investigate what he or she discovered.

No matter what happened, you did not actually “prove” or “disprove” your hypothesis. You only found results that supported it or failed to support it. “Proof” is more for mathematics than science -- scientists deal with evidence (facts), hypotheses (predictions), and theories (statements based on large amounts of evidence gathered over many, many experiments and observations). Scientifically “proving” a statement true or false is quite difficult and generally takes much more than one experiment.

Because they are so easy to do now with computers, some students include statistical calculations (for instance, t tests) in their science fair projects. This is fine, but only if you really understand what the statistics mean and interpret them correctly. If you report statistics that you don’t understand, you will be hurting, not helping, your project.

Example: One of several things could have happened in our musical tomatoes experiment: The plants exposed to classical music every day either grew taller or less tall, with more or fewer leaves than the control group, or there was no difference, or you didn’t have enough information to tell either way. Whichever it was, use your results to support your CONCLUSIONS about what happened with your experiments.



COMMUNICATE YOUR RESULTS

3. Communicating Your Results

A. Summarize what you did and what happened in a final report.

This report should have the following:

1. Title: Make it interesting and not too long, and be sure it relates to your project and makes sense.

2. Introduction: Include what you learned from your background research, how you got the idea for your project, and so on.

3. Hypothesis: Write a simple sentence that identifies the problem you set out to solve and what you predicted the results would be.

4. Materials and Procedures: Explain, in enough detail that someone could exactly repeat your work, what you did and what you used in your experiments.

5. Results: Summarize the data you collected (the measurements you made, etc.) in a clear and organized way. This is where you might include tables or graphs. It is not the place to list all of your raw data (that's what your project notebook is for).

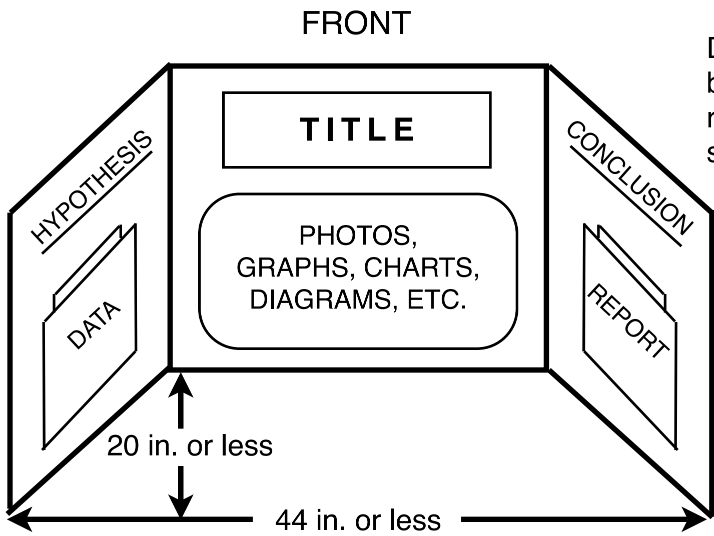
6. Conclusions: This is where you interpret the results of your experiment. Do they support your hypothesis or not? What new questions were raised by the results you got?

You should also write an ABSTRACT, which is a summary of your entire project in 200 words or less. Your abstract should include your hypothesis and a brief explanation of your procedures, results, and conclusions. If someone looked at nothing but your abstract, they should understand what you tested, why you tested it, how you tested it, and what your results were. It is not the same as the introduction or the conclusions section of your report.

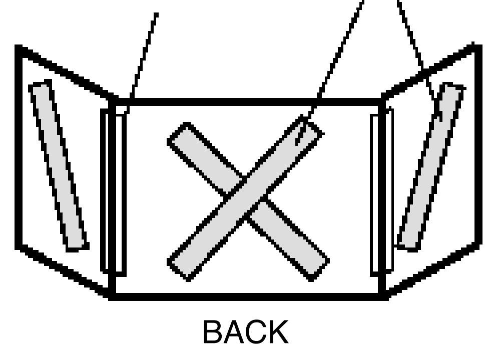
B. Be thorough.

Think about your project and what you have learned. Knowing what you know now, maybe you have some idea about what you could do better, or what someone else might do next. Include these thoughts in your report. You are also encouraged to include a title page, a table of contents, and a bibliography. If you got help from someone else in designing or carrying out your experiment (for example, if you found the basic idea for your experiment on the Internet, but changed it a little to make it your own), make sure you say so! This is called citing your references or collaborators and is a key part of doing ethical science.

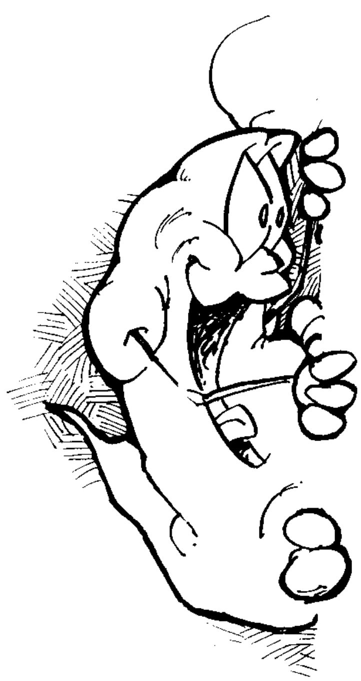
Example: Quite a few things could have affected how well your plants grew. Some factors you might have been able to control, such as the temperature of the room, how much water the plants got, or the amount of light in the room where your plants grew. Some things you may not have been able to control completely: how healthy the plants were when you got them, or whether they were exposed to other sounds like road construction outside, for example. Maybe tomato plants react differently to music than other kinds of plants (though this seems relatively unlikely). Maybe rap, rock, or country music would produce different results. Perhaps the same music played at a higher volume would make a bigger difference. Remember also that you did not prove that exposure to music makes plants grow better, you only showed that it MAY have this effect, according to your experiments. Writing these things in your report shows that you are thoughtful and thorough scientist.



Display boards are available in stores or can be made at home. If you make one yourself, reinforce the panels with wooden slats and the seams with duct tape.



NOTE: Data book and final report can also be attached to the project with a length of string or placed in binders or folders on the table in front of the display.



C. Make a display.

Your display should show what's in your final report, so make sure these are all there:

Title
Hypothesis
Materials and Procedures
Data/Results
Conclusions
Bibliography/Citation of help received

You must make a FREESTANDING display (one that does not need to hang on a wall or be propped up against anything), no more than 44 inches across and 20 inches front to back when set up (see illustration above). No matter how good your experiments were or how thorough your report is, if your display falls over or is too messy to read, people will have trouble looking at it and might ignore it.

Science shouldn't be dull and boring, so make the display fun and interesting to look at! Use drawings, photographs, charts, colored paper, and so on to make your work attractive. Make people want to come to your project and see what's happening there.

Since science fair judges may not have time to read your full report (and certainly won't be trying your experiment on the spot), make sure your stand-up display does a good job of explaining your work so that it can be understood and evaluated quickly and fairly. Be sure to use correct grammar and spelling throughout the project. Science is only as good as the scientist's ability to communicate his or her ideas!

Finally, because of the size and logistics of the San Francisco Science Fair, there are some things that might be appropriate to show off at your school fair but should NOT be included in the display you bring to the Randall Museum. Read the rules at the end of this guide carefully before constructing your display, and if in doubt about anything, check with your teacher or the science fair coordinator at the Randall Museum. In a nutshell:

- **<u>Make it sturdy, light, and portable</u>.** Your project needs to stand on its own for at least 2 weeks and may have to be moved several times during the course of the fair (finalists' projects in particular!). Heavy, fragile, or complicated displays and loose objects are more likely to get broken or have pieces go missing, and may be turned away. Leave your actual experiments at home; show them in photographs or drawings instead.

- **<u>Make it safe and neat</u>.** It's fine to liven up your project by attaching a moderate amount of materials or decorations to the display board. However, please **do not** include any of the following: live or dead ANIMALS (including insects), PLANTS, or SOIL; CULTURES (bacteria, molds, or fungi); **ANY** FOOD PRODUCT (packaged or not -- including candy, gum, vitamins, popcorn, etc.); LIQUIDS of any kind; SHARP OBJECTS, CHEMICALS, FIRE, GLASS, DRUGS, or other potentially hazardous items; VALUABLES of any kind (laptop computers, GPS devices, MP3 players, etc.); or anything else that might spill, rot, hurt someone, or attract pests. Because we are open to the public and unable to supervise the display areas at all times, please do not exhibit any "activities" that tell people to touch your display or any irreplaceable items (e.g., the only copy of your report).

- **<u>Make it anonymous</u>.** You should be proud of your work and want it to be recognized! However, for the judging to be fair, it's important that no one looking at your project can tell who did it. (Professional scientists do this, too: it's called anonymous peer review.) Make sure your face (your parents' faces, your teacher's face, your best friend's face, your school sweatshirt...) and any identifying information (name, school, teacher, etc.) is not visible on the front of the board or report, or is only in <u>one space small enough to cover with a 3"x5" card</u>. (It's fine to write your name, school, etc. on the back of the board.) After judging is finished, your registration card will be turned face-up so that everyone can see who did that fabulous science fair project!

We look forward to seeing you at the San Francisco Science Fair.

Good luck!

San Francisco Science Fair Rules and Guidelines

1) Work exhibited should be done by the entrant during the current school year. Outside advising from parents, teachers, or professionals is fine, but the student must do his or her own work and appropriately cite any help received.

2) Fair entry is subject to qualification through an approved school fair or other mechanism that may be established at the discretion of the Science Fair Coordinator, and to timely submission of project displays and registration materials. Entrants must reside and/or regularly attend school in the City and County of San Francisco, and must be in grade 6, 7, or 8.

3) Projects done by teams of up to four students in the same grade will be accepted into the San Francisco Science Fair at the Randall Museum, but please note that the regional San Francisco Bay Area Science Fair accepts only projects done by one student.

4) **The student's name and any identifying information (school, teacher's name, etc.) may appear only on the back of the project and/or in a single area of the display small enough to be covered by a 3" by 5" card.** Names and faces may not be visible during judging. Awards or ribbons from school science fairs must be removed before setting up a display.

5) When set up for display, the project must be **no larger than 44 inches wide by 20 inches deep** and must be able to **stand on a table by itself** for at least two weeks. Museum staff will not repair a poorly constructed display or in any other way attend to equipment. **Because it is often necessary to move projects after they are set up, the entire display must be sturdy and easily portable. Display of experimental apparatus is strongly discouraged; please use photographs, descriptions, and diagrams instead.**

6) All electrical apparatus used in experiments must be built according to standard electrical safety laws. Projects that use 110 or more volts may not use push-button switches (doorbell type) or open-knife switches. All projects using 110 or more volts must have a main disconnect switch of a type approved by the National Board of Underwriters. All wires must be of the size and insulation appropriate for the current and voltage used. All electrical apparatus of 110 or more volts must be enclosed to prevent users from receiving an electrical shock.

7) In keeping with SFBASF guidelines, electricity will not be provided by the San Francisco Science Fair. Working electrical devices included in the display can be powered only by batteries.

8) Dangerous chemicals, drugs, heat or flame, and explosives must not be exhibited.

9) No hypodermic needles, blades, glass, or other sharp or hazardous objects may be exhibited.

10) **No live or dead animals, plants, or cultures (bacteria, fungi, molds, etc.), soil, food, or liquids may be exhibited**; use photographs or drawings instead.

11) **Projects that involve animals, humans (including surveys!), pathogens, recombinant DNA, or controlled substances must meet the ethical and project proposal submission requirements of the San Francisco Bay Area Science Fair.** Students not eligible to enter SFBASF (6th graders and teams) need not file any forms with SFBASF, but must complete any applicable forms and file them with their teachers. Students should keep copies of all forms. For more information, see the SFBASF website, http://home.pacbell.net/sfbasf/.

12) Museum staff reserve the right to remove from display and, if necessary, dispose of inappropriate items as outlined above. Final decision as to the appropriateness of any item is at the discretion of the Science Fair Coordinator.

13) Entrants are responsible for the installation, maintenance, and removal of their projects. **All projects must be removed from the Randall Museum by 5 p.m. Saturday, March 8, 2008.** Leftover projects will be discarded after this date. Museum staff will not be responsible for the security of items exhibited.