TEACHER'S GUIDE TO THE SAN FRANCISCO SCIENCE FAIR, 2009 - 2010

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INTRODUCTION

The Randall Museum welcomes your participation in the 27th Annual San Francisco Science Fair. This event encourages students in grades 6 to 8 to conduct an original scientific investigation, making a best guess about the outcome and verifying its accuracy using good scientific procedures. The goal of the Science Fair is to encourage participation, not competition.
The three subject categories are:

1) BIOLOGICAL SCIENCES: e.g., plant growth, cell structure, molds, animal behavior, ecology;

2) PHYSICAL SCIENCES: e.g., airplanes, probability, friction, solar power, chemistry, insulation;

3) BEHAVIORAL, HEALTH AND SOCIAL SCIENCES: e.g., product comparisons, exercise, perception, aptitude tests, human behavior, medicine.

(In cases where a project could fit in more than one category, science fair staff will assign a category prior to judging so as to group similar projects together.)
Students must follow the procedures presented in this booklet in order to have their projects accepted into the San Francisco Science Fair. Please pay particular attention to project format and display, safety rules, and humane laws. Some projects from grades 7 and 8 will continue to the regional S. F. Bay Area Science Fair (SFBASF), generally held in Golden Gate Park in March. **If your school is in San Francisco, YOUR STUDENTS MUST ENTER AND WIN OUR FAIR BEFORE GOING ON TO SFBASF.** Our rules are designed so that projects qualifying for this fair can generally go on to SFBASF without revision.
NOTE: Students whose projects involve live animals, human subjects (including surveys and observations!), controlled substances, or pathogens MUST submit project proposal forms BEFORE BEGINNING THEIR EXPERIMENTS, absolutely no later than February 1. Experiments with human subjects (including surveys!) also require informed consent in advance from each subject. Students who cannot qualify for SFBASF (6th graders and teams) need not send forms to SFBASF, but still must complete any forms applicable to their projects and file them with their teachers. Please see the SFBASF website, **http://www.sfbasf.org**, for complete guidelines, forms, and addresses.
This guide is intended to augment the accompanying STUDENT'S GUIDE TO THE SAN FRANCISCO SCIENCE FAIR. If you have any questions not answered in the guides, please do not hesitate to contact us at 415-554-9604 or sciencefair@randallmuseum.org.

WHAT IS A SCIENCE FAIR PROJECT?

A science fair project is a logical and careful investigation of a scientific problem. Your students will begin with an idea or question of interest to them, experiment to test their best guess (hypothesis) at the answer to the problem, and conclude by writing up their methods and results and displaying them.

HOW DOES A STUDENT DO A SCIENCE FAIR PROJECT?

MAKE SURE THE PROJECT IS A DISCOVERY, NOT A DEMONSTRATION.
A project that shows how rubbing a plastic comb through cat fur creates static electricity, causing things to cling to the comb, is a demonstration of an established scientific fact. An investigation of which materials best accumulate static electricity, on the other hand, is a discovery. The difference is that in a discovery, the student did not know the answer in advance, and could not have found it easily by looking in a textbook.
The following guidelines will clarify the differences for you.

1. FINDING A PROBLEM TO EXPLORE

A. WHAT INTERESTS THE STUDENT? All scientists (students included!) work on things that they find interesting. As you know, if students are uninterested, their work will show it. Have them choose topics that they enjoy and could investigate.

EXAMPLE: A student is interested in gardening. This is too large and unspecific to handle, so the student must:

B. NARROW IT DOWN. The students need to limit their projects to single problems they can explore with the time and resources that they have. Students need to do RESEARCH using libraries, teachers, the Internet, and/or professionals in the sciences (e.g., a doctor) to find out what has been done (so they don't investigate something too obvious or trivial).

EXAMPLE: A student may have heard that music makes plants grow better. That may be, but the topic is still too general to cover in a single project. What kind of music? What kind of plant? How will the student define "growing better?" The project needs to be narrowed down to one tractable problem: for instance, "Does exposure to classical music make tomato plants grow taller or produce more new leaves than plants not exposed to music?"

C. WRITE A HYPOTHESIS. The student must state the problem precisely and make an educated guess at the answer, a HYPOTHESIS. It should be phrased as a simple, declarative sentence that could be either true or false. Reassure them that <u>a hypothesis is simply a statement to be shown true or false by scientific research; it is not important that they guess "right</u>." They will be judged on the basis of the originality, thoroughness, and clarity of their work, and <u>you should not give a lower grade just because a hypothesis proves to be incorrect</u>.

EXAMPLE: One hypothesis 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 also be that there is no effect, or a different effect. The student must select ONE possible outcome to test.

2. DOING EXPERIMENTS

A. DESIGN A TEST FOR THE HYPOTHESIS. The student must examine his/her best guess, WRITE IT DOWN, and design experiments to test it. <u>All factors that could affect the results must be kept the same, or CONTROLLED, in all experimental trials, except for the factor being tested in the project.</u> This can be difficult, because many factors that aren't obvious at first can skew results. Students must try to think of everything that could go wrong and figure out ways to avoid problems.

Remember, if any part of a student's project involves human or animal subjects, controlled substances, or pathogens, he or she <u>must</u> submit the SFBASF project proposal form <u>before</u> beginning to experiment. (Sixth graders and teams of more than one student must complete the forms and file them with their teachers, but do not need to send them in.) Human subjects must also give informed consent in advance.

EXAMPLE: In the experiment testing the effect of classical music on tomato plants, the plants must all be kept at the same temperature, receive the same amounts of sunlight and water, etc. Everything should be identical, except that half of the test subjects (plants) will be exposed to music (the EXPERIMENTAL GROUP) and half will not (the CONTROL GROUP). Subjects should be assigned RANDOMLY to the *experimental or control group. The student's procedures should be consistent (e.g., the same music at the same volume every day), and there should be enough difference between the experimental and control groups for there to be a chance of observing an effect (e.g., play the music daily for several weeks, so any differences have time to appear). All materials necessary to do the experiment correctly should be ready before beginning.*

B. DO MULTIPLE TRIALS. Students should do their experiments as many times as they can. Good science means examining a lot of information. If they do too few trials, unusual circumstances may have a greater effect on their results and thus decrease the value of their findings.

EXAMPLE: Perhaps some tomato plants would grow taller and produce more leaves anyway, because of preexisting differences in their health or genes. Remember: the more trials, the better, to produce a more universal and useful conclusion.

C. QUANTIFY OBSERVATIONS. Students should design a way to put their information into unambiguous numerical or quantitative form. They must be precise in order for their work to be repeatable, so a judge can tell exactly what they did and what they observed. Charts, graphs, tables, and diagrams are useful in organizing data clearly. Make sure that students are not tempted to make their data fit their hypotheses -- this is not good science! <u>Stress that good scientists are OBJECTIVE and do not try to make their experiments turn out a certain way</u>.

EXAMPLE: The student should record exactly how many new leaves each plant grew and exactly what the change in each plant's height was over the course of the experiment. These numbers should be separated into music vs. no-music groups and tabulated.

E. KEEP A PROJECT NOTEBOOK FOR THE RAW DATA. Have your students record ALL DATA and everything that happens during their work in a PROJECT NOTEBOOK, even if the data seem to contradict their hypotheses. Record-keeping is crucial to the scientific attempt to understand what happens.

F. EXAMINE RESULTS AND COME TO A CONCLUSION. When they have finished their experiments and organized their data, students must INTERPRET the information. **Do their results support their hypotheses? If not, reassure them that they should not feel bad. DON'T let anyone change a hypothesis to fit the data** (that's cheating!). A negative outcome to a hypothesis (the guess was incorrect) is just as important and illuminating as a positive one. If they have time, they can make new hypotheses, experiment, and see what happens. This is the way science often works (and how many of the best science fair projects happen!): with trial and error leading to further discovery.
Since personal computers have placed tremendous computing power at our fingertips, we are seeing more and more students reporting statistics (e.g., t tests) in their science fair projects. This is fine IF the student really understands the statistics and interprets them correctly (which is relatively uncommon among middle school students). In the absence of understanding, statistics are detrimental rather than helpful to a project.

EXAMPLE: Any of several things could have happened in the musical tomato experiment: the plants exposed to classical music grew taller or less tall with more or fewer leaves than the control group, or there was no difference, or the results were inconclusive. Whatever happened, the student should discuss the results in relation to the predictions, exploring both possible explanations for the outcomes and possible avenues for further research.

3. COMMUNICATING THE RESULTS

A. WRITE A FINAL REPORT. Some students doing science projects have good ideas and do accurate scientific work, but fail to explain their projects carefully. The students should communicate everything necessary for another person to do the same experiment again. They should not assume that anything is too obvious to write down. Good science means good communication! Everything must be clearly explained (with correct spelling and grammar) in a final REPORT, which should be placed in a pouch on the board or in a folder on the table, along with the project notebook full of data. The report should include:

TITLE
INTRODUCTION, including background research
HYPOTHESIS
PROCEDURES AND MATERIALS
RESULTS (data recorded during the course of experiments, perhaps in charts or tables)
CONCLUSIONS, including whether or not the hypothesis was correct
BIBLIOGRAPHY and citation of any help received

Each project also needs an ABSTRACT, which is a summary of the <u>entire project in 200 words or less</u>, communicating the hypothesis and a brief explanation of procedures, results, and conclusions. The abstract is NOT the same thing as the introduction or conclusions section of the report.

B. MAKE SURE THAT THEY ARE THOROUGH. A thorough scientist always points out weaknesses or alternative interpretations of the data and suggests research strategies for further study. Students are encouraged to include a title page, table of contents, and bibliography in their final reports. If the student received any help designing or carrying out the experiment, it is essential to acknowledge this as well.

EXAMPLE: Many factors may have influenced the outcome of the experiment, some of which may not have been controlled for. Alternate possibilities may occur to the student: perhaps rap or country music would have a different effect, or perhaps tomatoes respond differently to music than other plants. New experiments can be done to test these new hypotheses. In this example, please note that the student did not PROVE that music makes plants grow better (or worse). Rather, he or she obtained inferential evidence that music MAY have the observed effect.

4. MAKING A DISPLAY

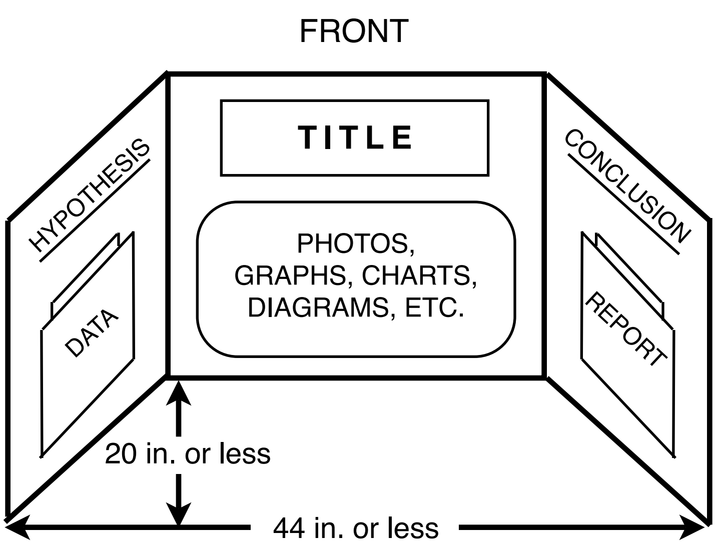
Each display must:

1) Be on a sturdy, **self-supporting** poster structure. (See diagram on the next page.)
2) **Summarize the work thoroughly enough for science fair judges to evaluate it quickly and fairly.** While judges are certainly welcome to read students' complete reports, this is usually not practical in the time available.
3) Be no wider than 44 inches and no deeper (front-to-back) than 20 inches.
4) Be able to stand on its own for at least two weeks. We will not repair flimsy displays. Foam core is the most durable display panel material. If mat board or thin cardboard are used, they should be reinforced on the back and sides.
5) **Show the student's name and other identifying information <u>only</u> on the back or in one corner of the display, <u>small enough to be covered with a 3"X 5" card</u> during judging.**

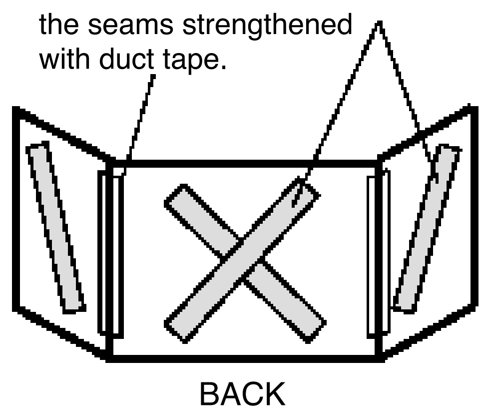
Students <u>may</u> also:

1) Attach to their displays a **limited** amount of materials they would like to show. However, **items from the following list are NOT acceptable for display and should be shown in photographs or drawings/diagrams instead:**
   - 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.)
   - Anything that might spill, rot, hurt someone, or attract pests
2) Liven up their displays with colorful graphics, drawings, photos, unusual type-styles -- anything to make them more interesting, fun to look at, and fun to build!
   In keeping with SFBASF guidelines, electricity will not be provided. Any working electrical apparatus may be powered only by batteries.

PLEASE NOTE: Fair logistics and judging procedures often make it necessary for us to move a project several times over the course of the fair. **Please have students limit the materials included in their displays so that the entire setup can be picked up and moved safely and easily by one person in a single trip.** Loose objects (Petri dishes, cups, cloth/tile/cardboard swatches, rocks, balls/marbles/toy cars, etc.) and excessively heavy or fragile displays are not appropriate and may be turned away. In most cases, experimental apparatus should be described and shown in photographs or drawings, <u>not</u> placed on display. Students who become finalists <u>do</u> have the option of bringing any non-hazardous portion of their experimental apparatus to their interviews if they wish.



Display boards are available in stores or can be made at home. Homemade boards should be reinforced with wooden slats and the seams strengthened 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.

Recycling of display boards (the board itself, not the contents!) from past years is strongly encouraged.

SUMMARY OF HOW TO DO A SCIENCE FAIR PROJECT

1) FIND A PROBLEM TO EXPLORE

Students should:

A. Choose scientific topics that INTEREST them.

B. Use books, the Internet, teachers, scientists, professionals, etc. to NARROW IT DOWN to something that is both possible and interesting to do.

C. State each problem as a one-sentence HYPOTHESIS that they will evaluate to be "true" or "false."

D. Make a DISCOVERY. They should NOT DO A DEMONSTRATION.

2) DO EXPERIMENTS

Students should:

A. TEST THE HYPOTHESIS. Students must decide what materials and instruments they will need to conduct their work and measure their results. Remember: if the student has chosen a topic that involves human subjects (this includes surveys and observation), animals, pathogens, or controlled substances, he or she must file the appropriate forms with the SFBASF (<u>not</u> with the Randall Museum) *before* beginning to experiment.

B. Use GOOD SCIENTIFIC METHODS. Students must make sure their experiments are well-controlled, repeatable, objective, and that they really test the hypothesis.

C. Run MULTIPLE TRIALS of their experiments so there will be lots of data from which to draw conclusions.

D. Collect and record their data in a measurable, repeatable way; that is, QUANTIFY the results.

E. Write down everything they observe in a PROJECT NOTEBOOK. Observations should be in some kind of numerical form for easy and unambiguous analysis.

F. Organize all information from the experimental trials in tables or diagrams, and then DRAW CONCLUSIONS. Did the results support or contradict the hypothesis?

3) COMMUNICATE RESULTS

Students should:

A. Summarize the whole process in a FINAL REPORT. Include title, introduction, hypothesis, materials and procedures, observations and data, results, and conclusions. Also write an ABSTRACT, summarizing the entire project in 200 words or less.

B. Be aware of both strengths and weaknesses in their work. Are they THOROUGH, and do they suggest further investigations?

C. Construct a freestanding DISPLAY, no more than 44 inches across and 20 inches front-to-back when set up, which outlines the final report. The display should include a title and be straightforward and clear. Students should use correct grammar and spelling. The display should be neat and interesting to look at, and MUST be sturdy enough to stand on its own for at least two weeks. Recycle foam core and other display board materials from past projects when possible. The display should use photographs, diagrams, and illustrations to show experimental apparatus and procedures; science fair rules and logistics do not permit the display of most equipment.

SOME HELPFUL HINTS ON RUNNING YOUR LOCAL SCHOOL SCIENCE FAIR

1) Steer students away from oft-repeated projects such as effects of colored light on plants or which paper towel brand is the most absorbent. Judges get tired of too many similar projects and may not give an unadventurous project the attention it deserves.

2) Make sure that students working with humans or animals, either by experiment or by observation, submit proposals to the Scientific Review Committee BEFORE they begin their experiments (or immediately, if they have already begun when you read this) and comply with all humane regulations. To avoid this step, you can steer students away from projects involving humans or animals.

3) Use parents, educators, and community contacts to full advantage to provide support and publicity for your local fair.

4) Difficulties often arise in judging projects and determining awards. Make sure you have an adequate number of qualified judges. No judge should look at more than about twenty projects -- beyond this point it is difficult for them to do justice to each project -- and each project should be seen by at least two judges. Judges should be impartial, ideally not teachers at your school or parents of students.

5) Be sure that all participants receive praise for their efforts and for what they have learned.

6) Try to ensure that similar projects are grouped together so that judging can be carried out fairly. At the San Francisco Science Fair, we sometimes will re-categorize a project if we feel it belongs in a different place. This should not substantially affect the outcome of judging.

7) Help students construct projects that are freestanding and will not require fixing later. Displays that are messy or falling apart are difficult to read and may divert attention away from otherwise good work.

8) **Supervision and appropriate mentoring are critical to middle school science fair projects!** We fully understand the burdens and busy schedules of teachers, but we also see many projects that could have been infinitely better if a teacher or mentor had stepped in at an early stage and gently redirected a stumbling young researcher. Make sure your students are aware of the rules of the fair from the beginning and check that they are following sound scientific procedures. At the same time, do what you can to ensure that the students (not their parents or mentors) are the primary scientists; including an interview in the judging process can be an effective way to control for this.

JUDGING CRITERIA

1) **SCIENTIFIC METHODOLOGY:** Does the experimental procedure test the hypothesis? Do the data support the conclusions? Was the work well controlled; were an adequate number of trials done; is the work repeatable; were good records kept; is the work ethically sound? Does the student recognize the limitations of the project and suggest further ideas for research?

2) **CREATIVITY:** Are there signs of insight and originality of approach? Is the project a discovery and not a demonstration? Do clarity of thought and imagination play a role in its development?

3) **COMMUNICATION:** Is the problem easily understood and concisely stated? Is it logically presented? Is the display attractive, dramatic? Is the exhibit neatly constructed, with legible lettering? Are grammar and spelling correct? Do the title and report convey information that helps to develop the project idea? Does the student cite references and any outside help appropriately?

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://www.sfbasf.org.
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 5, 2009.** Leftover projects will be discarded after this date. Museum staff will not be responsible for the security of items exhibited.