# STEP-BY-STEP STUDENT GUIDE

# AND CHECKLIST

# TO THE DEVELOPMENT OF

# SCIENCE AND ENGINEERING PROJECTS

**Senior Division**
**9th - 12th Grades**

West Central Indiana
Regional Science and Engineering Fair
DePauw University
Julian Science Center
Greencastle, IN

March 13, 2004

*This guide is adapted from the guide provided by the Greater San Diego Regional Science and Engineering Fair.*

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# Sample Timeline

**Get an early start on your project (Rules allow research to begin as early as June and run until the date the Fair begins).**

1. Deciding on a project. 1 week
2. Background research. 2 weeks
3. Forming a hypothesis/designing procedure. 1 week
4. Submit forms for teacher approval before starting experimentation
5. Experimentation. 4 - 8 weeks.
6. Results, conclusions, analysis. 1 - 2 weeks
7. Writing the project report. 1 - 2 weeks
8. Building a display board. 1 - 2 weeks

NOTE: There is a deadline for application to compete in the Regional Science and Engineering Fair. Applications must be received by February 28, 2003. Online applications will become available in January 2004 at the fair's website. www.vigoschools.org/~thnvhs/wcir It is recommended that you submit your application as soon as possible. Your project work can continue up until the Fair date of March 13, 2004.

| |
|---|
| MANY PROJECTS WILL REQUIRE **PRIOR SRC APPROVAL** BEFORE EXPERIMENTATION CAN BEGIN. BE SURE TO CHECK THE RULES AND GET APPROVAL FOR THESE PROJECST. TYPICAL TURN AROUND TIME IS TWO WEEKS FOR SRC REVIEW. SEE YOUR SCIENCE TEACHER FOR HELP ON THIS PART OF YOUR PROJECT. |

# GETTING THE IDEA

A science project! What'll I do? Do I have to find a cure for cancer? A way to end pollution? An endless supply of inexpensive electricity or water? HELP!

Whoa! Quit biting your fingernails. You're not expected to win a Nobel Prize with your very first project (that can wait a year or two).

What are you expected to do? Well, first of all, you've got to select a topic. And, how, you ask, do you do that? Checklist #1 should help. All you have to do is fill in the blanks. Note: The "Sample Timeline" on the preceding page should give you an idea of how much time you will need to spend on each checklist. Okay, here we go.....

**CHECKLIST #1. DECIDING ON A PROJECT**

**STEP 1**

List five things you are interested in

> Examples: the mathematics of music, sports medicine, computers, people-watching (human psychology), chemistry or have ever wondered about:

> Examples: Why is black print easier to read than blue?[1] Does the brand of chicken feed used affect the nutritional content of eggs? How does blade design affect the aerodynamics of helicopters? Can I design and implement a user-friendly graphics editor for my computer? What physical principles make it possible for me to catch a ten-pound fish on a six-pound test line?

1. ______________________________________________
2. ______________________________________________
3. ______________________________________________
4. ______________________________________________
5. ______________________________________________

If you listed things you like, pick one and ask yourself five questions about it. Questions you'd really like to know the answers to. For example, let's say you like computers. Your questions might include, "Can I design a better, more economical mass storage system for my computer?" "Can I write a program to design 'dungeons' for role-playing adventure games?" "Can I write a computer simulation of the predator-prey ecological balance in the canyons around my home?" "Can I write a program to compose rock music?" "Can I design a tracking system which will allow my computer to control the solar panels on my roof?" "Can I write a computer program to help beginners write computer programs? "Can I write a program to solve partial differential equations?"

Get the idea? Okay, your turn.

MY QUESTIONS ARE:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

Use separate pages to do this for each of your topics. Of course, if your first list is of things you've wondered about, you may have already taken this step.

Now, decide which question interests you the most and, after you fill in the next blank, you're on your way.

THE QUESTION MY SCIENCE PROJECT WILL ASK (ALSO CALLED THE "STATEMENT OF THE PROBLEM") IS:

______________________________

______________________________

______________________________

NOTE: Remember, your project must involve *actual experimentatio*n (i.e., "Designing and Testing a New Laser Steering System"). It should not be simply a report ("Lasers"), a demonstration ("How Lasers Work") or a system, however advanced, built from someone else's plans.

**STEP 2**

In choosing your topic be sure to not take on more than you can handle. Narrow it down, take an in-depth look at a single aspect of the problem that interests you. Tackle something that hasn't been done over and over again.

Examples

1. "Effect of Specific Acid Rain Concentrations on Kalanchoe Chlorophyll Production" would be better than "Effect of Acid Rain on the Growth of Plants."
2. "Effects of Ancient Indian Cacti Remedies on Bacterial Growth" would be more original and interesting than "Effect of Various Antibiotics on Bacterial Growth."

Try it. Before you go on to the next section, re-write your QUESTION as a WORKING TITLE, one, which simply and accurately describes your research. For example, let's take the five questions listed on the previous page. Good titles for them might be:

1. Blue Vision Decrement and Learning Problems: Study in Perceptual Response
2. Correlation between Chicken Feed and the Nutritional Content of Eggs

3. Effects of Blade Design on Helicopter Aerodynamics
4. A User-Friendly Graphics Editor for the Apple IIE
5. The Physics of Fishing: Fish Size vs. Line Test Weight

THE WORKING TITLE OF MY PROJECT IN **10 OR FEWER WORDS** WILL BE:

______________________________________________

______________________________________________

## LAYING A FOUNDATION

Okay, you've decided on the TOPIC (the one described by your QUESTION and TITLE) you want to investigate. What next? First you'll need to find out what's already known about the subject.

**CHECKLIST #2-- BACKGROUND RESEARCH**

If your QUESTION was "Are art talent tests biased against right-handers?" you'd study such things as art tests, right- and left-handedness, the works of famous artists, psychological testing and artistic judgment. Or, if your TOPIC were "Effect of Depth on Underwater Color Photography," you'd want to know more about underwater cameras, filters, light refraction, how depth affects color perception, underwater measurements and safety precautions. If, on the other hand, you were interested in how an oil spill would affect sea anemones, you might need to research such things as wave patterns, ocean currents, conditions and substances affecting the growth of anemones, the chemical makeup of oil and what happens when oil and sea water "mix." You'd also collect information on what can be done to prevent and clean up oil spills.

Got it? Okay, list five or more research TOPICS related to your QUESTION.

1. ______________________________________________
2. ______________________________________________
3. ______________________________________________
4. ______________________________________________
5. ______________________________________________

Additional TOPICS may be written on a separate page.

Now, head for the library. A search of the Internet, card or microfiche catalogs should start you in the right direction. Don't forget the *Reader's Guide to Periodical Literature*, which lists magazine articles by topic. Be careful when using Internet resources since there is no Internet filter for bogus or false claims. Only refer to reputable web sites and stay away from personal web pages where the authors reputation is questionable.

Take lots of notes (you'll need them later) and be sure you keep a list of your REFERENCES, using standard bibliographical format (see *Science Fair Handbook: A Guide for Teachers and Students*[2] and *Nuts & Bolts: A Matter of Fact Guide to Science Fair Projects*[3]). Note: At least ten REFERENCES should be consulted, with twenty-five being a better minimum number.

Catalog useful material from these REFERENCES, one note to a card, on 3" by 5" index cards. A sample REFERENCE NOTECARD might look like this: (a blank page of note cards is in the appendix for your use)

| | | | | |
|---|---|---|---|---|
| **Author:** | Randy Borden | | **Year:** | |
| **Title:** | EARTHWORM ANATOMY | | | |
| **Publication:** | | | | |
| **Publisher:** | The Science Man Press, Harwood Heights, Illinois | | **Year:** | 1976 |
| **Pages:** | 256 | **Library Reference:** | Ref 201.4 be | |
| Oligochaetes lack eyes except for a few aquatic forms. Earthworms do have photoreceptors in their epidermal layer though and thus, are light sensitive. | | | | |

Your turn. List below, continuing on a separate page, ten or more REFERENCES (books, magazine articles, etc.) you are using in researching your TOPIC.

1 ____________________

2 ____________________

3 ____________________

4 ____________________

5 ____________________

6 ____________________

7 ____________________

8 ____________________

9 ____________________

10 ____________________

Talk to your teacher and to experts on your subject. Write letters. Find out as much as you can before starting your experiments. If, for example, you were planning a project in which knowledge of the relationship of temperature to sound velocity were important, you might consult a physicist, a meteorologist and an electrical engineer.

Your turn again.

THE EXPERTS I WILL CONSULT ABOUT MY PROJECT ARE:

1. ____________________________________________

2. ____________________________________________

3. ____________________________________________

Additional experts should be listed on a separate page, include possible contact information.

Be sure your questions are good ones. Don't say, "I'd like to do a project on holograms. Where should I start?" Instead*, ask specific* questions that show you have already taken the trouble to learn something about your topic.

For example, if you were interested in whether mice learn a maze faster when one of their siblings is at the other end you might ask such questions as "Do you know of any research indicating that mice recognize their brothers and sisters?" "Have you found a particular size or shape maze to be best when working with mice?" "At what temperature should the room where the mice are housed be kept?" "What other factors could influence a mouse's maze-learning ability?" and "Based on your own research, would you recommend using very young mice for this experiment?"

Your turn. Write five questions you might ask about your project:

1. ____________________________________________

2. ____________________________________________

3. ____________________________________________

4. ____________________________________________

5. ____________________________________________

Preliminary BACKGROUND RESEARCH done? Okay, it's time to "design your EXPERIMENT." Remember, though, that other questions will arise as you work on your project. These may well require additional library work, the results of which should be added to your BACKGROUND RESEARCH materials.

## TAKE A GUESS

"Take a guess!"

Doesn't sound very scientific, does it? Agreed, but, hang in there and let's find out just what "guessing" has to do with developing a science project.

**CHECKLIST #3--FORMING A HYPOTHESIS**

You've finished your preliminary BACKGROUND RESEARCH. You've talked to lots of people, spent hours in the library and know a great deal more about your subject than you had thought possible. What next?

Here's where the "guessing" comes in. Based on what you've learned, you're going to make an "educated guess" about the probable outcome of your project.

Let's say you've been researching sales psychology and everything you've read indicates that both visibility and eye-catching displays are directly related to the volume of sales a merchant can expect. You work in your school store and decide to test these theories on the sale of candy bars. Your "educated guesses" which scientists call "HYPOTHESES" are that your experiments will show that 1) candy bars displayed at eye level will sell better than those at the bottom of the display case and 2) candy bars displayed against contrasting colors will sell better than those on backings similar in color to their wrappers. Your "guesses" may be wrong, of course, which is something you'll find out for yourself as your project progresses. You won't be trying to prove your HYPOTHESES right, by the way, merely to test them!

Your HYPOTHESES are

1) "Increased Visibility of Merchandise will Improve Sales" and

2) "Display Backings in Contrasting Colors will Improve Sales". Simple, straightforward statements (NOT QUESTIONS!) as to what you think the results of your tests will be.

Now, back to <u>your</u> project. <u>Based on your research</u>, what do you think the outcome of <u>your</u> project will be? State it, as a HYPOTHESIS, on the line below.

<u>MY HYPOTHESIS/HYPOTHESES IS/ARE:</u>

______________________________________________________________________________

______________________________________________________________________________

_____________________________________________________________________________

## TEST TIME

The next job is to decide on a way to test your HYPOTHESIS. The steps you take to do this are your PROCEDURES.

**CHECKLIST #4-- DESIGNING YOUR PROCEDURES**

SAMPLE PROJECT #1

If, for example, you want to know whether Zooplankton react to a probable gradient of Phytoplanktonic exudations, you would decide on the particular Zooplankton (copepods) and Phytoplankton (Coscinodiscus granii and Gonyaulax polyhedra) to be used and obtain a large supply. Then you would design and build a three-section cylinder (segments separated with 35 micron mesh) through which filtered seawater can flow at a carefully controlled rate, being certain other factors (light, heat, angle of tube, flow rate of water, etc.) remain constant.

EXPERIMENT 1

a. Allow copepods to distribute themselves in the central segment of the cylinder.

b. Introduce Coscinodiscus granii into the first segment.

c. Allow filtered water to flow through the cylinder.

d. Observe and record the positions of the zooplankton every 10 minutes for 90 minutes.

e. Repeat test 50 times.

f. Graph results.

g. Analyze data.

EXPERIMENT 2

Run steps a - g, using Gonyaulax polyhedra as the Phytoplankton.

CONTROL

Run steps a - g, using no Phytoplankton

In this project you have two EXPERIMENTAL GROUPS (one for each Phytoplankton) and a CONTROL GROUP (no Phytoplankton). Several hundred copepods, a minimum SAMPLE SIZE if your results are to mean anything are used. Multiple TEST RUNS are made for each combination. Fifty runs would be a good number. Think about it. What happens during a single run could be a fluke. If, however, you get similar results each time, you're probably "on to something." The TEST CONDITIONS for each group are the same: identical water flow, apparatus angle, temperature, light, etc. The only VARIABLE (a condition changed by the experimenter) is the Phytoplankton used (a different one for each EXPERIMENTAL GROUP. the same amount in each case, none for the CONTROL GROUP.

SAMPLE PROJECT #2

If you were interested in whether chemical fumes pose a threat to contact lens wearers, your project design might look something like this:

a. Obtain a large supply of sample lenses. an equal number each of hard and soft. from optometrists, manufacturers, etc.
b. Decide on and obtain the chemicals to be used, i.e. hydrochloric acid (12 molar), formaldehyde, bleach, lighter fluid, perfume (spray), freon (aerosol), acetone. Handle with care.
c. Place a soft contact lens in a box (50 cm x 25 cm x 25 cm) containing 100 ml of the first chemical to be tested, being sure it will be fully exposed to the fumes. Keep lens moist by dripping regulated drops of distilled water on it continuously for 30 minutes (averaging 1 ml per minute, the amount an irritated eye would tear).
d. Clean the box and replace the chemical with the same quantity of the same chemical. Place a hard lens in the container and repeat experiment.
e. Rerun steps C and D repeatedly with each chemical, using new lens for each test.
f. Each time a lens is removed make a quantitative analysis of the chemical extracted from it.
g. Run a new series of tests with the same chemicals. spraying and splashing them directly onto the lens. Determine the amount of chemical absorbed by each.
h. Observe physical damage (lessening of clarity, pitting, corrosion, etc.) to each lens.

**GUIDELINES/PARAMETERS FOR COMPUTER-ORIENTED SCIENCE PROJECTS**

Computer technology may be incorporated into science fair investigations in one or a combination of the following three ways:

I. As a tool to record/statistically analyze data gathered in another experiment

A. Projects of this type would be entered in the category of the experiment involved.

B. State whether the student wrote the program used, made a major adaptation of an existing program or used already available software. If the program is the original work of the student, that part of the project should be presented as outlined in III below.

II. Developing/building new computer circuits/hardware items

A. Project would be entered in the Engineering category.

B. Software/firmware programs that are original work of the student, they should be presented as shown in III below.

III. Writing a new computer program/software development

A. A project involving only the writing of an original computer program or a major adaptation of an existing program would be entered in the Computers category.

B. A project of this type should include:

1. A statement of the student's OBJECTIVE This should include a description (the configuration) of the computer system that will be used to achieve that objective and of the system's capabilities.

2. A summary of the research done by the student before writing the program. What else has been written/programmed about this topic? State why this new program will be different/better/more useful.

3. A chronological description of the development of the program. It should describe the various approaches tried and explain why they were accepted/rejected.

4. A concise block diagram or similar presentation to show the structure of the program design (maximum of two pages) and that it is cross-referenced to the program listing (#5 below).

5. A program listing that includes explanatory "remark statements" and is cross-referenced to the block diagram (#4 above).

1. Sample run(s) to show the product(s) of the program.

7. A critique of the completed program showing how well the objective was achieved and/or how the program is qualitatively different/better than other similar programs.

If you are doing and computer, mathematics or engineering project the elements of your procedures will vary. See International Rules for Pre-collegiate Research for additional advice. This resource is available at

http://www.sciserv.org/isef/students/about_projects_fairs.asp

USE THE FOLLOWING PAGE TO CREATE A ROUGH OUTLINE OF THE PROCEDURES YOU WILL USE IN YOUR PROJECT.

THE PROCEDURES I WILL FOLLOW IN TESTING MY HYPOTHESIS ARE:

NOTE: Either more or fewer steps may be required for your project. Additional steps should be recorded on a separate page.

On the following lines outline the basic design for your experiments:

## A MATTER OF TERMS

In the step above you learned the terms "EXPERIMENTAL GROUP," "CONTROL GROUP" and "VARIABLE." Different terms, such as those in the explanation below, are sometimes substituted for these.

> "All experiments (EXPERIMENTAL GROUPS) must have only ONE MANIPULATED VARIABLE (the part you change/experiment with). All other VARIABLES in the experiment must be CONTROLLED (unchanged). Only one change may be made in each EXPERIMENTAL GROUP, none in the CONTROL GROUP. If, for example, you were trying to determine the most effective shape and color combination for stop signs (in terms of driver response time), the MANIPULATED VARIABLES would be the colors and shapes chosen (a different combination for each GROUP. traditional colors and shape for the CONTROL GROUP, new pairings for the EXPERIMENTAL one. being sure tests are run for every possible grouping of size and color). The CONTROLLED VARIABLES would be the size and placement of the signs, the length of time the sign is seen, the distance from the TEST SUBJECT, lighting conditions, etc. These would be the same for all SUBJECTS-- both in the EXPERIMENTAL GROUPS and the CONTROL GROUP.
>
> "Another term used along with these is RESPONDING VARIABLE (changes occurring as a result of your experiment). In the stop sign experiment these might include reaction time (how long it takes for the subject to "hit the brake (initial lifting of the foot, point at which the foot touches the pedal, stopping time);" other responses by the "driver;" such measurements as eye motion, blood pressure, pulse rate, etc. In this worksheet you'll include such changes (RESULTS) in your OBSERVATIONS (CHECKLIST #8). Whether you call them RESULTS (to be observed and measured) or RESPONDING VARIABLES (to be observed and measured), however, it will help you to think now about some of the things you should be watching for in doing your project (there'll probably be others)."[5]

Give it a try.

<u>FIVE CHANGES WHICH MIGHT OCCUR AS A RESULT OF MY EXPERIMENT ARE:</u>

1. ____________________________________________
2. ____________________________________________
3. ____________________________________________
4. ____________________________________________
5. ____________________________________________

## TEACHER/ADVISOR APPROVAL OF PROJECT PROPOSAL

Before starting work on your project you must have the written approval of your science, math or computer teacher/advisor. Use **Forms 1A and 1B** (*Student Application, Research Plan and Approval Form*) AND **Checklist for Adult/Sponsor/Safety Assessment Form** for this purpose.

If not already done, DO IT NOW! This approval is subject to confirmation by the Regional Fair's Scientific and Review Committee at Screening and/or when application is made to the Fair. *These forms MUST be displayed with your project notebook at the Fair*.

I HAVE COMPLETED Application Forms **1A** and **1B** and **CHECKLIST FOR ADULT/SPONSOR/SAFETY ASSESSMENT FORM** and it has been approved by my teacher/advisor.

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## SPECIAL CASES

If you plan to use:

1. Human subjects/interviewees
2. Live vertebrate animals
3. Potentially mutagenic, carcinogenic, teratogenic or infectious agents (including but not limited to microorganisms, i.e., bacteria, fungi, protista, viruses and parasites)
4. Potentially hazardous substances or devices (including chemicals)
5. Human or other vertebrate tissue (including hair, teeth, blood, blood products or other body fluids)

in your project, some very important additional considerations are involved. The following pages are designed to help you consider the special requirements. Be sure to read thoroughly through each checklist.

**CHECKLIST #5—**

**PROCEDURES FOR PROJECTS USING HUMAN SUBJECTS/INTERVIEWEES**

Students doing research involving human subjects/interviewees MUST:

1. Read and complete the Intel ISEF Human Subjects Form (4)

2. *Be sure to get prior approval for the SRC before starting research.* Submit them to your teacher/advisor for approval BEFORE starting their projects (approval subject to confirmation by the Scientific Review Committee)

These approved forms **MUST** be included at the front of your project notebook when exhibited at the Fair.

make sure that

a. No physical, psychological or social risks are involved

b. The subjects are not embarrassed

c. Their right to privacy is respected

d. They (or if they are under 18, their parents or guardians) have given written consent for you to test them. Studies conducted in classrooms with the teachers' consent may be certified by the teachers involved

e. No professional (commercially available) psychological (or other) tests are used without written permission of the author(s).

For example, you decide to compare the reactions of senior high students, male vs. female, when asked personal questions. Your procedures might read something like this:

1. Make a list of ten general knowledge (i.e., Who was the 16th president of the United States?) and ten opinion questions (i.e., What is your favorite color?).

2. Review questions with teacher. Are the general knowledge ones appropriate for the age subjects you will use? Are the opinion ones too personal? If they could cause embarrassment or if they pry into areas that are "none of your business," write new ones!

3. Arrange for 300 boys and 300 girls, ages 15 - 18, to participate. telling them only that they will be asked some questions as part of a science project. Do not explain the purpose of study as this might affect the way they react. Do not press anyone unwilling to participate.

4. Seat subjects one at a time (over a period of several weeks. always at the same time of day) in a quiet room. Ask questions. general first then opinion in 100 of the cases, reversing the order in the second 100, alternating question types in the last 100. (Changing the sequence will help assure that other factors, i.e., tiredness, grouping, don't affect results.)

5. Make notes, identifying subjects by number only (i.e., #22. male, age 13), recording their body language reactions (i.e., arm folding, hair twisting, pencil tapping) to each question.

(Keep separate, confidential list of subjects by name and number but. DO NOT DISPLAY!)

IF your project involves humans re-write your PROCEDURES, showing the precautions you will take to protect your subjects.

1. ______________________________________________________________

2. ______________________________________________________________

3. ______________________________________________________________

4. ______________________________________________________________

5. ______________________________________________________________

Note: List additional procedures on a separate page.

__________ Check here when your Human Subject form has been completed, and submitted to your teacher and approved.

__________ Check here if these forms do not apply to your project.

**CHECKLIST #6—**

**PROCEDURES FOR PROJECTS USING LIVE VERTEBRATE ANIMALS**

You want to use live vertebrate animals in your project?

Well, before you do, there are lots of questions to be answered, lots of special steps to be taken.

First things first. Answer ALL of the following questions:

1. Think about why you want to use animals.

   a. Is your purpose humane? ____________________________________________

   b. Will it benefit the animals involved? ___________________________________

   c. Animals in general? _________________________________________________

   d. If not for their direct benefit, does it serve a useful purpose. WITHOUT harming them in any way? __________________________________________

2. Next, take a look at the question your project is designed to answer.

   a. Is it new? __________ (NOTE: If the answer can be found in a book, magazine or newspaper, there's little purpose in repeating it.)

   b. If not original, are new approaches involved? __________________________

3. Now, think about what you know about the animals you'd be using.

   a. What and how often do they eat? ______________________________________

   b. Drink? __________________________________________________________

   c. At what temperature are they comfortable? ______________________________

   d. In what environment? _____________________________________________

   e. How much room do they need? _______________________________________

   f. How much attention? ______________________________________________

4. Next, consider the time and work involved. Are you prepared to

   a. Take proper care of them

      i. in the middle of the night when you ache all over with the flu? __________

      ii. when you'd rather be swimming (dancing, etc.)? __________

      iii. when cleaning up after them is a real messy chore? __________

      iv. on weekends and holidays? __________

v. ALL OF THE TIME? __________

b. To arrange care while your family's on vacation? _______________________

c. To pay for necessary veterinary treatment? ____________________________

Do you, and your project, qualify? If not, consider doing something in computers (botany, engineering, behavioral sciences, etc.)!

Still enthused? Okay. The questions above are just the beginning. There's more to come!

Before you go any further, think about this:

Animals used in a science project (whether done at home, school, an outside laboratory or elsewhere) MAY NOT be medicated, drugged, deprived of adequate nutritional food and/or water, treated or used in any way that causes pain, discomfort, harmful stress (physical or emotional), injury, disease or death.

Any experiments involving them MUST be conducted humanely and with a respect for life (an attitude which must also be evident when dealing with non-vertebrates!)

Still interested?

To find out if your project idea is acceptable and BEFORE obtaining the animals you plan to use:

1. Read and complete the "*Nonhuman Vertebrate Animal Form* (**Form 5**) including all required signatures. Intel ISEF 2004 Rules and Guidelines available online at http://www.sciserv.org/isef/students/rules_regulations.asp

2. Submit it to your teacher for approval and signature (approval subject to confirmation by the WCIRSEF Scientific Review Committee (SRC)

The **Checklist for Adult Sponsor/Safety Assessment Form** and **Form 5** must appear in the student's notebook at the Science Fair.

Still there?

If you planned a project on the comparative behavior of gorillas in captivity and in their natural habitat, your PROCEDURES might read something like this:

2. Do extensive library research on behavioral studies made of gorillas "in the wild" (i.e., the work of Dian Fossey).

3. Chart all behaviors observed, noting conditions, time, and other factors that may have influenced the animals.

4. Spend hundreds of hours at the zoo, over a period of several months, observing the behavior of captive gorillas.

5. Chart as in Step 1.

6. Analyze the behavior of captive and free gorillas in similar situations.

Back to you. Re-write the PROCEDURES you will follow in doing your project (at least five. include additional steps on a separate page), showing your conformity with the animal rules:

1. ______________________________________________________________

2. ______________________________________________________________

3. ______________________________________________________________

4. ______________________________________________________________

5. ______________________________________________________________

_________ Check here when your **Form 5** has been completed, submitted to your teacher and approved.

_________ Check here if **Form 5** does not apply to your project.

**CHECKLIST #7—**
**PROCEDURES FOR PROJECTS INVOLVING, A) POTENTIALLY MUTAGENIC, CARCINOGENIC, TERATOGENIC OR INFECTIOUS AGENTS (INCLUDING BUT NOT LIMITED TO MICROORGANISMS, I.E., BACTERIA, FUNGI, PROTISTA, VIRUSES AND PARASITES) AND B) POTENTIALLY HAZARDOUS SUBSTANCES OR DEVICES (INCLUDING CHEMICALS)**

Students **MUST** complete **Form 3**, *Designated Supervisor Form* and have it approved by their teachers/advisors **BEFORE** starting projects involving these substances. (approval subject to confirmation by the WCIRSEF Scientific Review Committee).

The approved **Form 3**, **Form 1** and **Checklist for Adult Sponsor/Safety Assessment Form MUST** be included at the front of the project notebook when exhibited at the Science Fair.

________ Check here when your **Form 3** form has been completed and approved by your teacher/advisor.

________ Check here if **Form 3** does not apply to your project.

NOW. write the PROCEDURES to be used in doing your project (use a separate page for additional steps), showing your conformity to the rules covered by **Form 3**:

1. ____________________________________________
2. ____________________________________________
3. ____________________________________________
4. ____________________________________________
5. ____________________________________________

**CHECKLIST #8—**
**PROCEDURES FOR PROJECTS INVOLVING HUMAN OR OTHER VERTEBRATE TISSUE (INCLUDING HAIR, TEETH, BLOOD, BLOOD PRODUCTS OR OTHER BODY FLUIDS)**

Students **MUST** have a Qualified Scientist (see Rules for explanation) complete **Form 2**, *Qualified Scientist Form* **BEFORE** starting projects involving these substances. (approval subject to confirmation by the WCIRSEF Scientific Review Committee).

The completed **Form 2, Form 1 and Checklist for Adult Sponsor/Safety Assessment form MUST** be included at the front of the project notebook when exhibited at the Science Fair.

________ Check here when your **Form 2** has been completed and approved by your teacher/advisor.

________ Check here if **Form 2** does not apply to your project.

NOW. write the PROCEDURES to be used in doing your project (use a separate page for additional steps), showing your conformity to the rules covered by **Form 2**:

1. ______________________________________________________________

2. ______________________________________________________________

3. ______________________________________________________________

4. ______________________________________________________________

**CHECKLIST #9-- LOGGING IT IN**

You've planted your petunias, built a device to measure the effects of humidity on tennis ball bounce or ...... whatever your project, you're ready to go. Your project design is a good one, with a large SAMPLE SIZE, a single VARIABLE (one MANIPULATED VARIABLE, with all others being CONTROLLED), a CONTROL and plans to make several TEST RUNS.

What now?

Open your eyes. It's time to make notes. MAKW OBSERVATIONS of everything that happens, (DATA/RESPONDING VARIABLE MEASUREMENTS), during those TEST RUNS.

When those petunias start growing, for example, you'd note rate of growth, height, number of leaves, size of leaves (precise MEASUREMENTS, i.e., 3.1 cm by 2.3 cm, not "small," "big," etc.), color differences or changes, any problems or unusual developments. Always date and time your notebook entries and make drawings or take photographs to illustrate your notations.

The tennis ball project would require such information as the humidity at the times of testing, height from which each ball was dropped, height each ball bounces (exact measurements, not approximates), etc. Drawings or photographs in this case could also be effectively used to illustrate exactly how your device works.

A LOG ENTRY, in this case for a study of whether the distance between a person's eyes affects peripheral vision, might read something like this:

<u>October 12, 2002 6:30 pm</u>

1. Tested 3 subjects today. Female #12, age 15; Male #15, age 14 and Female #13, age 14.
2. Administered standard eye chart tests for visual acuity. Results:
    a. Female #12. left eye, 20/25; right eye, 20/20
    b. Male #15.-- left eye, 20/20; right eye, 20/20
    c. Female #13. left eye, 20/30; right eye, 20/25
3. Made eye distance measurements. Results:
    a. Female #12. 5.5 cm
    b. Male #15.-- 5.7 cm
    c. Female #13. 5.2 cm
4. Measured peripheral vision. Results:
    a. Female #12. 95o, left; 94o, right
    b. Male #15.-- 97o, left; 97o, right
    c. Female #13. 85o, left; 84o, right
5. Arranged to retest these subjects on October 25, November 15 and November 30.

You try it now. Write possible LOG ENTRIES for <u>your</u> project. Remember that ENTRIES should be made for mistakes and hard-to-explain (unexpected) results, too.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

**CHECKLIST #10 --THE RESULTS ARE IN. ADD THEM UP AND DRAW YOUR OWN CONCLUSIONS**

You've run all your TESTS several times. Your LOG is full of ENTRIES. Now, what do you do with all the information DATA (RESPONDING VARIABLE MEASUREMENTS)-- you've collected?

The first step is to tabulate that DATA. to add it up and see what you have. These figures are your FINDINGS or RESULTS.

In a study made to determine how the academic performance, extracurricular activity participation and social involvement of children with two wage-earning parents compare to that of those with one parent working outside the home, one portion of the results might read something like this:

Of the 2000 students studied:

1. 35.2% of those in Group A (two wage-earning parents) and 22.8% of those in Group B (one parent working outside the home) had grade point averages of 3.0 or better.
2. 44.6% of those in Group A and 44.3% of those in Group B had grade point averages better than 2.0 but less than 3.0.
3. 10.9% of those in Group A and 20.4% of those in Group B had averages better than 1.0 but less than 2.0.
4. 9.3% of those in Group A and 12.5% of those in Group B had averages below 1.0.

**NOTES:**
These DATA should also be presented in appropriate easy-to-read forms. i.e., GRAPHS, CHARTS. A number of computer programs that can be used to compile and display your data in chart or graph format are now available.

So, what do all these numbers mean? When you have the answers, when you've ANALYZED the DATA you've collected, you'll be able to draw some CONCLUSIONS.

In other words, RESULTS or FINDINGS (RESPONDING VARIABLE DATA) are what you learn from your TESTS (and bear in mind that negative RESULTS. i.e., test failures. are RESULTS and are to be reported); CONCLUSIONS are your interpretation of those facts and figures.

Which is where the ANALYSIS comes in. the use of STATISTICAL ANALYSIS will provide a solid basis for your CONCLUSIONS. not just "well, it looks as though...." but "analysis of the data indicates that....." You're probably asking, "What in the world is STATISTICAL ANALYSIS?" Mathematicians have developed several ways (averages, means, chi-square test, t-test, etc.) to study RESULTS (RESPONDING VARIABLE DATA) to help decide whether those results happened by chance or were really caused by the MANIPULATED VARIABLE of an experiment (in other words, was the "effect" really caused by the "cause?".

Note: A comparison of graphs is NOT statistical analysis.

Therefore, before you draw, or jump to conclusions, you need to ask yourself, "Are my results meaningful? How do I know they are or aren't?"

**CHECKLIST #11-- WRITING IT UP**

Your RESULTS are in, your CONCLUSIONS drawn and it is time to write your PROJECT REPORT. At this point you may want to change your WORKING TITLE. Remember that your final TITLE, the one used in your REPORT and on your DISPLAY BOARD, should contain no more than ten words. The following sample Table of Contents outlines the basic contents of that REPORT (see *Science Fair Handbook . A Guide for Teachers and Students* for additional contents, which may be needed in some REPORTS).

CONTENTS



And what goes into these?

ABSTRACT-- a brief (no more than 250 words) summary of the main points of your project (PROBLEM, PROCEDURES, RESULTS, CONCLUSIONS)

ACKNOWLEDGEMENTS-- credits to those providing you with help/advice, i.e., Thanks to your science teacher, the university, and/or professor who offered you use of your lab.

INTRODUCTION--.a brief look at the background and goals of your research, with separate entries for the STATEMENT OF THE PROBLEM and your working HYPOTHESIS

REVIEW OF THE LITERATURE-- (here's where all that background research comes into play). A report (minimum of 5 pages) on what others have done in your area of research. Contains such statements as, "perhaps the most important information is found in John Appleton, et al, (1981), where it was indicated that..." The full names of the publications involved are listed under LITERATURE CITED.

PROCEDURES-- a step-by-step description of how you did your project, including your use of MANIPULATED and CONTROLLED VARIABLES

FINDINGS-- the DATA you collected, the responses, reactions and RESULTS you observed, the results of your STATISTICAL ANALYSIS

CONCLUSIONS-- a simple statement of your interpretation of those results

RECOMMENDATIONS-- your ideas on possible uses for your FINDINGS and of additional tests that should be made

LITERATURE CITED-- bibliography of works mentioned or quoted in the body of the report

REFERENCES-- bibliography of works used in researching project

STATISTICAL ANALYSIS-- the actual worksheets on which your DATA was analyzed

PHOTOGRAPHS, GRAPHS, ETC-- those you feel will be most useful in illustrating your project

DAILY LOG and RAW DATA-- the day by day records you kept while doing your project (may also be presented in a separate notebook)

When you write the final draft of your REPORT, ask yourself these questions:

1. Is my REPORT neat? __________
2. Is it well organized? _________
3. Does it contain all necessary sections? _________
4. Is the spelling correct? ________
5. Is the grammar correct? _________
6. Is it written in 3rd person? ________ (ACKNOWLEDGMENTS. 1st person)
7. Is technical language used correctly? _________
8. Is it easy to read? (Double-spaced typing is best) ________
9. Is my TITLE short (no more than 10 words)? _________
10. Is it scientific (not "cutesy")? _________
11. Are ALL required ISEF forms included at the FRONT of my notebook? __________

When done, ask yourself one last question. "Have I made an extra copy?" (A wise precaution after so much work and effort!)

**CHECKLIST #12 -- DISPLAYING YOUR WORK**

The Display Board

The last step in doing your science project is to build your DISPLAY. Typically students use a three-section board (wide back panel hinged to side panels which angle forward at roughly 45 degrees) constructed of pegboard, masonite, hardboard, foam-core board or wood. It may be painted or covered with burlap or felt. SEE EXAMPLE OF A DISPLAY AT THE END OF THIS CHECKLIST.

Size? **Maximum Size of Project at the Regional Science Fair ISEF**

30 inches (76 centimeters) deep
48 inches (122 centimeters) wide
108 inches (274 centimeters) high including table

All equipment, notebooks and other display items must also fit into this space.

What goes on it? On the center segment, usually printed on poster board, are the PROJECT TITLE, HYPOTHESIS and STATEMENT OF THE PROBLEM. On the left go the PROCEDURES, on the right the RESULTS and CONCLUSION. Keep these brief and interesting, as the idea is to "hook" the judges and other viewers and make them want to read your REPORT. Important photographs, graphs, etc. may also be included, if properly labeled.

REMEMBER. Printing must be neat and large enough to be read from three meters away. Be sure spelling and grammar is correct.

To be certain your display is well done, answer the following questions:

1. Does it include all items listed above? _________
2. Is its size correct? _________
3. Is it easy to read from 3 meters away? _________
4. Is it neat? _________
5. Are spelling and grammar correct? _________
6. Is the material on it informative? _________
7. Will it make a judge want to "know more?" ________
8. Have I avoided clashing colors? _________
9. "razzle-dazzle" designs? _________
10. "cutesy/artsy" decorations?_________
11. overcrowding my DISPLAY? _________

12. Is my PROJECT REPORT chained or tied to my BOARD? ________

13. Have I removed expensive or fragile items? ________
    (use photos, drawings, models, etc. instead)

You may find it helpful to make a small mock-up of your DISPLAY BOARD before starting to construct the final project. A large index card, folded into three parts, can be used for this.

Safety Considerations

Be sure you are thoroughly aware of all safety rules and regulations relating to science projects (see *Rules and Regulations of the International Science and Engineering Fair*).

Everything okay? Great! It's time to enter your science fair!

Although you'll probably spend most of this research time at a school, city or county library, remember that many universities are open to you and that it is also possible -- by making an appointment -- to work at many of the libraries maintained by businesses, societies, medical facilities, museums, etc. and that interlibrary loans of materials not readily available to you can often be arranged by your school's librarian. It may also be possible to borrow technical publications from professional scientists.

**APPENDIX A SAMPLE PROJECT TITLES**

The following project titles were selected from among those featured at a recent *Regional Science and Engineering Fair*. Perhaps they will suggest ideas for your project.

- A Comparative Analysis of Cassette Tapes
- A Relationship Between Sex, Age, Culture and Color Preference
- A Study of the Breaking Point of a Falling Column of Water
- Adaptive Color Change in Two Species of Tropical Tree Frogs
- An Automated Periodic Table
- Apple/Pascal Animation
- Atmosphere and the Solar Spectrum
- Breath Test for Pancreatic Insufficiency
- Can a Rubik's Cube be Solved through a Logical Process?
- Can Amino Acids Attract Ghost Shrimp?
- Can Crickets be Led by Sound?
- Can Wheat be Grown Hydroponically in a Dilution of Seawater?
- Comparative Analysis of Organically and Inorganically Produced Spinach
- Comparing the Purity of Aspirin Brands
- Comparisons Between Cross-Dominance and Coordination
- Computer Speech in Education
- Computerized Carrollian Logic
- Correlation Between Geometric Shapes and Stress Patterns
- Data Storage Using Linked Lists
- Development and Comparison of Computer Spelling Programs
- Distribution of Beach Hoppers
- Diurnal Movement of Periwinkles
- Do Crayfish Rely on Eyes or Statocysts to Determine Body Position?
- Do Protein Molecules Aid in the Body's Defense?
- Does Age Affect the Way People Interpret an Abstract Painting?
- Does Elementary School Integration Reduce Racial Biases?
- Does Salt Affect Soybeans? -- Germination Field Analysis
- Does Ultra-Violet Radiation Inhibit or Promote the Growth of Molds?
- Effect of Cognitive Shifts Between Cerebral Hemispheres
- Effect of Contact Lens Wear on Glare Sensitivity
- Effect of Shading on the Eating Behavior of Mice
- Effect of Sound on Sympathetic Nervous Systems of High School Students
- Effect of the Classroom Environment on the Right Brain
- Effects of Antibiotics on Zinc Loving and Zinc Hating E. coli

- Effects of Anxiety on Memory Process: A Comparative Study
- Effects of Environmental Changes on Lactobacillus bulgaricus
- Effects of Intra-Stimulus Interval on Evoked Potential Correlates of Selective Attention
- Effects of Light Wave Alterations on Photosynthesis
- Efficiency in Aquaculture: Cost-Effective Production of Optimal Yields
- Energy Conservation Through the Use of Solar Power
- Factors Affecting Species Composition of Luminous Bacteria in Seawater
- Hormonal Regulation of Peripheral Glial Tumor Growth in von Recklinghausen's Disease
- How Closely Does Experimental Evidence Fit the Binomial Theorem?
- Hydrodynamics of Fish as Related to Function Within Their Habitat
- Mastermind: An Example of Logical Deduction by Computer
- Monaural Perception of Sinusoidal Wave
- Optical Automation
- Players' Reactions to Computer Game Sounds
- Post Thaw Storage of Erythrocytes
- Relationship of Shoot Gravitropism to Acid and Auxin Responsitivity
- Second Sonata -- A Computerized Composition of Music
- Society's Knowledge of and Opinions on Nuclear Power
- Solutions to 2nd Order Differential Equations Using Continued Fractions
- Some Alternative Propeller Designs for Wind Power Development
- Subliminal Suggestion: Does It Affect Decision Making?
- Synthesis of Sulphur Containing Amino Acids Under Prebiotic Earth Conditions
- Territorial Behavior of Land Hermit Crabs
- The Physics of Falling Leaves
- Thermal Comparison of San Diego County Woods
- Thermoregulation Related Color Change: Reptiles vs. Amphibians
- Various Cane-Soaking Solutions: Their Effect on Bassoon Reed Cane

## APPENDIX B SCIENCE FAIR PROJECTS TO AVOID

### PROJECTS, WHICH WILL NOT BE ACCEPTED

1. Survey projects (opinion sampling, product use, etc. However, an in-depth questionnaire, which probes into factors affecting opinions, may be used as a preliminary step in behavioral studies.)
2. Models, i.e. volcanoes
3. Demos, i.e. how a battery works
4. Anything in violation of animal regulations
5. Projects with small sample size
6. Projects with limited number of test runs
7. Illogical tests -- i.e., effect of rum on plant growth
8. Projects in which the results are common knowledge
9. Kit building, i.e., Radio Shack or Heath kit
10. Projects which duplicate standard class/text experiments
11. Collections, i.e., minerals
12. Anything with purely subjective measurements
13. Child-resistant caps tested on kids (arthritics, maybe)

### PROJECTS UNLIKELY TO BE ACCEPTED -- AVOID!

(Although frequently done, an original twist, combined with exceptional thoroughness and solid scientific method could provide the depth needed for acceptance.)

1. Effect of colored light on plants (or anything else)
2. Effect of music on plants (ditto)
3. Effect of talking on plants (ditto)
4. Effect of cigarette smoke on plants (ditto)
5. Mold growth
6. Crystal growth
7. Effect of Coke, coffee, etc. on teeth
8. Effect of running, etc. on blood pressure
9. Effect of music on blood pressure
10. Effect of video games on blood pressure
11. Effect of almost anything on blood pressure
12. Do we eat balanced diets? (data usually unreliable)
13. Strength/absorbency of paper towels (and other products)

14. Most consumer product testing ("Which is best?" approach generally without scientific merit)
15. Graphology
16. Astrology
17. ESP, especially standard card test
18. Basic maze running
19. Any project, which boils down to simple preference
20. Effect of color on memory, emotion, mood, etc
21. Effect of color on taste
22. Effect of color on strength
23. Optical Illusions
24. Reaction Times
25. Many male/female comparisons (especially if bias shows)
26. Basic planaria regrowth
27. Detergents vs. stains
28. Basic solar collectors
29. Acid rain projects (Important: to be considered, thorough research into the composition of acid rain and a scientifically accurate simulation of it would be necessary.)
30. Flight tests, i.e., planes, rockets
31. Battery life (plug in and run down type)
32. Basic popcorn volume tests
33. Stills
34. Pyramid power
35. Basic flower preservations techniques
36. Taste comparisons, i.e., Coke vs. Pepsi
37. Smelling vanilla, etc. to improve test scores
38. Sleep learning
39. Taste or paw-preferences of cats, dogs, etc.
40. Color choices of goldfish, etc.
41. Basic chromatography
42. Wing, fin shape comparison with mass not considered
43. Ball bounce tests with poor measurement techniques

**APPENDIX C LIBRARY RESEARCH**

Almost all research projects start with a literature search -- a careful look at what has already been done. As it is generally safe to assume the authors have "done their homework" and that their bibliographies are pertinent and up-to-date, you'll save time by starting with recent publications.

Library research is a lot like detective work and, fortunately, you're more likely to be swamped with clues than hampered by their lack. Find a good basic reference, check its bibliography and you're on your way. For starters, try these:

1. A recent encyclopedia (general)
2. *McGraw Hill Encyclopedia of Science and Technology*
3. *Van Nostrand's Scientific Encyclopedia*
4. *Kirk-Othmer Encyclopedia of Chemical Technology*
5. *The Harper Encyclopedia of Science*
6. Textbooks (college, comprehensive)
7. *Applied Science and Technology Index*
8. *The Education Index*
9. *Reader's Guide to Periodical Literature*
10. Periodicals, i.e.

    <u>Journal of Applied Physics</u>

    <u>Quarterly Review of Biology</u>

    <u>Science</u>

    <u>Science World</u>

    <u>The American Biology Teacher</u>

    <u>The Journal of Nutrition</u>

    <u>The Science Teacher</u>

    <u>The Scientific American</u>

(Many of these contain reviews of recent books.)

From here you'll be branching out into more specialized works. Your teacher or advisor can help you choose the most useful and authoritative references but, basically, you're on your own. READ, READ and READ some more. Learn as much as you can about the work others have done. And make notes -- on 3" by 5" cards or in a notebook, always including a full bibliographical listing. An extensive bibliography, properly referenced and cited, adds greatly to the authenticity and completeness of your work.

**GOOD LUCK ON YOUR PROJECT**

## APPENDIX D NOTE CARD TEMPLATE

| | | | |
|---|---|---|---|
| **Author:** | | **Year:** | |
| **Title:** | | | |
| **Publication:** | | | |
| **Publisher:** | | **Year:** | |
| **Pages:** | | **Library Reference:** | |
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