COMBINED JUNIOR & SENIOR DIVISION SCIENCE FAIR CHECKLIST

A STEP-BY-STEP GUIDE TO THE DEVELOPMENT OF SCIENCE PROJECTS

Fresno County Office of Education
Larry L. Powell, Superintendent

CENTRAL CALIFORNIA REGIONAL SCIENCE, MATHEMATICS AND ENGINEERING FAIR (CCRSMEF)

SAMPLE TIMELINE

1. DECIDING ON A PROJECT -- 1 - 2 WEEKS

2. BACKGROUND RESEARCH -- 2 - 3 WEEKS

3. FORMING A HYPOTHESIS/DESIGNING PROCEDURES -- 1 - 2 WEEKS

4. SUBMITTING ISEF-1, 1A & 1B ("Checklist for Adult Sponsor, Student Checklist, Approval Form") TO THE TEACHER FOR APPROVAL -- BEFORE STARTING EXPERIMENTATION

5. SUBMITTING ISEF-2 and 5A or 5B ("Qualified Scientist Form and Vertebrate Animal Form"), ISEF-4 ("Human Subject Form"), ISEF-3 ("Risk Assessment Form") AND/OR ISEF-6B ("Human and Vertebrate Animal Tissue Form") TO THE TEACHER FOR APPROVAL -- BEFORE STARTING EXPERIMENTATION

6. EXPERIMENTATION -- 4 - 8 WEEKS

7. RESULTS, CONCLUSIONS, ANALYSIS -- 1 - 2 WEEKS

8. WRITING THE PROJECT REPORT -- 1 - 2 WEEKS

9. BUILDING A DISPLAY BOARD -- 1 - 2 WEEKS

GET AN EARLY START (OCTOBER OR NOVEMBER)

TABLE OF CONTENTS

Most examples in this publication are adapted from projects previously exhibited in the *Central California Science, Mathematics and Engineering Fair.*

For more information visit our website at www.fcoe.org/smefair

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, select a topic. How do you do that? Checklist #1 will help. Just fill in the blanks. Note: The "Sample Timeline" on the preceding page should give you an idea of how much time you will 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, playing the piano, football

or have ever wondered about:

Examples: Is black print easier to read than blue? Why?[1] Do brown eggs have more cholesterol than white? Does the brand of chicken feed used affect the nutritional content of eggs? How does blade design affect the aerodynamics of helicopters? Would they fly better with more blades? What care do computer disks really need? Can I design and implement a user-friendly graphics editor for my computer? What physical principles make it possible to catch a ten pound fish on a six pound test line[1]?

1. ____
2. ____
3. ____
4. ____
5. ____

If you listed things you like, pick one and ask yourself five 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 that will allow my computer to control the solar panels on my roof?" "Can I write a computer

Most examples in this publication are adapted from projects previously exhibited in the *Central California Science, Mathematics and Engineering Fair*.

program to help beginners write computer programs? "Can I write a program to solve partial differential equations?" Or, if you prefer football, your questions might include, “Can I write a computer program to predict the outcome of next year’s NFL games?” “Would young players learn faster if the coach used a computer to diagram plays?” “Do computer game whizzes make better passers?” Or, getting away from computers, “Do players with thicker necks sustain fewer injuries?” “Does artificial turf produce more touchdowns?” “Can biorhythms be used to predict player performance?” “What is the relationship between body fat and running speed?”
Get the idea? Okay, your turn (yours should be different):

<u>MY QUESTIONS ARE:</u>

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.

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

____

NOTE: Remember, your project must involve actual experimentation (e.g., "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.

<u>Examples</u>

1. "Effect of Volcanic Ash on Chlorophyll Production in Creeping Charlies” would be better than “Effect of Volcanic Ash 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 of the questions listed earlier. 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
5. The Physics of Fishing: Fish Size vs Line Test Weight

THE WORKING TITLE OF MY PROJECT IS:

____

LAYING A FOUNDATION

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

CHECKLIST #2 -- BACKGROUND RESEARCH

If your QUESTION were "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 research 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 research such things as wave patterns, ocean currents, conditions and substances affecting the biology 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 through the card or Computer database should start you in the right direction -- and don't forget the *Reader's Guide to Periodical Literature*, which lists magazine articles by topic.

Take lots of notes (you'll use them later) and be sure you keep a list of your REFERENCES, using standard bibliographical format.

The bibliographies in many science journals follow the Style Manual for the Sciences issued by the U.S. Government Printing Office, while those in other journals follow the CBE Style Manual. Both may be found on Internet style manual search lists (try searching for “Style Manual, Science” or “Style Manual for the Sciences” (Note: you’ll find many different lists, e.g., for the biological sciences, psychology, etc.). Your school or school district may recommend yet another format, suggesting such sites as:

http://www.mla.org/

http://www.westwords.com/guffey/mla.html

and

http://www.noodletools.com/noodlebib/ (feed in your information and out pops the correct format!)

Bear in mind that different sources (e.g., books, magazines, Internet sites, CD ROMs, e-mail communications, etc.) require different formats!

Note: Regarding on-line resources, learn the difference in quality between opinion sources (e.g. personal websites and chat rooms) and published sources such as *Nature*, *Scientific American* and *Science*. Unpublished information should be avoided, as it has not been subjected to professional review.

It is important to recognize that simply placing downloaded material in your notebook does not constitute background research.

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.

.ADRENAL GLAND STRUCTURE . -- (what the note is about) . .
. Consists of an inner body, the .
. medulla, surrounded by an external . -- (the note itself, a quote
. “rind” or cortex. The medulla secretes . or summary. Use quotation
. epinepherine and norepinepherine . marks if a quote.)
. (adrenalin/noradrenalin). The cortex .
. secretes aldosterone and .
. cortisols. . . . . 4,102 -- (bibliographic reference refers to a book or article
listed in the BIBLIOGRAPHY. 1st number = which reference 2nd number = page number

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

4
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. Or, if you plan to compare the nutrients in fresh, canned and frozen carrots, you might consult a nutritionist, a chemist, a botanist and a representative of a company where carrots are processed.

Your turn again.

<u>THE EXPERTS I WILL CONSULT ABOUT MY PROJECT ARE:</u>

1. ____
2. ____
3. ____

List additional experts on a separate page.

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. Of course, some questions you might have asked you may already have answered by reading. So, there’s not point in re-inventing the wheel.

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. In fact, the more you learn from reading about your question, the less time you will waste in conducting unnecessary work and the fewer mistakes you will tend to make.

CHECKLIST #3 – FORMULATING YOUR HYPOTHESIS

NOTE

If you are doing a computer, math or engineering project, read the appropriate guidelines (Appendices 1 - 3) at the back of this book BEFORE formulating your hypothesis(es) or designing your procedures:

Ü¶ **Appendix 1 -- "Guidelines for Computer-Oriented Science Projects"**

Ü¶ **Appendix 2 -- "Guidelines for Science Fair Projects in Engineering"**

Ü¶ **Appendix 3 -- "Guidelines for Science Fair Projects in Mathematics"**

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?

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 ideas on the sale of candy bars. Your HYPOTHESES, then, might anticipate that both the height of a display and the colors used in it will affect candy sales.

Your HYPOTHESES might be, "Display Level Will Affect Candy Sales" and "Use of Contrasting Colors in Displays Will Affect Candy Sales"--simple, straightforward statements (**NOT QUESTIONS!**) as to the possible results of your tests[2].

Or, you've been researching zippers and everything you've read indicates that the material from which zippers are made will affect their durability and quality of operation. Your HYPOTHESIS, therefore, might anticipate that the material will affect both the number of times a zipper can be zipped without snagging or breaking and the overall life of the zipper.

Most examples in this publication are adapted from projects previously exhibited in the *Central California Science, Mathematics and Engineering Fair***.**

Your HYPOTHESIS, then, is “Zipper Material Will Affect Zipper Durability and Operation” – a simple straightforward statement (NOT A QUESTION!) as to the possible results of your tests.

Later on you will find that scientific hypotheses are more commonly couched as negatives or “null,” e.g., “zipper material has no effect on durability.” Thus, when the experimental results show that the material does determine the durability, the null hypothesis is tested (rejected). The null hypothesis is a position without advocacy.

Hypotheses are never proven or disproven, only supported (accepted) or weakened (rejected). What you may conclude from results using 100 samples of spring tomatoes may be placed in dispute by results from a new study using a sample of 10,000 winter tomatoes.

Now, back to <u>your</u> project. <u>Based on your research</u>, state your HYPOTHESIS or HYPOTHESES 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 – JUNIOR DIVISION EXAMPLES

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

1. If, for example, you compare the effectiveness of six fertilizers on the growth of bean plants, you would:

    a. Decide how many plants (seeds? seedlings? -- all should be at the same stage of development) you'll treat with each brand of fertilizer -- let's say 20 samples in each EXPERIMENTAL GROUP (one group for each fertilizer) and 20 samples in a CONTROL GROUP (no fertilizer). That's 140 bean plants -- a minimum SAMPLE SIZE if your results are to mean anything. (Think about it -- what happens to one, two, three or so plants could be a fluke. Maybe the neighbor's cat got into the act and added a little extra fertilizer!)

b. Decide how many TEST RUNS (trials) you'll make (how many times you'll do the experiment) -- let's say three (again, a minimum number, but if you get similar results on three runs of 140 plants each, you're probably "on to something”. If, on the other hand, the results vary among 3 trials then other trials are necessary. How would you be able to draw conclusions about the results of three trials when the first trial yielded a value of 100, the second yielded a 4000 and the third yielded a 10?
c. Make sure the TEST CONDITIONS for each group are the same -- identical soil, identical care (water, sun, insecticide, etc.). Decide, too, on the amounts of fertilizers to be used and the frequency of application -- basing your decisions on the manufacturers' recommendations. In this way the only EXPERIMENTAL VARIABLE (a condition changed by the experimenter) is the brand of fertilizer used.

2. If you test the comparative strength of eight differently shaped support beams (e.g., triangular, round, rectangular), your project design might look something like this:

   a. Decide on the shapes to be used and construct a large number of scale model beams (50, let's say) of each design -- making sure they are identical in all other ways (e.g., cross-sectional area, material used, weight, length).

   b. Design and build a mechanical device to test the structural strength of the beams.

   c. Test each beam under identical conditions. That's 50 test runs (trials) -- with eight beams used in each run.

Your turn again. On the following lines outline the basic design for your experiments:

<u>THE PROCEDURES I WILL FOLLOW IN TESTING MY HYPOTHESIS ARE:</u>

1. ____
2. ____
3. ____
4. ____
5. ____

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

CHECKLIST #4 -- DESIGNING YOUR PROCEDURES – SENIOR DIVISION EXAMPLE

5. 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 flow rate of water, etc.) remain constant.

<u>EXPERIMENT 1</u>

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. Measure exudate. 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.

<u>EXPERIMENT 2</u>

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

<u>CONTROL</u>

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. Fifty TRIALS are made for each combination -- 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 EXPERIMENTAL 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.

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, e.g.,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 25cm 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 and devise a way to quantitatively measure the degree of physical damage (lessening of clarity, pitting, corrosion, etc.) to each lens.

3. If you do a computer, engineering or mathematics project, read the appropriate Appendix at the end of this Checklist before designing your PROCEDURES.

Your turn again. On the following lines outline the basic design for your experiments:

<u>THE PROCEDURES I WILL FOLLOW IN TESTING MY HYPOTHESIS ARE:</u>

1. ____
2. ____
3. ____
4. ____

5. ____

NOTE: Either more or fewer steps may be required for your project. Record additional steps on a separate page.

DEFINITION OF TERMS

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

"All experiments (EXPERIMENTAL GROUPS) must have only one EXPERIMENTAL 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 EXPERIMENTAL VARIABLE would be the particular color and shape combination chosen for each group -- one per group. The CONTROLLED VARIABLES would be size and placement of the signs, the length of time the sign is seen, the distance from the TEST SUBJECT, lighting conditions, etc. (i.e., every other factor that might affect the outcome). These would be the same for all SUBJECTS -- both in the EXPERIMENTAL GROUPS and the CONTROL GROUP.

You will be observing any 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; such measurements as eye motion, blood pressure, pulse rate, etc. In this worksheet you'll include such measurable changes (RESULTS) in your OBSERVATIONS (CHECKLIST #8) -- and don't forget to use metric measurements! And, by the way, 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)."

Give it a try.

<u>FIVE RESULTS WHICH MIGHT BE OBSERVED DURING MY EXPERIMENT ARE:</u>

1. ____

2. ____

3. ____

4. ____

Most examples in this publication are adapted from projects previously exhibited in the *Central California Science, Mathematics and Engineering Fair***.**

5.____

<u>TEACHER/ADVISOR APPROVAL OF PROJECT PROPOSAL</u>

Before starting work on your project you must have the written approval of your science, math or computer teacher/advisor. Use ISEF-1, 1A (*Checklist for Adult Sponsor and Student Checklist*) for this purpose. If not already done, DO IT NOW! This approval is subject to confirmation by the CCRSMEF Scientific Review Committee at Screening and/or when application is made to the Fair.

I HAVE COMPLETED ISEF-1 & 1A (*Checklist for Adult Sponsor and Student Checklist, Project Description and Pre*-advisor.____________ *Screening Form*) and it has been approved by my teacher/

SPECIAL CASES

If you plan to use:

1. human subjects/interviewees
2. live vertebrate animals
3. toxic, corrosive, mutagenic, carcinogenic, teratogenic or infectious agents (including but not limited to microorganisms, e.g., bacteria, molds, fungi, protozoa, viruses and parasites); chemicals; venomous animals OR potentially hazardous substances or devices (ANYTHING SO LABLED OR WHICH, IF NOT HANDLED PROPERLY, CAN CAUSE INJURY) or
4. human or other vertebrate tissue (including hair roots or, teeth), blood, blood products or other body fluids)

in your project, some very important additional considerations are involved.

CHECKLIST #5 -- PROCEDURES FOR PROJECTS USING HUMAN SUBJECTS/INTERVIEWEES

Students doing research involving human subjects/interviewees MUST:

1. read and complete the Central California Science, Mathematics and Engineering Fair's "*Human Subject Form"* (ISEF-4) and submit it to their teachers/advisors for approval BEFORE starting their projects (approval subject to confirmation by the Scientific Review Committee at screening and/or when application to the CCRSMEF is made)

The approved **<u>ISEF-4</u>** AND **<u>ISEF-1, 1A & 1B</u>** (***Checklist for Adult Sponsor, Student Checklist and Approval Form***) **<u>MUST</u>** be included at the front of the project notebook when exhibited at the School Science Fair and, if the student is invited to apply for admission to the Central California Science, Mathematics and Engineering Fair, **<u>ISEF-4 MUST</u>** be submitted with the student's Application for Entrance.

2. 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 published 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 (e.g., Who was the 16th president of the United States?) and ten opinion questions (e.g., What is your favorite color?).

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

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. Excuse 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, e.g., tiredness, grouping, don't affect results.)

5. Make notes, identifying subjects by number only (e.g., #22 -- male, age 16), recording their body language reactions (e.g., 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 ISEF-4 form has been completed, submitted to your teacher and approved.

________ Check here if ISEF-4 does not apply to your project.

CHECKLIST #6 -- PROCEDURES FOR PROJECTS USING LIVE VERTEBRATE ANIMALS

Are you thinking of using 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. Will it benefit 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. What and how often do they drink? ___________________________

   c. At what temperature are they comfortable? _____________________

   d. Which other environmental factors are important to their comfort?____

e. How much room do they need? ______________________________

f. How much attention do they need? ___________________________

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

a. take proper care of them

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

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

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

-- on weekends and holidays? __________

-- 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 working with invertebrates or 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 <u>MUST</u> be conducted humanely and with a respect for life (an attitude which must also be evident when dealing with non-vertebrates!)

The Central California Regional Science, Mathematics and Engineering Fair rules, the "Humane Treatment of Animals" provisions of the California Education Code and the International Science and Engineering Fair's (ISEF) "Regulations for Experiments with Animals" (see *Rules and Regulations of the Central California Science, Mathematics and Engineering Fair*) MUST be followed.

Still interested?

To find out if your project idea is acceptable -- and <u>BEFORE</u> obtaining the animals you plan to use:

1. <u>read and complete</u> the Central California Regional Science, Mathematics and Engineering Fair "*Certification of Humane Treatment of Live Vertebrate*

Animals" form (CCRSMEF-2) -- including All required signatures, and

2. submit it to your teacher for approval and signature (approval subject to confirmation by the CCRSMEF Scientific Review Committee (SRC) at screening and/or when application is made to the Fair).

The *Checklist for Adult Sponsor, Student Check list, Project Description and Pre-Screening Forms* **(ISEF-1 & 1A)** and *Vertebrate Animal Form* **(ISEF-5A or 5B)** must appear in the student's notebook at screening. If the student is invited to apply for admission to the CCRSMEF, **ISEF-5A or 5B** must be submitted with the Application for Entrance.

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:

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

2. Chart all behaviors observed, noting conditions, time, other factors which may have influenced the animals.

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

4. Chart as in Step 1.

5. 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 CCRSMEF-2 form has been completed, submitted to your teacher and approved.

________ Check here if CCRSMEF-2 does not apply to your project.

CHECKLIST #7

-- PROCEDURES FOR PROJECTS INVOLVING, A) BACTERIA; B) MOLDS OR FUNGI; C) PROTOZOA; D) CHEMICALS; E) TOXIC, CORROSIVE, MUTAGENIC, CARCINOGENIC, TERATOGENIC OR INFECTIOUS AGENTS; F) VENOMOUS ANIMALS OR G) POTENTIALLY HAZARDOUS SUBSTANCES OR DEVICES (ANYTHING SO LABELED OR WHICH, IF NOT HANDLED PROPERLY, CAN CAUSE INJURY)

1. The use or handling by students of Ethidium Bromide or gel stained with Ethidium Bromide is prohibited. If a necessary part of the experiment, they must be handled only by qualified lab personnel trained in the standards for their use. Care must be taken that the student does not come into contact with them.

2. Projects involving tobacco, tobacco products, smokeless powder, black powder, gasohol or alcohol/other intoxicants (or the production of these) are prohibited.

Students **MUST** complete form **ISEF-3**, *Risk Assessment Form* and submit it to their teachers/advisors for approval -- **BEFORE** starting projects involving these substances (approval subject to confirmation by the CCRSMEF Scientific Review Committee at screening and/or when application is made for admission to the Fair).

The approved **ISEF-3**) **MUST** be included at the front of the project notebook when exhibited at the School Science Fair and, if the student is invited to apply for admission to the Central California Science, Mathematics and Engineering Fair, **ISEF-3 MUST** be submitted with the student's Application for Entrance.

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

________ Check here if **ISEF- 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 **ISEF- 3**:

1. ____
2. ____
3. ____
4. ____
5. ____

CHECKLIST #8

-- PROCEDURES FOR PROJECTS INVOLVING HUMAN OR OTHER VERTEBRATE TISSUE (INCLUDING HAIR ROOTS AND TEETH, BLOOD, BLOOD PRODUCTS OR OTHER BODY FLUIDS)

Students **MUST** complete form **ISEF-6B**, *Human and Vertebrate Animal Tissue Form* and have it approved by their teachers/advisors -- **BEFORE** starting projects involving these substances (approval subject to confirmation by the CCRSMEF Scientific Review Committee at screening and/or when application is made for admission to the Fair.

The approved **ISEF-6B MUST** be included at the front of the project notebook when exhibited at the School Science Fair and, if the student is invited to apply for admission to the Central California Science, Mathematics and Engineering Fair, **ISEF-6B MUST** be submitted with the student's Application for Entrance.

________Check here when your **ISEF-6B** form has been completed and approved by your teacher/advisor.

________ Check here if **ISEF-6B** 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 **ISEF-6B**:

1. ____
2. ____
3. ____
4. ____
5. ____

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

EXPERIMENTAL VARIABLE, with all others being CONTROLLED), a CONTROL and plans to RUN SEVERAL TRIALS.

What now?

Open your eyes. It's time to make notes – Quantitative OBSERVATIONS -- of everything that happens (DATA MEASUREMENTS) during those TRIALS.

When those petunias start growing, for example, you'd note rate of growth, height, number of leaves, size of leaves (precise METRIC MEASUREMENTS, e.g., 3.1 cm by 2.3 cm, not "small," "big," etc.), measured color differences or changes, any problems or unusual developments -- always dating your notebook entries and making drawings or taking photographs to illustrate your notations.

The tennis ball project would require such information as the temperature and humidity at the times of testing, height from which each ball was dropped, height each ball bounces (exact measurements, not approximations), etc. Drawings or photographs in this case also could 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, 2001</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 your project. Remember that ENTRIES should be made for mistakes and hard-to-explain (unexpected) results, too.

1.____

____

____

2.____

____

____

3.____

____

____

4.____

____

____

5.____

____

____

CHECKLIST #10

RESULTS, CONCLUSIONS, ANALYSIS

You've run all your TESTS -- several times. Your LOG is full of ENTRIES. Now, what do you do with all the information -- DATA -- 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:

1. These DATA should also be presented in appropriate easy-to-read forms -- e.g., GRAPHS, CHARTS.
2. A number of computer programs which 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 are what you learn from your TESTS (and bear in mind that negative RESULTS -- e.g., 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 RESULTS are used to evaluate the HYPOTHESIS, allowing you to make a subjective interpretation of the outcome -- your CONCLUSIONS. A more sophisticated analysis that gives greater precision to your interpretation of the results is made by using STATISTICAL TESTS. Proper statistical tests that show an experimental effect to be highly significant (i.e., strongly correlated with high probability) are almost universally used by scientists to support their interpretations of their results. They are almost a competitive necessity in high school science fair projects and are becoming increasingly more common in junior high school science fair projects. You're probably asking, "What in the world is STATISTICAL TESTING?" Mathematicians have developed several ways (averages, means, chi-square test, t-test, etc.) to study RESULTS to help decide whether those results happened by chance or were really caused by the VARIABLE of an experiment (in other words, was the "effect" really caused by the "cause?". Note: An eyeball comparison of graphs is NOT statistical analysis.

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

Nevertheless, statistics don’t prove anything. (For that matter, neither does one science project, so don't use the word "prove" in your CONCLUSIONS.) Appropriate statistical testing can tell you, based on your DATA, whether your RESULTS are really meaningful (i.e., “significant”) or if they could have occurred by chance.

For help in learning how to ANALYZE your DATA, try Appendix C of *The Science Fair Handbook: A Guide for Teachers and Students* (out of print – your teacher may have a copy) or consult your math teacher.

Looking at the DATA collected in the experiment above, it would appear that the children of two wage-earning parents performed better in school. Remember, though, until you have ANALYZED the DATA, you can't claim that any differences are significant.

Okay, you've analyzed the DATA and the figures allow you to accept your HYPOTHESIS. You can now draw your CONCLUSIONS. In this case, they would read something like this:

> "Statistical analysis of the data collected indicates (or suggests) that in this study sample, children with two wage-earning parents had significantly better grades than did those with only one parent working outside the home."

If, however, the STATISTICAL ANALYSIS leads you to reject your HYPOTHESIS, the CONCLUSIONS might read:

> "Although in this study more children with two parents working outside the home had better grades than those with only one wage-earning parent, this difference was not found to be statistically significant."

While your RESULTS may encompass several pages of DATA, presented in a variety of forms, your CONCLUSIONS are generally brief -- succinct interpretations of those RESULTS.

Your turn:

THE RESULTS OF MY PROJECT ARE:

1. ____
____
____
2. ____
____
____
3. ____
____
____
4. ____
____
____
5. ____

____
____

I WILL USE THE FOLLOWING TYPE GRAPHS (histogram, broken-line graphs, frequency polygon, etc.) to present my RESULTS:

1. ____
2. ____
3. ____
4. ____
5. ____

I WILL ANALYZE MY DATA IN THE FOLLOWING WAYS (chi-square test, t-test etc.):

1. ____
2. ____
3. ____

When you have done the previous steps, you'll be ready to complete the following:

My CONCLUSION(S) is (are):

____
____
____
____
____
____
____
____
____
____

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 decide to change your WORKING TITLE. Remember that your final TITLE, the one used in your REPORT and on your DISPLAY BOARD, must contain no more than ten words.

The following sample *Table of Contents* outlines the basic contents of that REPORT:

CONTENTS

And what goes into each of these sections?

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

ACKNOWLEDGMENTS -- credits to those providing you with help/advice, i.e., "Thanks to Dr. Brian Tsukimura, Fresno State University, for allowing me to use his lab to conduct my tests."

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 from John Appleton, et al. (1981), who 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 (and whether they support or weaken your HYPOTHESIS) and the results of your STATISTICAL TESTS. If not in the last part of your RESULTS, the FINDINGS should appear in the first part of your CONCLUSIONS.

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

RECOMMENDATIONS -- your ideas on possible uses for your FINDINGS and of additional work that could be conducted

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 worksheets on which your DATA were analyzed (tested)

PHOTOGRAPHS, GRAPHS, ETC. – include those you think will be useful in illustrating your project **(NO PHOTOS OF SUBJECTS**)

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 technical language used correctly? _________
7. Is it easy to read? (double-spaced typing is best) ________
8. Is my TITLE short (no more than 10 words)? _________
9. Is it scientific (not "cutesy")? _________
10. Are ALL required CCRSMEF forms in 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!)

CHECKLIST #12 -- DISPLAYING YOUR WORK

The Display Board

The last step in doing your science project is to build your DISPLAY -- 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. No lights may be attached to the board.

Size? No larger than 76 cm (30 inches) deep (front to back), 122 cm (48 inches) wide (side to side) and 274 cm (108 inches) high (floor to top, including height of 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. The idea is to "hook" the judges and other viewers and make them eager to read your REPORT. Important photographs, graphs, etc. may also be included, if properly labeled.

IMPORTANT -- printing must be neat and large enough to be read from three meters away. Be sure spelling and grammar are correct.

Now, 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 eager to "know more?" ________
8. Have I avoided clashing colors? _________

-- "razzle-dazzle" designs? _________

-- "cutesy/artsy" decorations?_________

-- overcrowding my DISPLAY? _________

9. Is my PROJECT REPORT chained or tied to my BOARD? ________
10. 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 Central California Science, Mathematics and Engineering Fair*). Then, check off the items on the following list:

My display contains no:

-- flammable materials ________

-- chemicals ________

-- fuels _________

-- flames _________

-- unshielded heat-producing devices

-- live or preserved animals or animal parts (whether vertebrate or invertebrate), plants or other living organisms ________

-- microbial cultures _________

-- fungi _________

-- drugs _________

-- wiring/switches that do not meet safety standards _________

-- wet-cell batteries _________

-- unshielded vacuum tubes, lasers, etc. ________

-- anything which could be dangerous ________
(Look at it this way – if a two-year-old can't handle it safely, out with it!)
-- liquids (including water) ________

-- dry ice ________

-- sublimating solids ________

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

APPENDIX 1
GUIDELINES FOR COMPUTER-ORIENTED SCIENCE FAIR PROJECTS

Guidelines for Computer-Oriented Science Fair 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. If the software/firmware programs are the 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 Computer Science category.
- B. A project of this type should include:
  1. A statement of the student's <u>OBJECTIVES.</u> This should include a description (the configuration) of the computer system that will be used to achieve those objectives 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).
  6. A sample run(s) to show the product(s) of the program.
  7. A critique of the completed program showing how well the objectives were achieved and/or how the program is qualitatively different from or better than other similar programs.

APPENDIX 2

GUIDELINES FOR SCIENCE FAIR PROJECTS IN ENGINEERING

Guidelines for Science Fair Projects in Engineering

Competitive Engineering projects will contain the following:

I. Good overall plan

II. Step-by-step test procedures

III. Schematic(s) and/or Drawing(s)

IV. Test Results

V. Test Data which include the following:

- A. Date
- B. Time
- C. Temperature
- D. Initial Conditions
- E. Other conditions (peculiar to test)
- F. Final Conditions
- G. Interval between each data point. There should be several data points. It is not enough to show only one at the beginning, one in the middle and one at the end.
- H. Repeatability, if practical
- I. Tests should be scheduled far enough in advance to allow for repeat runs and modifications

VI. Photos of test subject(s)/specimen(s) and test setup

VII. Recordings if data recorder used or copies of same

VIII. Test specimen characteristics (Use metric measurements)

- A. Weight
- B. Size (dimensions)

IX. Site of test(s)

X. Disposition of test specimens

XI. Observations, notes, analysis

XII. If a continuation project, summary of original project should be included

XIII. All data should be given in appropriate units

XIV. Summarize data in graphical or bar chart form as well as in written form

XV. Final conclusions

XVI. List of test equipment and materials. Include accuracy of test equipment and explain how accuracy was determined.

XVII. In summary, report should include:

A. Introduction
B. Summary
C. Objective
D. Background data
E. Plan
F. Procedures
G. Description of test item(s)
H. Test results & analysis
I. Conclusions
J. Test data and conditions
K. Drawings, schematics
L. Photos and/or recordings
M. List of materials and test equipment
N. Appropriate graphs and/or bar charts

APPENDIX 3

GUIDELINES FOR SCIENCE FAIR PROJECTS IN MATHEMATICS

Guidelines For Science Fair Projects in Mathematics

These guidelines are intended to serve the student and supporting teacher in the preparation of Science Fair projects in the category of Mathematics. In the following paragraphs are suggestions for steps to be followed to produce a finished project.

1. The first and most important step is to come up with a project idea which is achievable. Discovering a previously unknown result or formula would be the ideal Mathematics project. However, a new approach to deriving or obtaining a known fact, or a new way of looking at a known concept are also perfectly acceptable ideas. Topics from newer branches of mathematics such as Fractals, Fuzzy Sets, Chaos, and Game Theory are well within the capabilities of high school students and offer a relatively untapped resource for project ideas. Looking through recent books, journals and magazines can also provide ideas. Students can talk over these ideas with their math teachers, parents, and other students to clarify their approach. Simply performing an experiment and tabulating results (e.g. counting the number of heads which occur in N flips of a coin) does not rate highly. Analysis of experimental results, including computing means and variances, makes a better project. Computers can be used to help analyze data when appropriate.

2. After the idea has been formulated, it should be researched to determine whether the project has already been done, or whether the approach is already known. Repeating a project which has already been done does not rate a very high score. For example, tabulating coin flips, dice rolls, the Pythagorean Theorem, Pascal's Triangle are well- worn ideas. Students should talk to their teachers or consult previous Science Fair programs to see whether they are repeating old projects. Once the student is satisfied with the originality of the project, research should be performed to find all known facts related to the project idea.

3. The next step is to derive or calculate the results. This is usually the most time consuming part of the project. Originality and innovation during this step will result in higher scores for the project.

4. Finally, the project must be written up and a project display produced according to Science Fair guidelines. The project write-up and display should include the following items:

a. A statement of the objective - a clear description of the main idea of the project.

b. A summary of the research done to find previous related results.

c. A statement of what is new, better, or different from previous results.

d. Details of the development of the project.

e. A statement of the results or conclusions

f. A critique of the results and ideas for future research or extensions of the results