GATEWAY SCIENCE ACADEMY of ST. LOUIS

How to Do My Science Fair Project Report

2012-2013

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Today your teacher announced that your school is going to have a science fair and students are responsible for exhibiting their projects. What do you feel?

- **Enthusiastic?**
- **Despondent?**
- **Dreadful?**
- **Fearful?**
- **Excited?**

Whatever you are feeling, don't worry; this booklet is designed to walk you through the world of science fairs. Yes, this is for YOU!

WHY SHOULD I DO A SCIENCE FAIR PROJECT?

What do market analysts, forensic crime technicians, and backyard gardeners have in common? They all apply the inquiry process to the research necessary in their careers. Most careers have common skills that are required for success. Skills, such as critical and creative thinking and communicating, gaining and applying knowledge, and working collaboratively and contributing, are common themes in education and technology. These common themes involve habits of mind such as curiosity, open-mindedness balanced with skepticism, a sense of stewardship and care, respect for evidence, and persistence. All these skills and themes are integral parts of doing a science fair project and help to prepare you for a changing technological world.

Working on a science fair project requires using the skills gained in Social Studies, English, Math, Technology, the Arts, and the Sciences, making a science fair project an interdisciplinary activity. Science fair projects provide opportunities to collaborate with many teachers, especially in Math and English, and implement cross-curriculum, or team, leadership and cooperation.

A science fair project allows you to pose your own question and answer it. Doing a science fair project involves developing and "owning" the question; researching literature; forming a hypothesis; designing an experiment; gathering and organizing the data; analyzing, graphing, and discussing the data; making a conclusion; writing the literary and research reports; and making an oral and visual presentation. Therefore, you develop and apply skills in literary and laboratory research, statistical analysis, and public speaking, while gaining a sense of empowerment and building self-esteem. Because science fair projects are actually cross-curriculum projects that train you for real-life problem solving, the science fair project integrates all aspects of your education and helps to prepare you for real-world job assignments. Having completed a science fair project, you will have the skills necessary to design future investigations in a variety of different fields. A science fair project may become the impetus for a future career.

Science fair projects are fun and filled with self-discovery. Although when first beginning the process you may feel overwhelmed at its enormity, you will experience tremendous growth and fulfillment as you progress through the steps and are evaluated by peers, teachers, and judges. This experience builds self-confidence and often enables you to present ideas to others in various situations, such as college and job interviews.

WHAT IS A SCIENCE FAIR PROJECT?

A science fair project is simply your independent research of a science topic using the scientific method. All work and ideas are yours, giving you "ownership" of the research problem and results. By doing a science fair project, you will find yourself doing the job of a practicing, professional scientist, giving you a taste of how the body of knowledge we call science is accumulated.

SELECTING A TOPIC

There are several factors that need to be considered when selecting a topic. Often, the simplest of projects present the greatest challenges to an imaginative and intelligent student.

Consider the following guidelines when selecting the topic of your research project:

Choose a topic that interests you.

- A hobby such as music, gardening, or model rocketry, might give you something to investigate.
- Sometimes your interest in a sport can provide ideas for a science fair project.
- Magazine or newspaper articles on science-related events can spark your interest.
- Find out if there is a sizable amount of information and equipment available pertaining to the selected topic.

Determine if the project is feasible.

- Can the project be completed within the amount of time allowed? Have you considered the time needed for retrials or repeats of the experiment? For example, in plant projects, you will need a large sample of plants ready to go in two- or three-week intervals.
- Are there environmental concerns? For example, is it the right time of year to make your observations or collect samples?
- Do you have adequate laboratory resources or natural resources, or both, to carry out your investigation?
- What is the cost of completing the project? Is it within your budget? Do you need special equipment beyond what is available? How will you get it? Have you budgeted for retrials?
- Is the design of the experiment adequate? Are the effects measurable in an objective way?
- Does the project conform to ALL state or federal laws pertaining to scientific research?

DO YOU HAVE ENOUGH INFORMATION?

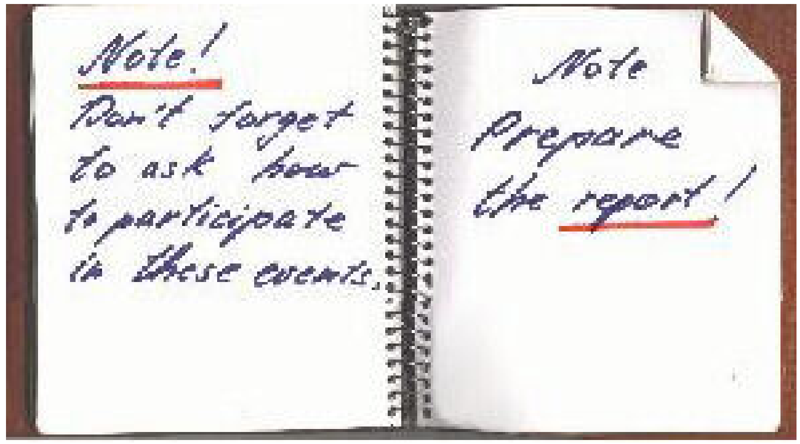
Information Sources

Before deciding on a topic, check these sources of information:

- ✓ Libraries (school, public, and college)
- ✓ Previous projects you or others have done
- ✓ Students who have already completed science fair projects
- ✓ Local college or scientific institution support (for information, equipment, and facilities)
- ✓ Local research firms

KEEPING A SCIENTIFIC NOTEBOOK OR LOG

One of the most important aspects of doing a science fair project is documentation. Every experiment should be reproducible and the instructions in your notes should be sufficient for someone else to reproduce the experiment.



The first thing to do when beginning a science fair project is to get the notebook. You will work out your thinking and the development of your problem in the notebook.

The validity of your documentation partly depends upon insuring the work has not been tampered with or pages removed. The notebook must include all the steps of the scientific method, from the inception of the project to its completion. Scientific notebooks include literary and experimental research, the development of your idea or product and its evaluation, and all calculations.

Entries made by people other than you must be signed and dated by those people.

You can keep a log or daily journal in a section of your scientific notebook, or in a separate book. If you plan to use a separate book for your log or daily journal, use the same type of bound book. The logbook is the chronological record of events during the experimentation.

What Makes A Great Science Project Logbook?

Joanne Rebbeck, Ph.D.

February 24, 2005

Whether you are a research scientist or a first time science fair student, a logbook is a crucial part of any research project. It is a detailed account of every phase of your project, from the initial brainstorming to the final research report. The logbook is proof that certain activities occurred at specific times. Journals and logbooks are subject to scrutiny by the scientific community and are acceptable evidence in a court of law.

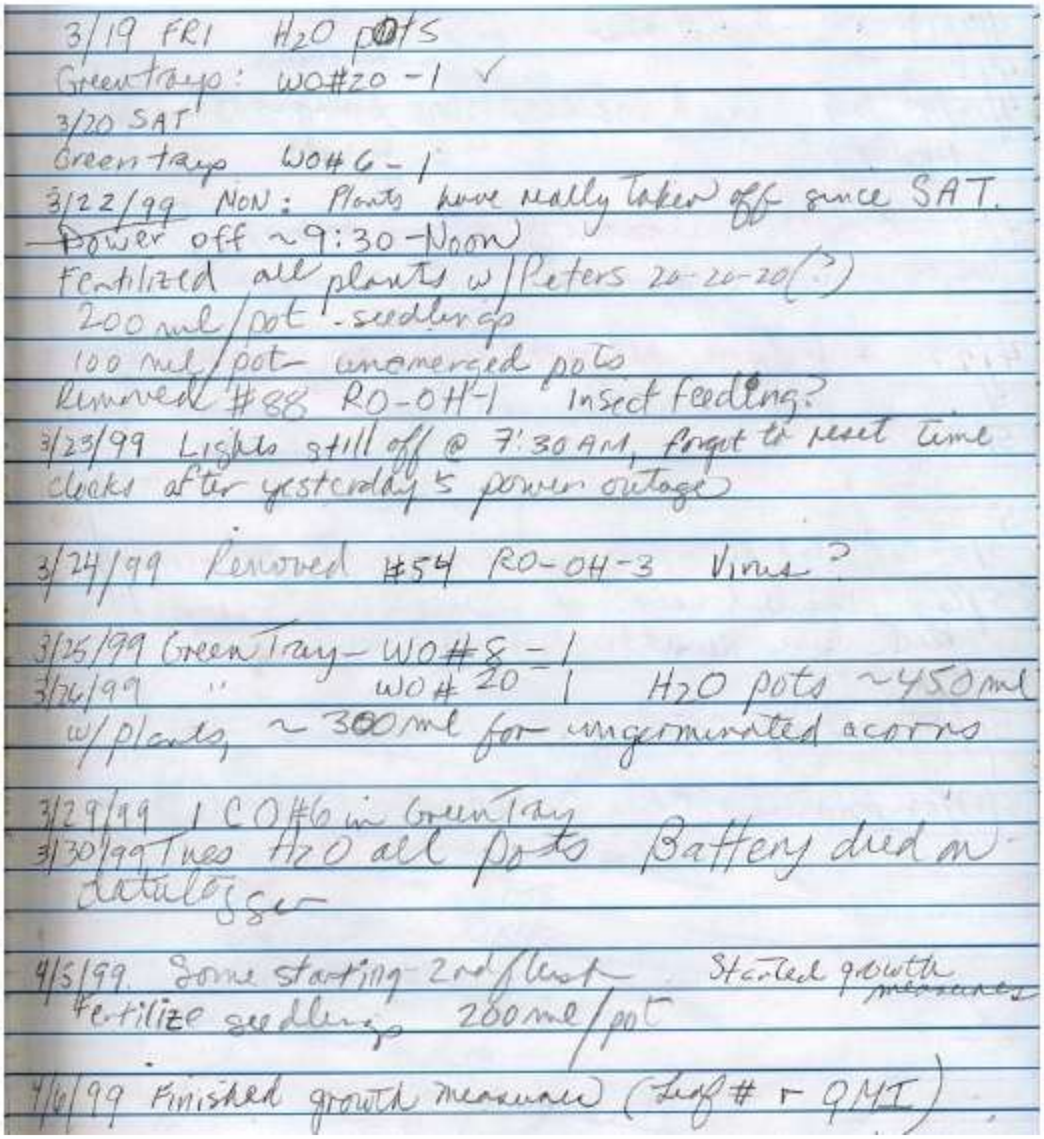
Here are a few pointers that are easy to follow. As a research scientist, I practice these suggestions everyday. They should help keep you organized, and certainly will impress any science fair judge. It's a great opportunity to show off all of your hard work!

1. **Find a durable hard-bound notebook or black and white composition book**, typically a lined journal works great. Do not attempt to use a spiral bound notebook. They won't hold up over the course of your experiment. Papers are too easily removed or torn from them, and before you realize it, important items are missing. Loose papers are a disaster waiting to happen.

2. **Label your logbook** with your name, phone number, email address, and teacher's name in a prominent location. Make logbook entries in pen not in pencil. This is a permanent record of all of your activities associated with your project.

3. **Number the pages in your logbook before using it**, unless already numbered for you.

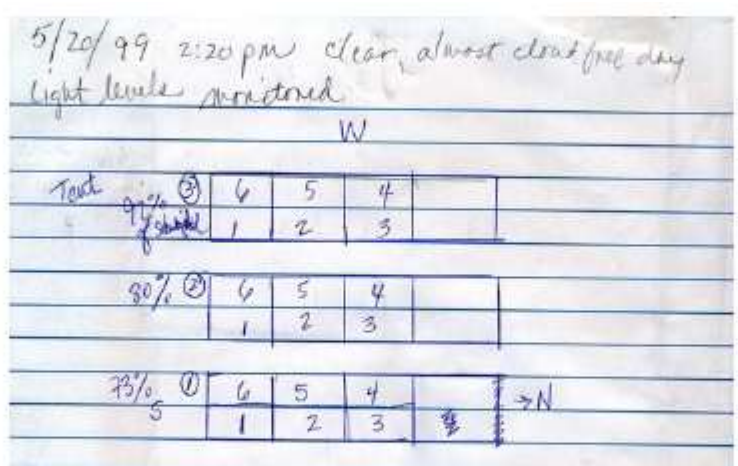
4. **Always date every entry**, just like a journal. Entries should be brief and concise. Full sentences are not required.


3/19 FRI H2O pots
Greentrays: WO#20 -1 ✓
3/20 SAT
Green trays WO#6 - 1
3/22/99 MON: Plants have really taken off since SAT.
Power off ~9:30-Noon
Fertilized all plants w/ Peters 20-20-20(?)
200 ml/pot - seedlings
100 ml/pot - unemerged pots
Removed #88 RO-OH-1 Insect feeding?
3/23/99 Lights still off @ 7:30 AM, forgot to reset time
clocks after yesterday's power outage
3/24/99 Removed #54 RO-OH-3 Virus?
3/25/99 Green Tray - WO#8 - 1
3/26/99 " WO# 20 - 1 H2O pots ~450ml
w/ plants, ~300ml for ungerminated acorns
3/29/99 1 CO#6 in Green Tray
3/30/99 Tues H2O all pots Battery died on
datalogger
4/5/99 Some starting 2nd flush Started growth measures
Fertilize seedlings 200ml/pot
4/6/99 Finished growth measures (Leaf # + QMI)

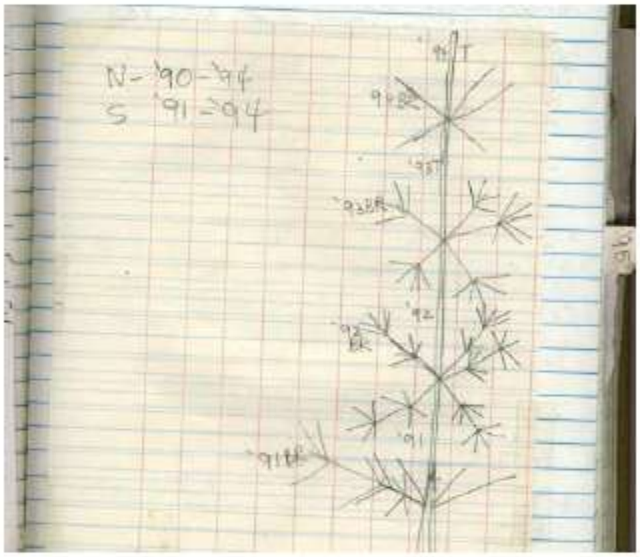
Logbook entry of observations made while watering planted oak acorns in greenhouse

5. **Don't worry about neatness**. It's a personal record of your work. Do not re-do your logbook because it looks sloppy. Think of the logbook as your "Dear Diary" for science fair. It's not just for recording data during the experimental phase of your project and it's not just for your teacher.

6. **It should be used during all phases of your project**, jotting down ideas or thoughts for a project, phone numbers, contacts or sources and prices of supplies, book references, diagrams, graphs, figures, charts, sketches, or calculations.



Sketch of layout of sample points inside shade tents



Hand drawing showing different ages of tree branches that were sampled during an experiment

Log entries should include your brainstorming, calculations, library/internet searches, phone calls, interviews, meetings with mentors or advisors, notes from tours of laboratories, research facilities and other related activities. Remember that it's documentation of your work.

7. **Use it regularly and write down everything**, even if it seems insignificant, it could later be extremely useful. For example, it's the middle of the night and you're frantically preparing that final report but you can't find the title of that crucial reference. Make sure that you describe things completely, so that when you read your notes weeks or months later you will be able to accurately reconstruct your thoughts and your work..

8. **Glue, staple or tape any loose papers**, photocopies of important items. Loose papers or other unsecured items are prohibited as they tend to fall out and can end up missing.

9. **Organize your logbook**. Make a table of contents, index, and create tabs for different sections within your logbook. This helps keep you organized for different activities. For example, have a data collection section, a section with contacts, sources, etc. and a section of schedule deadlines.

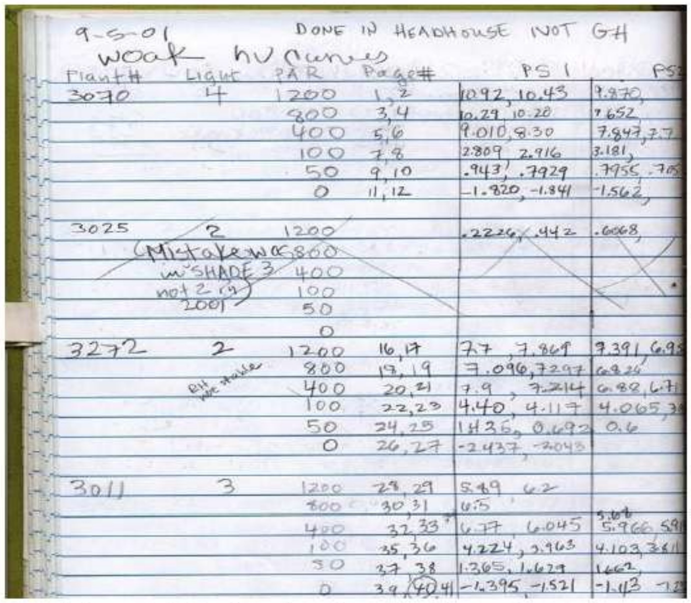
Table of Contents	Tab color	Page #
Deadline Schedule	Red	1
Daily Notes & Reflections	White	2
Background Research Library & Internet	Blue	20
Information Contacts, Supply sources	Green	26
Experimental Setup	Yellow	35
Data collection	Purple	40
Results (pictures, graphs, summary tables)	Orange	50
Reflections	Light blue	60

10. **Include a reflections section in your logbook.** For example, what, if anything would I do differently next time? What part of the experiment could be changed to improve the experimental procedure?

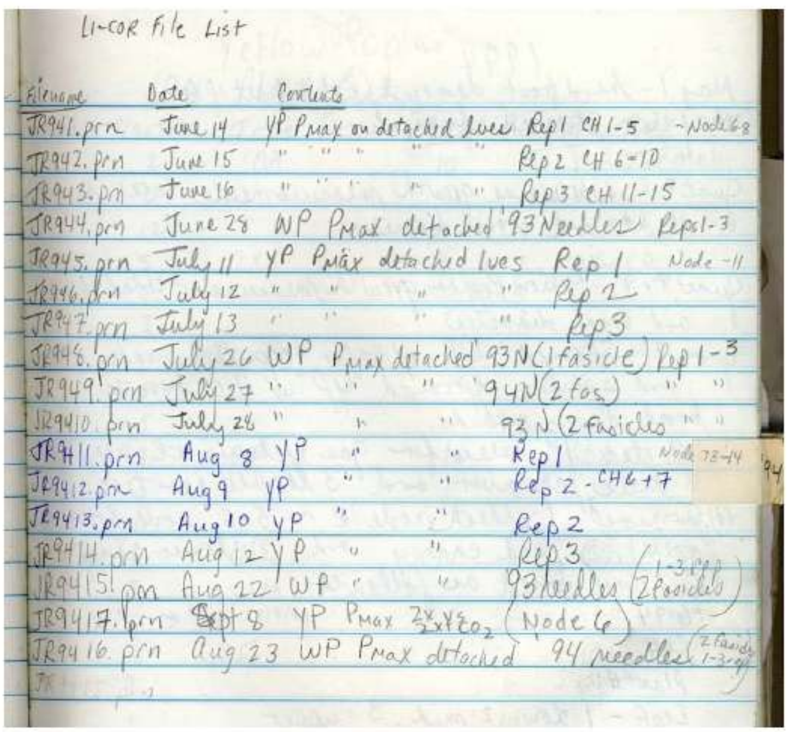
11. **Always include any changes made to procedures**, mishaps, failures, or mistakes. As human beings, all of us make mistakes!

1/4/05 my cat, Sheba scratched the pots of soil, and ate 4 of my 12 plants. I will have to replant everything! I need to protect plants from the silly cat. Maybe i should try putting a screen around the pots or keep cat outside!	2/5/05 Disaster in the lab this morning. Setup manure digoestors last night in incubators, temperature was set at 25 °C but came into a real mess, samples heated up too much and caps blew off. I will need to try a lower temperature to avoid this accident from happening again!!!! HUGE MESS TO CLEAN UP.....

12. **Include any and all observations made during your experiment.** In other words, record ALL data directly in your logbook. If that is not possible, then staple photocopies of data in the logbook.



Entry of photosynthetic data from oak seedlings. Data files were also stored electronically on a computer as shown in the next example.



A list of data files and description of contents stored on a personal computer

Remember, keeping up a great logbook throughout the entire duration of the science project really pays off later! Not only will a nicely maintained logbook impress your teacher and the judges at the fair, it will also help you stay out of trouble later when you need to look back and provide details of what you did.

CONDUCTING THE EXPERIMENT

Once your literary search is complete, it is the time to perform the experiment.

Plan and organize the experiment. Perform the experiment under controlled conditions. Keep careful records in the bound scientific notebook. The notebook is for your records and notes. If anyone else writes in it, have that person sign and date his or her entry.

Document everything you do, whether talking to a person about the project, visiting a library for research, or doing the lab work.

BEFORE YOU START YOUR EXPERIMENT:

Organize all material and equipment to be ready for use as you need them. Organizing your work before starting is important.

Outline the procedure and make a timeline. An outline of the proposed timeline to complete each part of the experimentation is helpful.

- Can the entire experiment be completed at one time? Are multiple time slots needed for completion of experimentation? If so, what plans needed to be made for securing materials between the experimentation sessions?
- What do you need to measure results? Are the measuring devices you are using in metric units? Do you know how to read them? Do the instruments give accurate measurements?
- Do you need other people with you while doing the experimentation?
- Have you talked to those people about scheduling an appointment at a time convenient for everyone involved so that the experimentation can be carried out?

Keep your scientific notebook/log and graph paper handy. Design and set up the tables and graphs you expect to use prior to starting your experimentation. Include units you expect to use on each axis.

Keep a camera on location. The camera is a useful tool for documenting your project. Have another person take photos of you performing the experiment, and use the camera to record the progress and the results of experimentation.

Complete all certification forms and compliance forms. Make certain you have completed the Research Plan and all necessary forms for restricted areas *before* experimentation begins.

Observe safety rules. Cover safety issues with your teacher and, if appropriate, with the research scientist or lab instructor at a research facility, or both. Do not use any equipment that is unfamiliar to you; learn to use it before beginning the experiment.

BEGIN EXPERIMENTATION

Make entries in your scientific notebook as you go. Record data, both quantitative and qualitative, in your logbook. Sometimes what appears to be irrelevant or a failure on one day may become important information at a later date.

Enter measurements in your tables. As you proceed with your project, make certain you include the units and the degree of uncertainty of each measurement based on the exactness of the measuring device. Record your error as a +/- to indicate the amount of uncertainty.

Make repeated measurements periodically. Some experiments (e.g., plant-growth projects) require repeated measurements over an extended period. Take measurements periodically (e.g., every day at 4:00 PM, every third day at noon) to reduce extraneous variables, and make entries into the log when you make the measurements.

Repeat the experiment, if necessary. After completing the experiment, you may decide you need to repeat the experiment for accuracy of your results. You may need to clarify or even alter the hypothesis, redesign the experiment, and get ready to begin again. You may learn more from the process of revision than you learn when all goes "perfectly." Remember, do not discard or remove any data from your scientific notebook/logbook. These pieces of data often are valuable later. Talk with your teacher, make necessary improvements, and, if necessary, begin the experimentation again.

When other people make entries or comments in the scientific notebook/logbook. Material put in the scientific notebook/logbook by someone else must be acknowledged clearly, and that person's signature must be in clear view and dated.

Engineering/Computer Project considerations.
If you are doing an engineering project, after you have defined the need, developed design criteria, and done the literature search, you should:

- ✓ prepare preliminary designs
- ✓ build a prototype
- ✓ test the prototype
- ✓ retest and redesign as necessary

DATA COLLECTION

Begin your experimentation/investigation at least two months before the fair to allow yourself enough time to repeat the experimentation if necessary. Keep careful observations in a logbook. **Record failures as well as success. Keep track of all the steps performed and all tests made.** Where possible, keep a control group to make comparisons with experimental group. The groups should be identical except for one variable. Repeat the experimentation to remove any doubts over the results. Be sure that measurements are always made in a consistent manner.

As any experimenter, you will probably find that unexpected questions and problems will arise, and it is this unexpected aspect of science that makes it exciting. It may be necessary to change the experiment or add new tests to answer unsolved problems. **The path the experiment takes may be more interesting then the one originally planned. Always record all findings and observations.** The negative and hard to explain results may lead to findings as important as the results that support the hypothesis.

Organize the data into charts. Display the numerical result in the way that best summaries and explains the work.

One of the foundations of science is that an experiment can be reproduced by different scientists in different laboratories. **Record the experiment in enough detail so that another investigator could perform it.**

VARIABLES AND HYPOTHESIS

Variables

Scientists use an experiment to search for **cause and effect** relationships in nature. In other words, they design an experiment so that changes to one item *cause* something else to vary in a predictable way.

These changing quantities are called **variables**, and an experiment usually has three kinds: independent, dependent, and controlled.

The **independent variable** is the one that is changed by the scientist. In an experiment there is only one independent variable.

As the scientist changes the independent variable, he or she **observes** what happens.

The **dependent variable** changes in response to the change the scientist makes to the independent variable. The new value of the dependent variable is *caused* by and *depends* on the value of the independent variable. For example, if you open a faucet (the independent variable), the quantity of water flowing (dependent variable) changes in response--the water flow increases. The number of dependent variables in an experiment varies, but there is often more than one.

Experiments also have **controlled variables**. Controlled variables are quantities that a scientist wants to remain constant, and he must observe them as carefully as the dependent variables. For example, if we want to measure how much water flow increases when we open a faucet, it is important to make sure that the water pressure (the controlled variable) is held constant. That's because both the water pressure and the opening of a faucet have an impact on how much water flows. If we change both of them at the same time, we can't be sure how much of the change in water flow is because of the faucet opening and how much because of the water pressure. Most experiments have more than one controlled variable. Some people refer to controlled variables as "constant variables."

Some Very Simple Examples of Variables

Question	Independent Variable	Dependent Variables	Controlled Variables	Comments
How much water flows through a faucet?	Water faucet opening (closed, 1/2 open, fully open)	Volume of water flowing measured in liters per minute	Water pressure (how much the water is "pushing")	A better measure of the independent variable would be to find area of the opening in the pipe in square centimeters.
How fast does a candle burn?	Time measured in minutes	Height of candle measured in centimeters	Use same type of candle for every test Wind--make sure there is none	In this case, time is what causes the dependent variable to change. The scientist simply starts the process, then observes and records data at regular intervals.
Does fertilizer make a plant grow bigger?	Amount of fertilizer measured in grams	Growth of the plant measured by its height Growth of the plant measured by the number of leaves	• Same plants • Same soil • Same size pot • Same amount of water and light • Make measurements of growth at the same time	
Does an electric motor turn faster if you increase the voltage?	Voltage of the electricity supplied to the motor measured in volts	Speed of rotation measured in RPMs	• Same motor for every test • Same load on the motor	

Hypothesis

After having thoroughly researched a topic, you should have some prediction about what you think will happen in your experiment. This educated guess concerning the outcome is called your hypothesis.

The hypothesis is worded so that it can be tested in your experiment. Do this by expressing the hypothesis using your independent variable (the variable you change during your experiment) and your dependent variable (the variable that changes in response and *depends* on changes in the independent variable). Not only must you incorporate all these variables in your hypothesis, but you also must express them in a way that you can readily measure.

For example: "My hypothesis is that doubling the opening created by the faucet [independent variable] will double the flow of water [dependent variable]."

Not every question can be answered by the scientific method. The hypothesis is the key. If you can state your question as a testable hypothesis, then you can use the scientific method to obtain an answer.

Is all science accomplished using this same method that is taught in schools and emphasized at science fairs? Should you worry if you end up disproving your hypothesis? Actually, the answers are no it's not, and no don't worry if you disprove your hypothesis.

Grading Yourself

What Makes for Good Variables?	**For Good Variables, You Should Answer "Yes" to Every Question**
The independent variable is measurable?	Yes / No
You can change the independent variable during the experiment?	Yes / No
You have identified all relevant dependent variables, and they are all caused by and depend on the independent variable?	Yes / No
All dependent variable(s) are measurable?	Yes / No
You have identified all relevant controlled variables?	Yes / No
All controlled variables can be held constant during the experiment?	Yes / No

What Makes a Good Hypothesis?	**For a Good Hypothesis, You Should Answer "Yes" to Every Question**
The hypothesis is based on information contained in the review of literature?	Yes / No
The hypothesis includes the independent and dependent variables?	Yes / No
You have worded the hypothesis so that it can be tested in the experiment?	Yes / No
If you are doing an engineering or programming project, have you established your design criteria?	Yes / No

COMMON MISTAKES OF SCIENCE FAIR PROJECTS

Before continuing a project, you should check to avoid common mistakes of science fair projects:

1. **Jumping to a conclusion based on a single observation or test.** There is often a tendency to try something once, see what happens, and draw a conclusion from it. How many times did Jonas Salk test his polio vaccine before it could be used? Results must be verified by repeated experiments.

2. **Failing to include a control in the experiment design**. Part of finding out what will happen to the growth of bean seeds if they are fertilized is to also find out what happens if they are not fertilized. The unfertilized seeds are the control part of the experiment.

3. **Failing to recognize and/or control variables.** Not only must experiments be repeated many times over, but also variables must be controlled in the same way each time if the results are to be reliable.

4. **Not keeping complete and/or accurate records.** Science involves a lot of paperwork. Keeping good records while doing a science project involves reading, writing, spelling, and composition. Teflon was invented a full 30 years after DuPont first created it in a laboratory, because he kept accurate records that were easy to read and understand.

In general, science projects must embody those characteristics that yield reliable results. It must be done carefully with attention to detail.

ANALYSIS OF DATA AND RESULTS

Graphs

All graphs must further have a descriptive title. Generally, the independent variable is graphed on the vertical axis. Label each axis, the numerical division along each axis, and the units of measurement.

Interpretations

Interpretation should directly accept or reject the hypothesis. Explain the meaning of your observations and numerical results. **Support the meaning of experimental results with the data collected. Discuss the shapes of graphs.** Be careful in drawing a conclusion only from data. **Data needs to be interpreted.**

Statistical Analysis

Do a statistical analysis if possible. **The arithmetic mean or chi square test can help show the validity of data.** Ask the science advisor if there is a method of statistical analysis that can assist in the presentation of a project. **Many spreadsheet programs now offer statistical analysis packages.**

Determine the Precision of Your Data Points

In everyday speech, *accuracy* and *precision* are often used synonymously; however, these words do not mean the same thing to scientists.

Accuracy refers to how close the result of an experiment or a data point comes to the "True value." (See Percent Error below.)

Precision refers to how many digits your measuring instrument is able to determine in a measurement, or how many significant digits your instrument can measure. A good-quality measuring device can usually measure more precisely, that is, give more digits, than a poorer quality device.
Example: If you determine the acceleration due to gravity (g) to be 11.9971 m/s^2, your data is precise but not very accurate. (The number 11.9971 is precise to 6 digits. In other words, it has 6 significant digits.) A measurement of 10 m/s^2 is not very precise but it is quite accurate. (The true value for g is about 9.81 m/s^2.) Consult with your teacher or a textbook on how to correctly make calculations that take into account the number of significant digits in your data.

Precision is also used to discuss the variability of a set of data. This is discussed further under Measurements of Variability (see below).

Example: One student obtained the following data when measuring the acceleration due to gravity: 9.8 m/s^2, 9.7 m/s^2, 9.9 m/s^2, 9.6 m/s^2, and 9.8 m/s^2. Another student obtained this data: 10.5 m/s^2, 9.8 m/s^2, 8.3 m/s^2, 11.7 m/s^2, and 7.9 m/s^2. The first data set is very precise while the second is not. Both data sets give similar mean values and appear to be quite accurate.

Find the Central Tendency in Your Data

The statistics listed below are used as a measurement of the central tendency in a data set. Most scientific calculators will calculate these statistics for you; learn how to use a scientific calculator.

- Mean or average
- Median - the middle data point
- Mode - the most common data point

Determine the Variability in Your Data

Variability refers to how close together your data points are or how close your data points are to given curve (often a line).

- Range - the smallest data point subtracted from the largest data point
- Standard Deviation - (□for samples, □for populations)
- Correlation Coefficients (R): Used for data that has been curve fitted.

Graph Your Data

It is always a good idea to graph your data either on graph paper or using computer software such as Excel™, Kaleidagraph™, or Mathcad™. Choose from the following types of graphs.

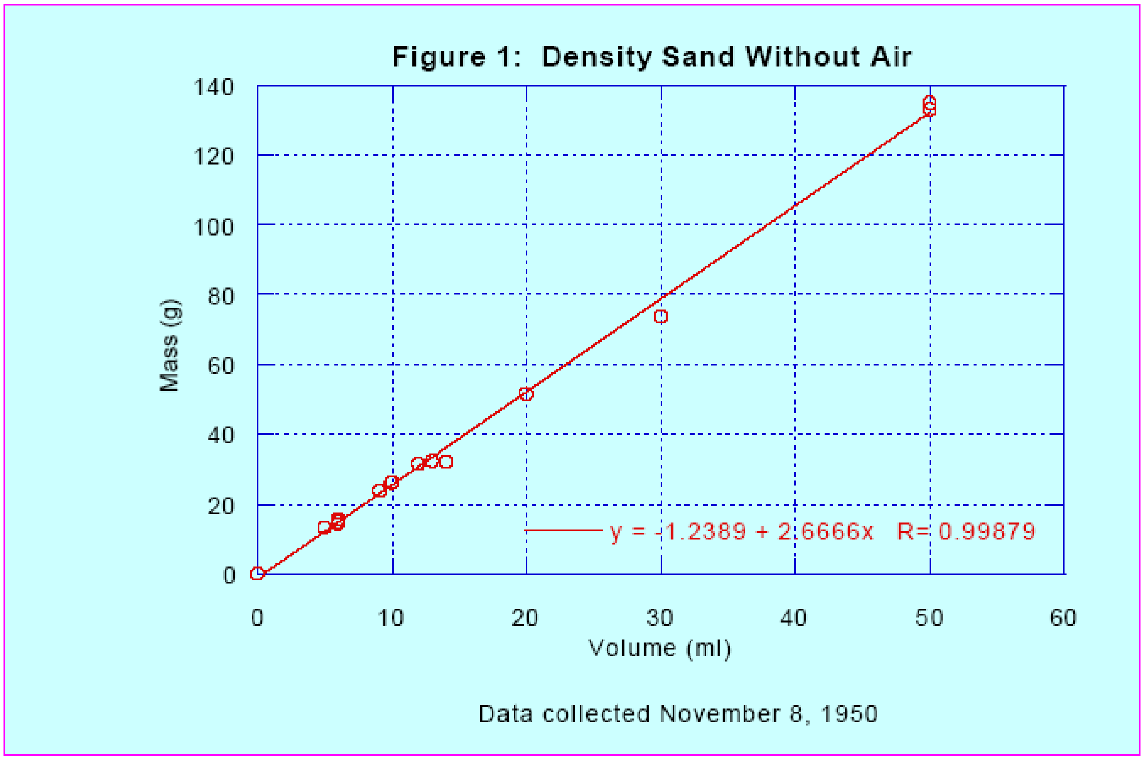
- line graph
- bar graph
- pie graph
- pictogram
- histogram
- scatter plot

When both variables involve data that is continuous (decimal numbers can, in theory at least, be found) most scientists prefer to use scatter plots. You will be able to infer the “true” shape of the data with this type of graph. Scatter plots can be line- or curve-fitted.

Remember that each graph should have axes that are properly calibrated (i.e., each increment should represent the same numerical amount). Be sure to include the entire range of your data in the scales of your axes. The **independent variable** is plotted on the ***x*-axis**, and the **dependent variable** is plotted on the ***y*-axis**.

Do your data vary directly with *x* (that is, as *x* increases, *y* increases)?

Do your data vary inversely with *x* (that is, as *x* increases, *y* decreases)?



If your data looks as if it might be describing a line, you can do a best-fit line using a clear plastic ruler or using computer software. The correlation coefficient (R) is a measure of how closely your data is fitted. (R=1 means that all data points are exactly on the line or curve.) When using a ruler, make sure that you have as many data points above the line as below, and that the distances of the data points to the proposed line on average are minimized. Other kinds of curves can also be fitted using mathematics or computer software. By fitting your data to an appropriate line or curve, you can obtain an equation that describes your data. Predictions can be made from this equation, which can be used to verify your results with further experimentation.

Compare with Accepted Values to Determine its Accuracy

Percent Error

If there is an accepted value associated with your data or if other scientists have data with which you can compare your data, the appropriate statistic for this comparison is percent error. This statistic is used to assess the accuracy of your data.

$$\text{Percent error} = \frac{\text{(your value - accepted or true value)}}{\text{accepted value}} \times 100$$

HYPOTHESIS TESTS

You may want to learn more about testing null hypotheses and how to determine confidence levels for the credibility of your results. The t-test is a hypothesis test used for small samples.

ANALYZING ERRORS

Ask yourself these questions:

- What were the limitations of your experiment?
- How were extraneous variables minimized?
- Comment on your percent error. Was this favorable or not favorable?
- What went wrong? What went right?
- How might you improve your experimental design in future studies?

LOOKING FOR TRENDS & FORMING A CONCLUSION

Now is the time to look at the results of your experimentation and the analysis of your findings.

- ✓ Did you collect enough data?
- ✓ Do you need to collect more data?
- ✓ Were your variables and control properly designated?
- ✓ Which variables are important?
- ✓ How do your results compare with other studies? (Refer to your background information)
- ✓ Do your results seem reasonable?

  Percent error = (your value - accepted or true value) X 100 accepted value
- ✓ Are there any trends in your quantitative/qualitative data?
- ✓ What might explain these trends?
- ✓ How might the results of your work be relevant to society or to other scientists working in your field?
- ✓ Do you need to do more experimentation?
- ✓ Do your results support your hypothesis? If not, why not? You have done your experimentation to test the hypothesis.
- ✓ Ask and answer as many questions about the project as you can. This will help to direct your thoughts and help you to decide whether or not you need to modify, do retrials, or complete the project at this time.

Remember one very important thing — keep an open mind about your findings.

Never change or alter your results to coincide with what you think is accurate or with a suggested theory. Sometimes the greatest knowledge is discovered through so-called mistakes.

DISCUSSION

This is the student's opportunity to give an honest impression of the project.

- **How did you decide on your idea?**
- **What was your favorite aspect of the experiment?**
- **What was something new that you learned?**
- **Was there something unexpected that happened?**
- **What were the ups and downs of the whole process?**
- **What did your data show?**
- **What would you do differently next time***?*
- **What were the problems?**
- **How do the project results might fit into the greater scheme of things.**
- **What are the possibilities for future experimentation?**

WRITTEN REPORT

Now you have:

- **Taken notes on library research**
- **Written a hypothesis**
- **Listed the type and amount of materials used**
- **Recorded step by step procedures**
- **Maintained a log**
- **Collected data in tabular form**
- **Created graphs**
- **Interpreted the findings**
- **Discussed the general impressions**

The report is almost completed. Organization and transitions between areas are remaining. Technical language may be used, but it is more important to be clear and concise, rather than using too much technical terminology. Label each section of the report clearly. The written report must have correct spelling and grammar, be easy to read (**double-spaced typing**), and appear neat and well organized. Follow the chart on the next page in planning your report.

- **But you say, "I am not good at writing." Or, "I can't stand writing." Believe it or not, I use to freeze every time I had to look at a computer or paper to write even a sentence.**
- **Here's one secret... Don't worry about it. Just write what you know... after all, you lived the experience. Then go back and fix it up. And remember to have someone edit your report... more on that later.**

If someone read your report and knew nothing about the project, s/he would be able to experience all the details of your investigation as if s/he did it themselves.

SECTIONS OF THE PROJECT REPORT

Your report is the written record of your entire project from start to finish. When read by a person unfamiliar with your project, the report should be clear and detailed enough for the reader to know exactly what you did, why you did it, what the results were, whether or not the experimental evidence supported your hypothesis, and where you got your research information. This written document is your spokesperson when you are not present to explain your project, but more than that, it documents all your work.

Much of the report will be copied from your journal. By recording everything in your journal as the project progresses, all you need to do in preparing the report is to organize and neatly copy the journal's contents. Neatly and colorfully prepare tables, graphs, and diagrams. If possible, use a computer to prepare some or all of these data displays.

Check with your teacher for the order and content of the report. It should contain a title page, a table of contents, an abstract, an introduction, one or more experiments and data, a conclusion, a list of sources, and acknowledgments.

Title Page

Ideally the title of your project should be catchy, an "interest-grabber," but it should also describe the project well enough that people reading your report can quickly figure out what you were studying.

It should capture the theme of the project but should not be the same as the problem question.

Table of Contents

The second page of your report is the table of contents. It should contain a list of everything in the report that follows the contents page, as shown in Figure 2.

Contents

Figure 2: A Table of Contents

Abstract

The abstract is a brief overview of the project. It should not be more than one page and should include the project title, a statement of the purpose, a hypothesis, a brief description of the procedure, and the results. There is no one way to write an abstract, but it should be brief, as shown in Figure 3. Often, a copy of the abstract must be submitted to the science fair officials on the day of judging, and it is a good idea to have copies available at your display. This gives judges something to refer to when making final decisions. It might also be used to prepare an introduction by a special award sponsor, so do a thorough job on this part of your report.

Abstract
Up and Down:
Seasonal Temperature versus Sun Ray Angle

The purpose of this project was to find out whether the angle of the Sun's rays at noon affects seasonal temperatures. The experiments involved measuring the air temperature and the angle of the Sun's rays at noon during different seasons. This was done by recording air temperature and measuring the angle of shadows
at noon on the first day of the month from October through April.

The measurements confirmed my hypothesis that as the angle of the Sun's rays decreases during the year, the outdoor temperature increases. These findings led me to believe that seasonal temperatures are the result of the difference in the angle of the Sun's rays. As the ray angle decreases, sunlight is more concentrated on an area, resulting in a higher temperature.

I discovered that during seasons with high temperatures, the angle of the Sun's rays is lower than during seasons with low temperatures.

Figure 3: An Abstract

Introduction

The introduction is a statement of your purpose, along with background information that led you to make this study. It should contain a brief statement of your hypothesis based on your research. In other words, it should state what information or knowledge you had that led you to hypothesize the answer to the project's problem question. Make references to information or experiences that led you to choose the project's purpose. If your teacher requires footnotes, then include one for each information source you have used. The introduction shown in Figure 4 does not use footnotes.

> **Introduction**
>
> The air temperature generally changes quite a bit during the day, but any change from one day to the next at the same time of day is, as a rule, relatively small. But the temperature of some regions changes significantly over the course of a year, resulting in different seasons.
>
> While reading about my project topic, the effect of the angle of the Sun's rays at noon on seasonal temperatures, I thought about my own experience of the Sun's high noon altitude and small shadow angles occurring at the same time as high summer temperatures. Further research provided the facts that as the angle of the Sun's rays decreases, the more concentrated the rays, thus the hotter the area of Earth receiving them. I reasoned that the angle of the Sun's rays at noon must change during the year.
>
> My curiosity about the relation of angle of the Sun's rays to temperature resulted in a project that has as its purpose to discover how the angle of the Sun's rays affects air temperature during the year and thus causes seasons. Based on previous stated research and the fact that it is cooler in the morning when the angle of the Sun's rays is least due to the Sun's low altitude, my hypothesis was that as the angle of the Sun's rays increases during the year, the outdoor temperature increases, causing seasons.

Figure 4: Introduction

Experiment and Data

List each project experiment in the experiment section of the report. Experiments should include the problem of the experiment, followed first by a list of the materials used and the amount of each, then by the procedural steps in outline or paragraph form, as shown in Figure 5. Note that the experiment described in Figure 5 determines the average monthly angle of the sun's noon rays during seven consecutive months. A second experiment is needed to measure the average temperature of each month. Write the experiments so that anyone could follow them and expect to get the same results.

Following each experiment, include all the measurements you took and all the observations you made during each experiment. Graphs, tables, and charts created from your data should be labeled and, if possible, colorful. Figure 6 shows a table and Figure 7 a bar graph for the experiment shown in Figure 5. If there is a large amount of data, you may choose to put most of it in an appendix, which can be placed in a separate binder or notebook. If you do separate the material, place a summary of the data in the data section of the report.

Experiment

Purpose

To determine the angle of the Sun's rays at noon (standard time) during different seasons.

Materials

yardstick (meterstick)

cup with pencil and string prepared in the Sample Experiment

protractor

Procedure

1. At around 11:45 A.M., set the measuring stick on a flat surface in a sunny area outdoors with its pointer end facing the horizon directly below the Sun.
2. Set the cup in the middle of the stick. Move the pointer end of the stick so that the shadow cast by the pencil falls on the stick.
3. At 12:00 P.M. (noon), move the cup back and forth along the stick until the end of the shadow touches the measuring line. *NOTE: If the shadow is longer than the measuring stick, place two measuring sticks end to end.*
4. Hold the cup in place and extend the string from the top of the pencil to the measuring line. Ask a helper to use the protractor to measure the angle between the pencil and string.
5. Repeat steps 1 through 3 one or more times each week during 6 or more consecutive months.
6. Average the angles measured for each month.

Figure 5: An Experiment

SUN RAY ANGLES AT NOON

Month	Average Monthly Angle (degrees, °)
October	40
November	31
December	24
January	31
February	40
March	48
April	56

Figure 6: A Table

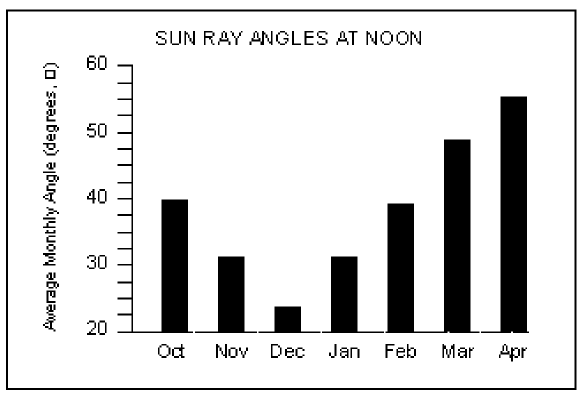


Figure 7: Example of a Bar Graph

Conclusion

The conclusion summarizes, in about one page or less, what you discovered based on your experimental results, as shown in Figure 8. The conclusion states the hypothesis and indicates whether the data supports it. The conclusion can also include a brief description of plans for exploring ideas for future experiments.

> **Conclusion**
>
> As stated in my hypothesis, I believe that the size of Sun ray angles at noon cause seasonal temperatures, small angles causing warm temperatures and large angles causing cold temperatures. The experimental data supported my hypothesis, indicating a direct relation between the angle of the Sun's rays and the air temperature. This direct relation between the ray angles and the temperatures was found to apply over different seasons. The smaller the ray angle, the warmer the season, and the greater the angle, the cooler the season. Experimental data also showed an inverse relation between the Sun's noon altitude and the angle of the Sun's rays; thus, as the altitude of the Sun increases, its ray angle decreases. The experiments confirmed that more direct Sun rays (those with the least angle) heat the earth more.
>
> Through my research as well as experience, I discovered that the length of each day is not exactly the same. Ideas for a future experiment would be to determine the effect of day length on the average daily temperature.

Figure 8: A Project Conclusion

Sources

Sources are the places where you obtained information, including all of the written materials as well as the people you have interviewed.

For the written materials, write a bibliography. List the people that you interviewed, separately, in alphabetical order by last name. Provide their titles and with permission give their business addresses and telephone numbers, as shown in Figure 9. Do not list home addresses or home telephone numbers.

> **Source Interviewed**
>
> Lynn, Jennifer
> Astronomer
> 100 Rainy Drive
> San Francisco, California 00001
> (001)222-0000

Figure 9: An Interview Source

Bibliography: (Sometimes called "Works Cited.") List all books, encyclopedias, journal articles, web sites, etc., you used. Different disciplines often follow different referencing formats; check an article from a scientific journal in your field if you want perfection, but most importantly, be consistent!

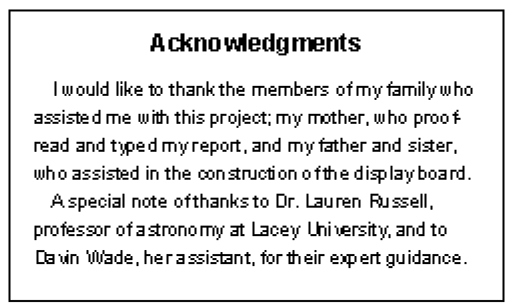
- A **book** reference might look like this:
  Smith, J. D. (1989). *A Study of Plant Life*. New York: Johnson Printing Co.

- A **scientific journal article** reference might look like this:
  Foley, J. D. (1987). "Interfaces for Advanced Computing." *Scientific American*, 257:127-135.

- A **World Wide Web** reference might look like this:
  Author. (June 8, 1999). "Title of Page." Title of Site. Online. Available: http://www.etc. Accessed August 4, 2000.

Acknowledgments

Even though technically your project is to be your work alone, it is permissible to have some help. The acknowledgments is not a list of names, but a short paragraph stating the names of people who helped you and how, as shown in Figure 10.



Acknowledgments

I would like to thank the members of my family who assisted me with this project; my mother, who proof-read and typed my report, and my father and sister, who assisted in the construction of the display board.

A special note of thanks to Dr. Lauren Russell, professor of astronomy at Lacey University, and to Davin Wade, her assistant, for their expert guidance.

Figure 10: Acknowledgments

Note that when listing family members or relatives, it is generally not necessary to include their names.

Often scientists thank others who have helped them with their research project. This is the place to do so. You should always credit those who assisted you, including individuals, businesses, and educational or research institutions.

THE DISPLAY

The display communicates the essential parts of the project in a quick, visual way. The display should be sturdy, **free standing**, colorful, simply illustrated, well labeled, and **attractive**.

The backboard may be made of pegboard, masonite, or plywood no larger than 76-cm deep, 122-cm wide, and 366 cm high. (Of course, the display does not need to be this large). An easy-to handle folding design is made from pegboard held together by three notebook rings between each section. Scrap wood can be covered with fabric for an attractive display. Try requesting scraps at lumberyards, construction sites, hardware stores, or yardage stores before spending money. Foam core or folding backboards may also be purchased from science or office supply stores.

The title and section headings on the backboard should be clearly visible and readable from a distance of three to four feet. Use complementary colors as background and bright or dark letters for the titles of each section.

If using a computer to generate headings, **use a boldface font of at least 18 points**. Cut paper strips and frame and/or mount the title of each section. A photocopier can also be used to enlarge text for titles and section headings. The title should have the largest print on the display board and be neatly done.

Enlarge graphs and use color for the different lines or bars. Use photographs that are clear and sharp, with the correct exposure. A 5 x 7 photo creates a better display. **There should be an explanation under each photo and graph.**

Set the entire display board flat on the floor and arrange the various parts before beginning the final assembly. Be certain all titles, graphs, photos, and text are lined up properly and in place before gluing them down. **Use rubber cement instead of glue so pieces can be replaced if necessary**. Make sure the edges of the paper are glued down securely to the backing to prevent peeling or drooping later. All this attention to detail will result in a display board that is attractive, easy to read and as neat as possible.

ORAL PRESENTATION

When you decide to be in a science fair, you must consider your presentation as important as any other part of your project. Practice will make the difference in how well you present yourself to the judges.

Here is a step-by-step approach to constructing your presentation:

1. Introduce yourself. "Hello, my name is ______________."
2. Give the title of your project. "The title of my project is___________."
3. Explain the purpose of your project. "The purpose of my project is__________."
4. Tell the judges how you got interested in this topic.
5. Explain your procedure. "The procedure I followed was_________."
6. Show your results. If you have charts, graphs, or a notebook, show them to the judges and explain them. If results are shown on your backboard, point them out.
7. List your conclusions. Explain what you have proven. If you think that you had some problems or error in your experiments, don't be afraid to admit these.
8. Tell the judges what you might do in the future to continue your experimentation. What would you have done differently if you were to do the project again?
9. Of what importance is your project to the world? Explain any applications of your study.
10. "Do you have any questions?" If you do not know the answer to a judge's question, then say, "I'm sorry, I don't know the answer, but I think the answer is____________." Do not "fake" like you truly know an answer when you really don't. If a judge is asking a question, then he / she most likely knows the real answer.
11. Thank the judges.

Other Tips For Presenting

Regional science fairs limit the amount of time for your presentation. Therefore, it is very important to use that time well. You will want to impress your judges with your project, your knowledge, and your **enthusiasm**. All people are affected in one way or another by the way we look, the way we talk, and the way we act. Adults are usually impressed with good manners and nice cloths. Here are some tips:

1. Wear your best clothes. Really dress up.
2. Stand up straight on both feet when a judge approaches your project. Don't sway from foot to foot.
3. Stand to the side of your exhibit so the judge can get a good look at your project.
4. Look straight into the eyes of your judges. Pay attention to each of your judges.
5. Get the judges involved in your project. Let them hold your research paper, notebook, or apparatus. Point out charts, graphs, and photos.
6. **DO NOT CHEW GUM OR CANDY!**
7. Speak loudly enough to be heard by all of your judges. Remember some of them are "OLD" and hard of hearing.
8. Smile!
9. Be Polite!

DO’S AND DON’T’S AT THE FAIR

Do bring activities, such as puzzles to work on or a book to read, to keep yourself occupied at your booth. There may be a lengthy wait before the first judge arrives, and even between judges.

Do become acquainted with your neighboring presenters. Be friendly and courteous.

Do ask neighboring presenters about their projects, and tell them about yours if they express interest. These conversations pass time and help relieve nervous tension that can build when you are waiting to be evaluated. You may also discover techniques for research that you can use for next year's project.

Do have fun.

Don't laugh or talk loud. This may affect the person nearby who is being judged.

Don't forget that you are an ambassador for your school. This means that your attitude and behavior influence how people at the fair think about you and the other students at your school.

"How do we prevent global warming?" would not be a good question for a science fair experiment on the environment. The question is not specific enough to design an experiment that can answer it. A better question might be, "How does increasing temperature affect plants that normally grow in cool places?" It would be easier to design an experiment to attempt to answer this question.

Make sure that you don't pick a question that is specific but is too difficult to answer. Consider the question, "Do larger gills allow fish to swim faster?" This question is specific but getting fish with different gill sizes and measuring how fast they swim would not be easy. Keep in mind that the question must lend itself to an experiment that can be conducted with available time and resources.

Think ahead, and try to avoid any problems that might arise in designing an experiment to answer the question. Before setting up an experiment, you should do some research to see what's already known about the question. This research may also help you decide if the question needs to be narrowed down. Or, it could help you discover a related topic with its own potential questions for a science fair project. Make sure your project is safe by checking with your teacher before you begin.

In an **invention** or **design** project you devise and demonstrate a new tool or system with which to accomplish a task or process. Like the types of projects mentioned above, invention and design projects still require research, testing, and detailed observations. For example, you might devise and demonstrate a system for waking someone up without noise, or a new utensil for eating spaghetti. Because not all schools allow invention and design projects, you should find out what the rules say before starting.

- GOOD LUCK -