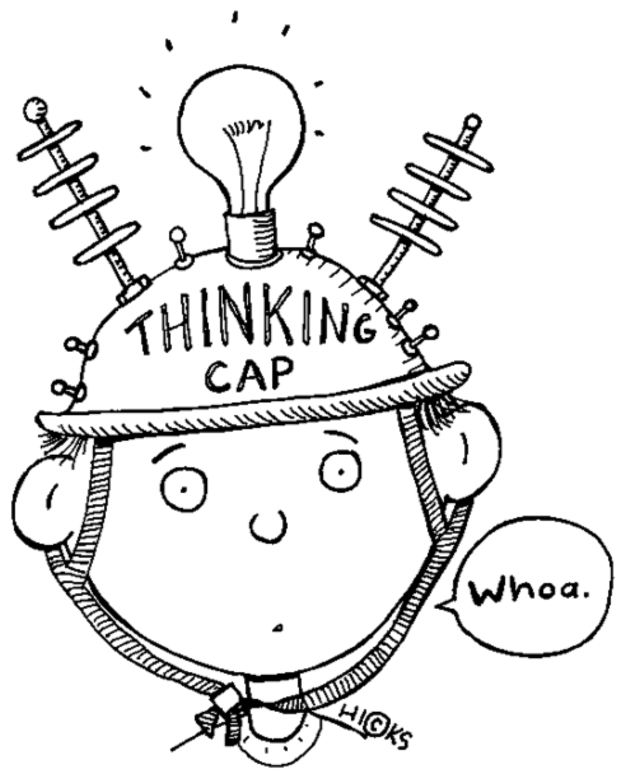
Science Fair Guide

Ms. Dinh, 5th Grade



Student Name ______________________________

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(Resource: www.sciencebuddies.org)

Project Timeline

Project Section	Due Date	Date Submitted	Points Earned
Science Project Proposal: Topic & Question			/5
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Hypothesis			/5
Experimental Procedure			/10
Data & Collection Check			/20
Results & Conclusion			/20
Rough Draft			/15
Final Report (Placed in a binder/folder)			/40
Display Board			/25
Oral Presentation			/20
		Project Grade	**/200**

Beacon Heights Science Fair will be on _______________________. All display boards and written reports need to be ready to share (communicate) with judges and peers.

Finding an Idea for Your Science Fair Project

One of the most important considerations in picking a topic for your science fair project is to find a subject that you consider interesting. You'll be spending a lot of time on it, so you don't want your science fair project to be about something that is boring.

Finding a topic is the hardest part of a science fair project, and sometimes you just need a little help focusing on what sorts of topics would be of interest to you. To help you find a science fair project idea that can hold your interest, Science Buddies has developed the Topic Selection Wizard. By answering a series of questions about everyday interests and activities, you will better identify an area of science that is best for you. To get started, go to www.sciencebuddies.org and take the survey!

- The Topic Selection Wizard asks you a series of questions about everyday interests and activities then recommends an area of science and science fair project ideas that are best for you.
- Science Fair Project Ideas lets you browse through hundreds of science fair project ideas.

Scientific Method Key Information

The scientific method is a way to ask and answer scientific questions by making observations and doing experiments.

The steps of the scientific method are to:

- **Ask a Question**
- **Do Background Research**
- **Construct a Hypothesis**
- **Test Your Hypothesis by Doing an Experiment**
- **Analyze Your Data and Draw a Conclusion**
- **Communicate Your Results**

It is important for your experiment to be a fair test. A "fair test" occurs when you change only one factor (variable) and keep all other conditions the same.

Throughout the process of doing your science fair project, you should keep a journal containing all of your important ideas and information.

Steps of the Scientific Method	
1	***Ask a Question:*** The scientific method starts when you ask a question about something that you observe: How, What, When, Who, Which, Why, or Where? And, in order for the scientific method to answer the question it must be about something that ***you can measure***, preferably with a number.
2	***Do Background Research:*** Rather than starting from scratch in putting together a plan for answering your question, you want to be a savvy scientist using library and Internet research to help you find the best way to do things and insure that you don't repeat mistakes from the past.
3	***Construct a Hypothesis:*** A hypothesis is an educated guess about how things work: "If ______*[I do this]*______, then ______*[this]*______ will happen because ____________." You must state your hypothesis in a way that you can ***easily measure***, and of course, your hypothesis should be constructed in a way to ***help you answer your original question.***
4	***Test Your Hypothesis by Doing an Experiment:*** Your experiment tests whether your hypothesis is true or false. It is important for your experiment to be a fair test. You conduct a fair test by making sure that you change only one factor at a time while keeping all other conditions the same. You should also ***repeat your experiments several times*** to make sure that the first results weren't just an accident.
5	***Analyze Your Data and Draw a Conclusion:*** Once your experiment is complete, you collect your measurements and analyze them to see if your hypothesis is true or false. Scientists often find that their hypothesis was false, and in such cases they will construct a new hypothesis starting the entire process of the scientific method over again. Even if they find that their hypothesis was true, they may want to test it again in a new way.
6	***Communicate Your Results:*** To complete your science fair project you will communicate your results to others in a final report and/or a display board. Professional scientists do almost exactly the same thing by publishing their final report in a scientific journal or by presenting their results on a poster at a scientific meeting.

Even though we show the scientific method as a series of steps, keep in mind that new information or thinking might cause a scientist to back up and repeat steps at any point during *the process.* A process like the scientific method that involves such backing up and repeating is called an **iterative process**.

Your Science Fair Project Question

The question that you select for your science fair project is the cornerstone of your work. The research and experiment you will be conducting all revolve around finding an answer to the question you are posing. It is important to select a question that is going to be interesting to work on for several months and a ***question that is specific*** enough to allow you to find the answer with an experiment. ***A scientific question usually starts with: How, What, When, Who, Which, Why, or Where***. Here are some characteristics of a good science fair project question:

- The question should be interesting enough to read about, and then work on for the next couple months.
- There should be ***at least 3 sources*** of written information on the subject. You want to be able to build on the experience of others!

It is important to think ahead. This will save you lots of unhappiness later. Imagine the experiment you might perform to answer your question. How does that possible experiment stack up against these issues?

- The experiment should measure changes to the important factors (variables) using a number that represents a quantity such as a count, percentage, length, width, weight, voltage, velocity, energy, time, etc. Or, just as good might be an experiment that measures a factor (variable) that is simply present or not present. For example, lights ON in one trial, then lights OFF in another trial, or USE fertilizer in one trial, then DON'T USE fertilizer in another trial. If you can't measure the results of your experiment, you're not doing science!
- You must be able to control other factors that might influence your experiment, so that you can do a fair test. A "fair test" occurs when you change only one factor (variable) and keep all other conditions the same.
- Is your experiment safe to perform?
- Do you have all the materials and equipment you need for your science fair project, or will you be able to obtain them quickly and at a minimal cost?
- Do you have enough time to do your experiment before the science fair? For example, most plants take weeks to grow. If you want to do a project on plants, you need to start very early! For most experiments you will want to allow enough time to do a practice run in order to work out any problems in your procedures.
- Does your science fair project meet all the rules and requirements for your science fair?
- Have you avoided the bad science fair projects listed in the table below?

If you don't have good answers for the above issues, then you probably should look for a better science fair project question to answer.

Background Research Plan

Why the Need for Background Research?

So you can design an experiment, you need to research what techniques and equipment might be best for investigating your topic. Rather than starting from scratch, savvy investigators want to use their library and Internet research to help them find the best way to do things. You want to learn from the experience of others rather than blunder around and repeat their mistakes. A scientist named Mike Kalish put it humorously like this: "A year in the lab can save you a day in the library."

Background research is also important to help you understand the theory behind your experiment. In other words, science fair judges like to see that you understand why your experiment turns out the way it does. You do library and Internet research so that you can make a prediction of what will occur in your experiment, and then whether that prediction is right or wrong, you will have the knowledge to understand what caused the behavior you observed.

Making a Background Research Plan: How to Know What to Look For

When you are driving a car there are two ways to find your destination: drive around randomly until you finally stumble upon what you're looking for OR look at a map before you start. (Which way do your parents drive?)

Finding information for your background research is very similar. But, since libraries and the Internet both contain millions of pages of information and facts, you might never find what you're looking for unless you start with a map! To avoid getting lost, you need a background research plan.

Keywords

The place to start building your background research plan is with the question for your science fair project Let's imagine that you have asked this one:

Question: Does drinking milk help decrease spiciness better than water or Pepsi?

Begin by identifying the keywords and main concepts in your question. In this case, keywords would be:

- Milk
- Spiciness
- Pepsi
- Water

That's pretty easy! Now, what might be some of the main concepts that relate to these keywords? Let's think about spiciness first. You're going to do a science experiment, so knowing that a spicy food tastes "hot" is probably not sufficient. Hmmmm, this is a little tougher than finding the keywords.

The secret to use the “question words" (why, how, who, what, when, where) with your keywords. Ask why things happen, ask how things happen, ask what causes things to happen, ask what are the properties of key substances.

Talk to People with More Experience: Networking

As you can see with the above examples, spiciness and milk, the question word will work better for some keywords than others. You might have a science fair project question where none of the keywords generate relevant questions. Yikes! What do you do then?

One of the most important things you can do is talk to other people with more experience than yourself: your mentors, parents, and teachers. This is called "networking." Some of these people will have had classes or work experience that involved studying the science involved in your project. Ask them, "What science concepts should I study to better understand my project?" Be as specific as you can when asking your question. Even experts will look puzzled if you ask a question that is so generic it leaves them pondering where to start. Instead of asking, "How do airplanes fly," try asking, "What physical forces are involved in the flight of an airplane," or "What role do propellers play in the flight of a helicopter?" (After all, there's gotta be something that causes that hunk of metal to go up, right?)

For example, let's imagine your science fair project question is: Does the velocity of a roller coaster car affect whether it falls off a loop? If you ask someone who has studied physics in high school or college, they will tell you to ask the research question, "What is centripetal force?"

Sometimes there is even a specialized area of science that studies questions similar to the one for your science fair project. Believe it or not, there are actually people who study "roller coaster physics." (Is that a cool job or what?) Often a good topic for your background research is simply the specialized area of science that covers your project. For the roller coaster example you would research "roller coaster physics."

How do you find the area of science that covers your project? By networking with your mentors, parents, and teachers.

How to Find Information

Library Research

One of the most valuable resources at the library is not a book, but a person. Public librarians, college librarians and certified school librarians are specially trained to teach information literacy. Librarians are excellent sources for organizing research, for teaching how to search, how to read and use citations, how to narrow down web searches, and how to winnow out the good from the bad. Many public libraries also have virtual reference services, where a client can online chat, email or talk on the phone with a reference librarian. So, be smart; talk to your librarian.

Often the best place to start your background research is by looking up your keywords in an encyclopedia, dictionary, or textbook. Your library may have specialized dictionaries for different topics like science, sports, music, and so on, which offer more complete information than a regular dictionary. Ask the librarian to help you.

"Read the background information and note any useful sources (books, journals, magazines, etc.) listed in the bibliography at the end of the encyclopedia article or dictionary entry. The sources cited in the bibliography are good starting points for further research. By using this technique of routinely following up on sources cited in bibliographies, you can generate a surprisingly large number of books and articles on your topic in a relatively short time.

You can also check the subject headings of books and articles as you look them up in the library catalog. Check to see if other books in the same subject area contain relevant information.

Periodicals are printed material like magazines and newspapers. Depending on your topic, they may also contain useful information.

Internet Research

If you want some advanced tips on using the Internet to find information, here are two good sites. There is valuable information here even for people who think that they are good at Internet searching.

- http://www.lib.berkeley.edu/TeachingLib/Guides/Internet/FindInfo.html A tutorial offered by the Teaching Library at the University of California at Berkeley.
- Librarians' Index to the Internet: Internet Guides and Search Tools. Check out the tips in "Internet Searching."

To do an internet search for books containing information about a specific science fair project, the Science Fair Project Index (developed by the Akron Summit Public Library) is a great place to start. The Index is designed to allow the user to locate a particular experiment by the general topic; by keywords in the experiment title or book information; by grade level; by the materials or equipment employed; or by the principle demonstrated.

- http://www.akronlibrary.org/scifair/

Before you begin your internet research, review internet safety with your parents. Here are some important tips to help you stay safe online, such as:

- Email addresses, user account names, and screen names should never include your name, birthday, name of your school, or any combination of personally identifiable information.
- Don't assume blogging is private. It's possible for search engines to pick up the information you post. If you publish photos or links to private websites on your blog, you also reduce your level of protection. Check out your blog host's setting options to find out if you can turn off some of these features, and be cautious of what you post on your blog.
- Never allow a stranger to join a buddy list, a chat, or an IM conversation.

Finding Too Much or Too Little Information

If you are finding too much information, for example pages and pages of irrelevant hits on Google or a periodical index, you need to narrow your search. You can narrow your search by borrowing some of the terms in your research questions. For example, let's imagine that searching on "milk" brings up too much irrelevant information about cows. Here are the research questions we listed having to do with milk:

- What is the composition of milk, Pepsi, and water?
- What are the properties and characteristics of milk, Pepsi, and water?

Try searching on:

- milk composition
- milk properties characteristics

This will narrow your search, and hopefully give you more relevant results.

If you aren't finding enough information, you need to simplify your search. Let's imagine that searching on "measuring spiciness" isn't finding what you want. Try searching on:

- measure spiciness
- spiciness , spice

Too Complicated or Too Simple Information

Sometimes the information you find will be relevant, but either too complicated given your science background or too babyish. This is a problem that we all experience. Just keep looking and ask for advice if you're really stuck.

Your Goal

Never forget, the goal of your searching is to find information to answer the research questions you asked about your topic. Don't stop looking until you have sources that will answer your questions! Be sure to ask for help from mentors, parents, and teachers if you're having trouble.

Bibliography

A bibliography is a listing of the books, magazines, and Internet sources that you use in designing, carrying out, and understanding your science fair project. But, you develop a bibliography only after first preparing a background research plan -- a roadmap of the research questions you need to answer. Before you compose your bibliography, you will need to develop your background research plan.

With your background research plan in hand, you will find sources of information that will help you with your science fair project. ***As you find this information it will be important for you to write down where the sources are from***. You can use the Bibliography Worksheet to help you, be sure to take it with you to the library. As you find a source, write in all of the necessary information this way, when you are typing your bibliography you won't need to go back to the library and find any missing information. The more information you write down about your source, the easier it will be for you to find if you want to read it again.

When you are writing your report, you will use the sources in your bibliography to remind you of different facts and background information you used for your science fair project. ***Each time you use some information from a source, you will need to cite the source that it came from.*** To cite a source, simply put the author's name and the date of the publication in parentheses (Author, date) in your text. If the person reading your report wants to find the information and read more about it, they can look up the reference in your bibliography for more detail about the source. That is why ***each source you use must be listed in a detailed bibliography*** with enough information for someone to go and find it by themselves.

Your bibliography should include ***a minimum of three written sources*** of information about your topic from books, encyclopedias, and periodicals. You may have additional information from the Web if appropriate.

Format Examples

Books

Format:

Author's last name, first initial. (Publication date). *Book title*. Additional information. City of publication: Publishing company.

Examples:

Allen, T. (1974). *Vanishing wildlife of North America*. Washington, D.C.: National Geographic Society.

Boorstin, D. (1992). *The creators: A history of the heroes of the imagination*. New York: Random House.

Nicol, A. M., & Pexman, P. M. (1999). *Presenting your findings: A practical guide for creating tables*. Washington, DC: American Psychological Association.

Searles, B., & Last, M. (1979). *A reader's guide to science fiction*. New York: Facts on File, Inc.

Toomer, J. (1988). *Cane*. Ed. Darwin T. Turner. New York: Norton.

Encyclopedia & Dictionary

Format:

Author's last name, first initial. (Date). Title of Article. *Title of Encyclopedia* (Volume, pages). City of publication: Publishing company.

Examples:

Bergmann, P. G. (1993). Relativity. In *The new encyclopedia britannica* (Vol. 26, pp. 501-508). Chicago: Encyclopedia Britannica.

Merriam-Webster's collegiate dictionary (10th ed.). (1993). Springfield, MA: Merriam-Webster.

Pettingill, O. S., Jr. (1980). Falcon and Falconry. *World book encyclopedia*. (pp. 150-155). Chicago: World Book.

Tobias, R. (1991). Thurber, James. *Encyclopedia americana*. (p. 600). New York: Scholastic Library Publishing.

Magazine & Newspaper Articles

Format:

Author's last name, first initial. (Publication date). Article title. *Periodical title, volume number(issue number if available)*, inclusive pages.

Note: Do not enclose the title in quotation marks. Put a period after the title. If a periodical includes a volume number, italicize it and then give the page range (in regular type) without "pp." If the periodical does not use volume numbers, as in newspapers, use *p*. or *pp*. for page numbers.
Note: Unlike other periodicals, p. or pp. precedes page numbers for a newspaper reference in APA style.

Examples:

Harlow, H. F. (1983). Fundamentals for preparing psychology journal articles. *Journal of Comparative and Physiological Psychology, 55*, 893-896.

Henry, W. A., III. (1990, April 9). Making the grade in today's schools. *Time, 135*, 28-31.

Kalette, D. (1986, July 21). California town counts town to big quake. *USA Today, 9*, p. A1.

Kanfer, S. (1986, July 21). Heard any good books lately? *Time, 113*, 71-72.

Trillin, C. (1993, February 15). Culture shopping. *New Yorker*, pp. 48-51.

Website or Webpage

Format:

Online periodical:

Author's name. (Date of publication). Title of article. *Title of Periodical*, volume number, Retrieved month day, year, from full URL

Online document:

Author's name. (Date of publication). *Title of work*. Retrieved month day, year, from full URL

Note: When citing Internet sources, refer to the specific website document. If a document is undated, use "n.d." (for no date) immediately after the document title. Break a lengthy URL that goes to another line after a slash or before a period. Continually check your references to online documents. There is no period following a URL.
Note: If you cannot find some of this information, cite what is available.

Examples:

Devitt, T. (2001, August 2). Lightning injures four at music festival. *The Why? Files*. Retrieved January 23, 2002, from http://whyfiles.org/137lightning/index.html

Dove, R. (1998). Lady freedom among us. *The Electronic Text Center*. Retrieved June 19, 1998, from Alderman Library, University of Virginia website: http://etext.lib.virginia.edu/subjects/afam.html

Note: If a document is contained within a large and complex website (such as that for a university or a government agency), identify the host organization and the relevant program or department before giving the URL for the document itself. Precede the URL with a colon.

Fredrickson, B. L. (2000, March 7). Cultivating positive emotions to optimize health and well-being. *Prevention & Treatment*, 3, Article 0001a. Retrieved November 20, 2000, from http://journals.apa.org/prevention/volume3/pre0030001a.html

GVU's 8th WWW user survey. (n.d.). Retrieved August 8, 2000, from http://www.cc.gatech.edu/gvu/usersurveys/survey1997-10/

Health Canada. (2002, February). *The safety of genetically modified food crops*. Retrieved March 22, 2005, from http://www.hc-sc.gc.ca/english/protection/biologics_genetics/gen_mod_foods/genmodebk.html

Hilts, P. J. (1999, February 16). In forecasting their emotions, most people flunk out. *New York Times*. Retrieved November 21, 2000, from http://www.nytimes.com

Hypothesis

After having thoroughly researched your question, you should have some educated guess about how things work. This educated guess about the answer to your question is called the hypothesis.

The hypothesis must be 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 you observe-changes in the dependent variable depend on changes in the independent variable)**. In fact, many hypotheses are stated exactly like this: "If a particular independent variable is changed, then there is also a change in a certain dependent variable."

Example Hypotheses

- "If I open the faucet [faucet opening size is the independent variable], then it will increase the flow of water [flow of water is the dependent variable].
- "Raising the temperature of a cup of water [temperature is the independent variable] will increase the amount of sugar that dissolves [the amount of sugar is the dependent variable]."
- "If a plant receives fertilizer [having fertilizer is the independent variable], then it will grow to be bigger than a plant that does not receive fertilizer [plant size is the dependent variable]."
- "If I put fenders on a bicycle [having fenders is the independent variable], then they will keep the rider dry when riding through puddles [the dependent variable is how much water splashes on the rider]."

Note: When you write your own hypothesis you can leave out the part in the above examples that is in brackets [ ].

Notice that in each of the examples it will be easy to measure the independent variables. This is another important characteristic of a good hypothesis. If we can readily measure the variables in the hypothesis, then we say that the hypothesis is **testable**.

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.

Write your hypothesis below *and in your project journal.*

If ____,

then ____,

because ____.

Advanced Topic -- Cause & Effect or Correlation?

In some experiments it is not possible to demonstrate that a change in the independent variable **causes** a change in the dependent variable. Instead one may only be able to show that the independent variable is related to the dependent variable. This relationship is called a **correlation**. One of the most common reasons to see a correlation is that "*intervening* variables are also involved which may give rise to the *appearance* of a possibly direct cause-and-effect relationship, but which upon further investigation turn out to be more directly caused by some other factor".

Advanced Topic -- Is it OK to Disprove Your Hypothesis?

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. Learn more in this essay written by a veteran Science Buddies Adviser, Dr. Bruce Weaver.

Experimental Procedure

Write the **experimental procedure** like a step-by-step recipe for your science experiment. A good procedure is so detailed and complete that it lets someone else duplicate your experiment exactly!

Key Elements of the Experimental Procedure

- Description and size of all experimental and control groups, as applicable
- A step-by-step list of everything you must do to perform your experiment. Think about all the steps that you will need to go through to complete your experiment, and record exactly what will need to be done in each step.
- The experimental procedure must tell how you will change your one and only independent variable and how you will measure that change
- The experimental procedure must explain how you will measure the resulting change in the dependent variable or variables
- If applicable, the experimental procedure should explain how the controlled variables will be maintained at a constant value
- The experimental procedure should specify how many times you intend to repeat your experiment, so that you can verify that your results are reproducible.
- A good experimental procedure enables someone else to duplicate your experiment exactly!

Variables (for Beginners)

Doing a Fair Test

It is important for an experiment to be a **fair test**. You conduct a fair test by making sure that you change one factor at a time while keeping all other conditions the same.

For example, let's imagine that we want to measure which is the fastest toy car to coast down a sloping ramp. If we gently release the first car, but give the second car a push start, did we do a fair test of which car was fastest? No! We gave the second car an unfair advantage by pushing it to start. That's not a fair test! The only thing that should change between the two tests is the car; we should start them down the ramp in exactly the same way.

Let's pretend we're doing an experiment to see if fertilizer makes a plant grow to be larger than a plant that doesn't receive fertilizer. We put seeds of the same kind in three pots with fertilizer and rich soil. But, we run out of soil so we put the seeds without fertilizer in three pots filled with sand. We put all six pots in the same location and water each one with the same amount of water every other day. The plants with soil and fertilizer grow to be much larger than the ones grown in sand without fertilizer. Is that a fair test of whether fertilizer makes a plant grow to be larger? No! We changed two things (type of soil and fertilizer) so we have no idea whether the plants with fertilizer grew to be larger because of the fertilizer or whether the other plants were stunted by being grown in sand. It wasn't a fair test! All of the plants should have been in the same kind of soil.

Conducting a fair test is one of the most important ingredients of doing good, scientifically valuable experiments. To insure that your experiment is a fair test, you must **change only one factor at a time while keeping all other conditions the same**.

Scientists call the changing factors in an experiment **variables**.

Materials List

What type of supplies and equipment will you need to complete your science fair project? By making a complete list ahead of time, you can make sure that you have everything on hand when you need it. Some items may take time to obtain, so making a materials list in advance represents good planning!

Make the materials list as specific as possible, and be sure you can get everything you need before you start your science fair project.

Conducting an Experiment

Preparations

With your detailed experimental procedure in hand, you are almost ready to start your science experiment. But before you begin there are still a few more things to do:

- **Know what to do.** Read and understand your experimental procedure. Are all of the necessary steps written down? Do you have any questions about how to do any of the steps?
- **Get a laboratory notebook** for taking notes and collecting data.
- **Be prepared**. Collect and organize all materials, supplies and equipment you will need to do the experiment. Do you have all of the materials you need? Are they handy and within reach of your workspace?
- **Think ahead about safety!** Are there any safety precautions you should take? Will you need adult supervision? Will you need to wear gloves or protective eye wear? Do you have long hair that needs to be pulled back out of your face? Will you need to be near a fire extinguisher?

Data Table

Prepare a **data table** in your laboratory notebook to help you collect your data. A data table will ensure that you are consistent in recording your data and will make it easier to analyze your results once you have finished your experiment.

During the Experiment

It is very important to take very detailed notes as you conduct your experiments. In addition to your data, record your **observations** as you perform the experiment. Write down any problems that occur, anything you do that is different than planned, ideas that come to mind, or interesting occurrences. Be on the lookout for the unexpected. Your observations will be useful when you analyze your data and draw conclusions.

Keep a laboratory notebook so that all your information is kept in one place (don't use loose-leaf notebooks, you want to make sure all your information stays together). The data that you record now will be the basis for your science fair project final report and your conclusions so capture everything in your **laboratory notebook**, including successes, failures, and accidents.

If possible, take **pictures** of your experiment along the way, these will later help you explain what you did and enhance your display for the science fair.

Remember to use numerical measurements as much as possible. If your experiment also have qualitative data (not numerical), then take a photo or draw a picture of what happens.

Be as exact as possible about the way you conduct your experiment, especially in following your experimental procedure, taking your measurements, and note taking. Failures and mistakes are part of the learning process, so don't get discouraged if things do not go as planned the first time. You should have built enough time in your schedule to allow you to repeat your test a couple of times.

In fact, it's a good idea to do a quick **preliminary run** of your experiment. Show your preliminary data to your mentor or teacher, and make revisions to your experimental procedure if necessary. Often there are glitches in the procedure that are not obvious until you actually perform your experiment--this is normal. If you need to make changes in the procedure (which often happens), write down exactly the changes you made.

Stay organized and be safe! Keep your workspace clean and organized as you conduct your experiment. Keep your supplies within reach. Use protective gear and adult supervision as needed. Keep any chemicals away from pets and younger brothers or sisters.

Data Analysis & Graphs

Conclusions

Your conclusions will summarize whether or not your science fair project results support or contradict your original hypothesis. You may want to include key facts from your background research to help explain your results. Do your results suggest a relationship between the independent and dependent variable?

If Your Results Show that Your Hypothesis is False

If the results of your science experiment did not support your hypothesis, don't change or manipulate your results to fit your original hypothesis, simply explain why things did not go as expected. Professional scientists commonly find that results do not support their hypothesis, and they use those unexpected results as the first step in constructing a new hypothesis. If you think you need additional experimentation, describe what you think should happen next.

Scientific research is an ongoing process, and by discovering that your hypothesis is not true, you have already made huge advances in your learning that will lead you to ask more questions that lead to new experiments. Science fair judges do not care about whether you prove or disprove your hypothesis; they care how much you learned.

Final Report

At this point, you are in the home stretch. Except for writing the abstract, preparing your science fair project final report will just entail pulling together the information you have already collected into one large document.

- Your final report will include these sections:
    - Title page.
    - Abstract. An abstract is an abbreviated version of your final report.
    - Table of contents.
    - Question, variables, and hypothesis.
    - Background research. This is the Research paper you wrote before you started your experiment.
    - Materials list.
    - Experimental procedure.
    - Data analysis and discussion. This section is a summary of what you found out in your experiment, focusing on your observations, data table, and graph(s), which should be included at this location in the report.
    - Conclusions.
    - Ideas for future research. Some science fairs want you to discuss what additional research you might want to do based on what you learned.
    - Acknowledgements. This is your opportunity to thank anyone who helped you with your science fair project, from a single individual to a company or government agency.
    - Bibliography.
- Write the abstract section last, even though it will be one of the first sections of your final report.

- Your final report will be several pages long, but don't be overwhelmed! Most of the sections are made up of information that you have already written. Gather up the information for each section and type it in a word processor if you haven't already.

- ***Save your document often!*** You do not want to work hard getting something written the perfect way, only to have your computer crash and the information lost. Frequent file saving could save you a lot of trouble!

- Remember to do a spelling and grammar check in your word processor. ***Also, have a few people proof read your final report.*** They may have some helpful comments!

Writing an Abstract

An **abstract** is an abbreviated version of your science fair project final report. For most science fairs it is limited to a maximum of 250 words. The science fair project abstract appears at the beginning of the report as well as on your display board.

Almost all scientists agree that an abstract should have the following five pieces:

- **Introduction**. This is where you describe the purpose for doing your science fair project or invention. Why should anyone care about the work you did? You have to tell them why. Did you explain something that should cause people to change the way they go about their daily business? If you made an invention or developed a new procedure how is it better, faster, or cheaper than what is already out there? **Motivate** the reader to finish the abstract and read the entire paper or display board.

- **Problem Statement**. Identify the problem you solved or the hypothesis you investigated.

- **Procedures**. What was your approach for investigating the problem? Don't go into detail about materials unless they were critical to your success. Do describe the most important variables if you have room.

- **Results**. What answer did you obtain? Be specific and use numbers to describe your results. Do not use vague terms like "most" or "some."

- **Conclusions**. State what your science fair project or invention contributes to the area you worked in. Did you meet your objectives? For an engineering project state whether you met your design criteria.

Why Is an Abstract Important?

Your science fair project abstract lets people quickly determine if they want to read the entire report. Consequently, at least ten times as many people will read your abstract as any other part of your work. It's like an advertisement for what you've done. If you want judges and the public to be excited about your science fair project, then write an exciting, engaging abstract!

Since an abstract is so short, each section is usually only one or two sentences long. Consequently, every word is important to conveying your message. If a word is boring or vague, refer to a thesaurus and find a better one! If a word is not adding something important, cut it! But, even with the abstract's brief length, don't be afraid to reinforce a key point by stating it in more than one way or referring to it in more than one section.

How to Meet the Word Limit

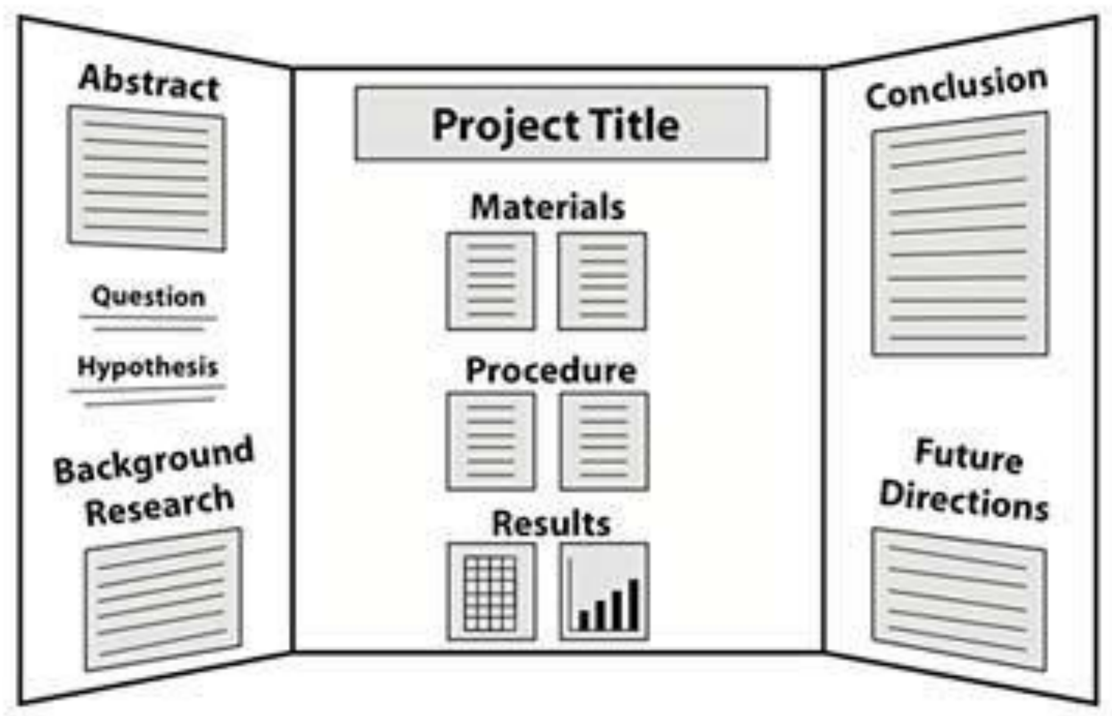
Most authors agree that it is harder to write a short description of something than a long one. Here's a tip: for your first draft, don't be overly concerned about the length. Just make sure you include all the key information. Then take your draft and start crossing our words, phrases, and sentences that are less important than others. Look for places where you can combine sentences in ways that shorten the total length. Put it aside for a while, then come back and re-read your draft. With a fresh eye, you'll probably find new places to cut. Before you know it you will have a tightly written abstract.

Example Abstract

Advertisers are always touting more powerful and longer lasting batteries, but which batteries really do last longer, and is battery life impacted by the speed of the current drain? This project looks at which AA battery maintains its voltage for the longest period of time in low, medium, and high current drain devices. The batteries were tested in a CD player (low drain device), a flashlight (medium drain device), and a camera flash (high drain device) by measuring the battery voltage (dependent variable) at different time intervals (independent variable) for each of the battery types in each of the devices. My hypothesis was that Energizer would last the longest in all of the devices tested. The experimental results supported my hypothesis by showing that the Energizer performs with increasing superiority, the higher the current drain of the device. The experiment also showed that the heavy-duty non-alkaline batteries do not maintain their voltage as long as either alkaline battery at any level of current drain.

Display Board

For almost every science fair project, you need to prepare a **display board** to communicate your work to others. In most cases you will use a standard, three-panel display board that unfolds to be 36" tall by 48" wide.



Science Fair Judging

- Preparing for **Science Fair Judging**— Practice Makes Perfect!
    - If you can communicate your science fair project well, you maximize your chances of winning.
    - Write up a short "speech" (about 2–5 minutes long) summarizing your science fair project. You will give this speech when you first meet the judges. (Remember to talk about the theory behind your science fair project-why your project turns out the way it does.)
    - Organize a list of questions you think the judges will ask you and prepare/practice answers for them. Practice explaining your science fair project to others and pretend they are judges.
    - Practice explaining your science fair project in simple terms so anyone can understand it.

- Presenting yourself during the science fair judging period-be professional!
    - Always dress nicely for the science fair judging period

- Make good use of your display board. Point to diagrams and graphs when you are discussing them.
- Always be positive and enthusiastic!
- Be confident with your answers; do not mumble.
- If you have no idea what the judge is asking, or do not know the answer to their question, it is okay to say "I do not know."
- Treat each person who visits you like a judge, even nonscientists.
- *After* the science fair, always ask for feedback from the judges to improve your project.

Name: **Sample Research Paper**

Date

Which Battery Is Better?

Abstract

Advertisers are always touting more powerful and longer lasting batteries, but which batteries really do last longer, and is battery life impacted by the speed of the current drain? This projects looks at which AA battery maintains its voltage for the longest period of time in low, medium, and high current drain devices. The batteries were tested in a CD player (low drain device), a flashlight (medium drain device), and a camera flash (high drain device) by measuring the battery voltage (dependent variable) at different time intervals (independent variable) for each of the battery types in each of the devices. My hypothesis was that Energizer would last the longest in all of the devices tested. The experimental results supported my hypothesis by showing that the Energizer performs with increasing superiority, the higher the current drain of the device. The experiment also showed that the heavy-duty non-alkaline batteries do not maintain their voltage as long as either alkaline battery at any level of current drain.

Question

Which AA battery maintains its voltage for the longest period of time in low, medium, and high current drain devices?

Variables

Independent Variable: Time, how long each battery operates.

Dependent Variable: Voltage.

Table 1

Variables

Experimental Group	Controlled Variables for Each Group
Low current drain	Same portable CD player Play the same music track Play at the same volume level
Medium current drain	Identical flashlight Identical light bulb
High current drain	Same camera flash
All groups	Battery size (AA) Constant temperature (A battery works better at a warm temperature.)

Hypothesis

As I test for increasingly long periods of time, the Energizer AA battery will maintain a higher voltage than other batteries.

Background Research

Batteries come in many shapes and sizes. Some are no larger than a pill while others are too heavy to lift, but most batteries have one thing in common-they store chemical energy and change it into electrical energy. The cell is the basic unit that produces electricity. A battery has 2 or more cells, but people often use the word battery when talking about a single cell, too, like a dry cell. A dime-sized battery in a watch is a cell. Cells act like pumps to force electrons to flow along conductors (DK Science 150).

“The electrical force of a cell or battery is called its electromotive force (emf). This force, which makes electrons flow around a circuit, is measured in units called volts (v.). Each kind of cell has a particular emf. A dry cell, for example, has an emf of 1.5 volts” (DK Science 150).

Another way to measure a battery is by how much current it can provide. Current measures how many electrons flow through the cell. The unit used to measure current is amps.

A common cell has several important parts: the positive terminal and electrode, the negative terminal and electrode, and the electrolyte, which is between the two electrodes. The positive electrode is made out of a carbon rod. Powdered carbon and manganese oxide prevents hydrogen from forming on the carbon rod, which would stop the cell from working normally. The negative electrode is made out of zinc, which serves, as a case for the cell. Electrons flow from the negative terminal through a wire in the device the battery is powering into the positive terminal (Learning Center).

The most common cell is the dry cell and different types have different types of electrolytes. The dry cell works like the cell invented by the French engineer Georges Leclanche in 1865. His cell had a liquid electrolyte, but in the modern version the electrolyte is ammonium chloride paste (DK Science 150). Ordinary dry cells are used in most flashlight batteries. These dry cells use ammonium chloride as the electrolyte. "Cells needed to supply heavier currents use zinc chloride. Alkaline cells, which last longer and can supply even heavier currents, use the alkali potassium hydroxide" (DK Science 150).

Most flashlights take two or more dry cells. Cells are connected in series one after another. Large powerful flashlights may take four or more cells. The size of a cell has no effect on its emf. The chemicals in the cell determine its emf, but large cells last longer than small cells of the same basic type.

How long a battery lasts also depends on how it's used. Two batteries may last the same length overall but one might maintain higher voltage over more of its lifetime, in a sense providing better quality. A high powered device such as a motorized toy running constantly takes more current than a less power hungry device such as a personal stereo that alternately runs and rests. Batteries also don't perform as well at low temperatures (Best Batteries 71).

As you use a battery, its emf drops. You can consider an alkaline battery dead at 0.9 volts. The paper you are reading is posted as an example on the Science Buddies website.

In order to work well in high drain devices you need to make the shell of the battery thinner so it can hold more electrons and deliver more current (Booth 127).

Companies have made improvements in their batteries so they are better in high drain devices. A high drain device is a thing that takes a lot of current. Low drain devices would include CD and cassette players and related devices. "Eveready meanwhile quantifies the power requirements as 400 to 800 mA for halogen lamps; 400-1000 mA for cellular phones; and 500-900 mA for camcorders. Digital cameras are in the 800-1200 mA range, while photoflash units are the thirstiest of all-1000 to 2000 mA according to Eveready" (Booth 127).

Materials List

- CD player & a CD (low drain device)
- Three identical flashlights (medium drain device)
- Camera flash (high drain device)
- AA size Duracell and Energizer batteries
- AA size of a "heavy-duty" (non-alkaline) battery (I used Panasonic)
- Voltmeter & a AA battery holder
- Kitchen timer

Experimental Procedure

1. Number each battery so you can tell them apart.
2. Measure each battery's voltage by using the voltmeter.
3. Put the same battery into one of the devices and turn it on.
4. Let the device run for thirty minutes before measuring its voltage again. (Record the voltage in a table every time it is measured.)
5. Repeat #4 until the battery is at 0.9 volts or until the device stops.
6. Do steps 1-5 again, three trials for each brand of battery in each experimental group.
7. For the camera flash push the flash button every 30 seconds and measure the voltage every 5 minutes.
8. For the flashlights rotate each battery brand so each one has a turn in each flashlight.
9. For the CD player repeat the same song at the same volume throughout the tests.

Data Analysis and Discussion

Table 2

Flashlights: Energizer Batteries

Battery #	**3**	**4**		**19**	**20**		**31**	**32**		
Time (hrs)	**Voltage (v)**	**Voltage (v)**	**Dead?**	**Voltage (v)**	**Voltage (v)**	**Dead?**	**Voltage (v)**	**Voltage (v)**	**Dead?**	**Avg Voltage (v)**
0.0	1.605	1.610		1.607	1.609		1.604	1.605		1.607
0.5				1.396	1.402		1.400	1.412		1.403
1.0	1.356	1.363		1.343	1.351		1.354	1.360		1.355
1.5				1.307	1.314		1.318	1.327		1.317
2.0	1.295	1.295		1.280	1.288		1.304	1.311		1.296
2.5	1.273	1.280		1.267	1.284		1.268	1.278		1.275
3.0	1.260	1.265		1.255	1.262		1.261	1.267		1.262
3.5	1.249	1.256		1.245	1.247		1.247	1.252		1.249
4.0				1.226	1.232		1.230	1.238		1.232
4.5	1.221	1.226		1.206	1.216		1.212	1.224		1.218
5.0				1.197	1.204		1.196	1.210		1.202
5.5	1.160	1.186		1.170	1.178		1.177	1.190		1.177
6.0				1.128	1.150		1.174	1.184		1.159
6.5	1.108	1.135		1.085	1.117		1.132	1.144		1.120
7.0	0.630	1.120	Yes	1.012	1.063		1.125	1.137		1.015
7.5				0.515	0.586	Yes	1.063	1.095		0.815
8.0							0.609	0.900	Yes	0.755

[Note: This table is only one of many completed for this project.]

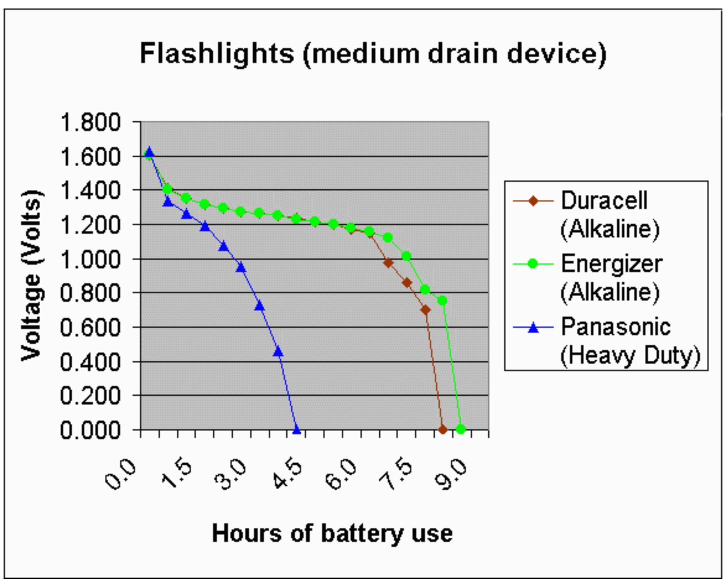


Fig. 1. Graph of voltage vs. hours of battery use in flashlights for three brands of batteries.

[Note: This graph is one of three that the student prepared.]

According to my experiments, the Energizer maintained its voltage (dependent variable) for approximately a 3% longer period of time (independent variable) than Duracell in a low current drain device. For a medium drain device, the Energizer maintained its voltage for approximately 10% longer than Duracell. For a high drain device, the Energizer maintained its voltage for approximately 29% longer than Duracell. Basically, the Energizer performs with increasing superiority, the higher the current drain of the device.

The heavy-duty non-alkaline batteries do not maintain their voltage as long as either alkaline battery at any level of current drain.

Conclusions

My hypothesis was that Energizer would last the longest in all of the devices tested. My results do support my hypothesis.

I think the tests I did went smoothly and I had no problems, except for the fact that the batteries recover some of their voltage if they are not running in something. Therefore, I had to take the measurements quickly.

An interesting future study might involve testing the batteries at different temperatures to simulate actual usage in very cold or very hot conditions.

Acknowledgements

I would like to thank my teacher Mrs. Garmon, and my father who let me take over his workshop while I worked on my experiment.

Works Cited

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"Best Batteries." *Consumer Reports Magazine* 32 Dec. 1994: 71-72.

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"Cells and Batteries." *The DK Science Encyclopedia*. 1993.

"Fun Learning." The Gillette Company. 24 Jan. 1999 <http://www.duracell.com/Fun_Learning/index.html>.

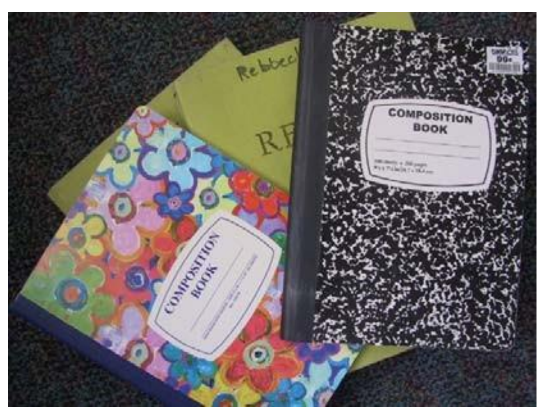
"Learning Center." Eveready Battery Company, Inc. 24 Jan. 1999 <http://www.energizer.com/learning/default.asp>.

What Makes a Great Science Lab Notebook?

Joanne Rebbeck, Ph.D.
February 24, 2005

Whether you are a research scientist or a first-time science fair student, a lab notebook 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 lab notebook is proof that certain activities occurred at specific times. Journals and lab notebooks 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!

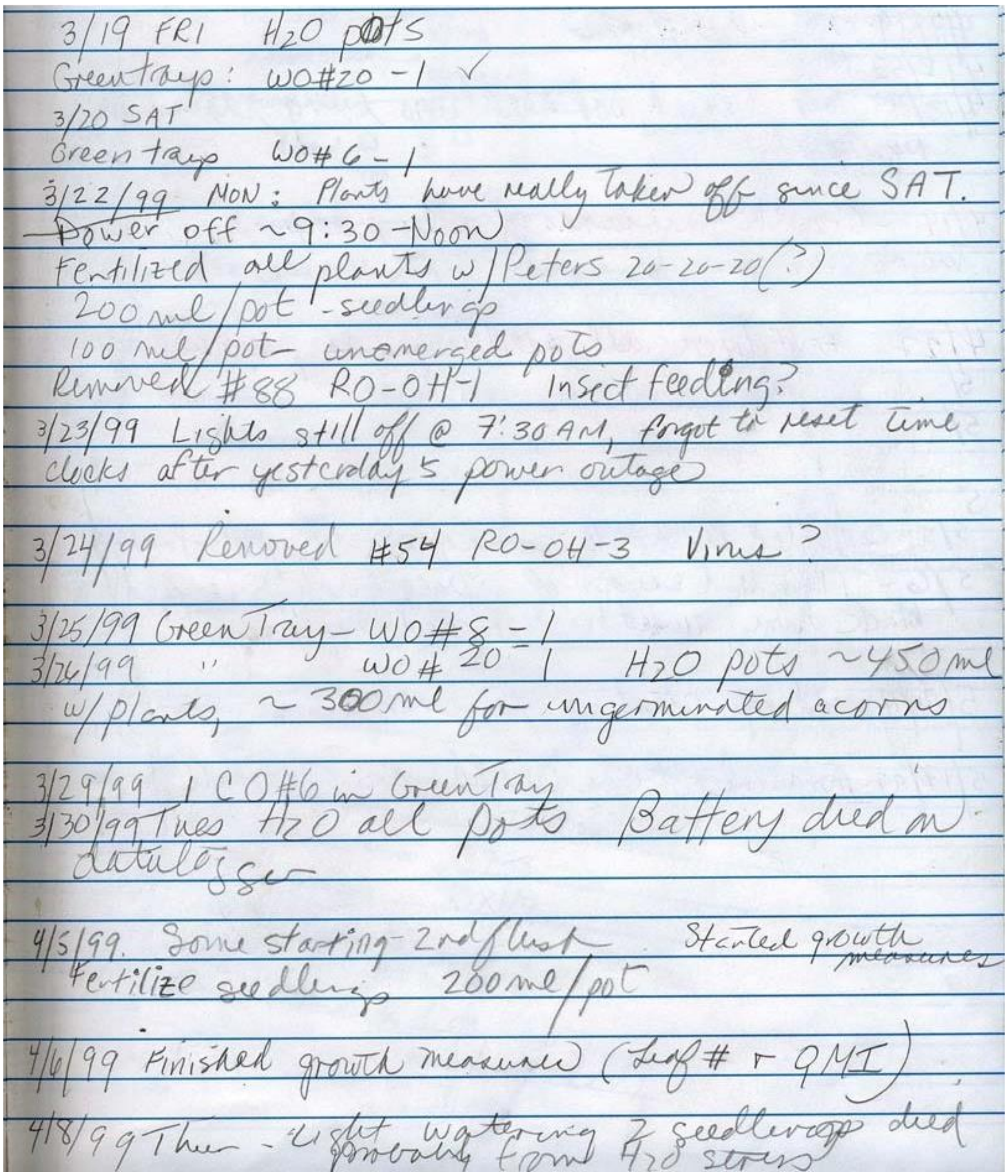


1. **Find a durable hard-bound notebook or black and white composition book**, typically a lined journal works great. Do not attempt to use a spiral bound notebook. They won't hold up over the course of your experiment. Papers are too easily removed or torn from them, and before you realize it, important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

2. **Label your lab notebook** with your name, phone number, email address, and teacher's name in a prominent location. Make lab notebook 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 lab notebook 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.

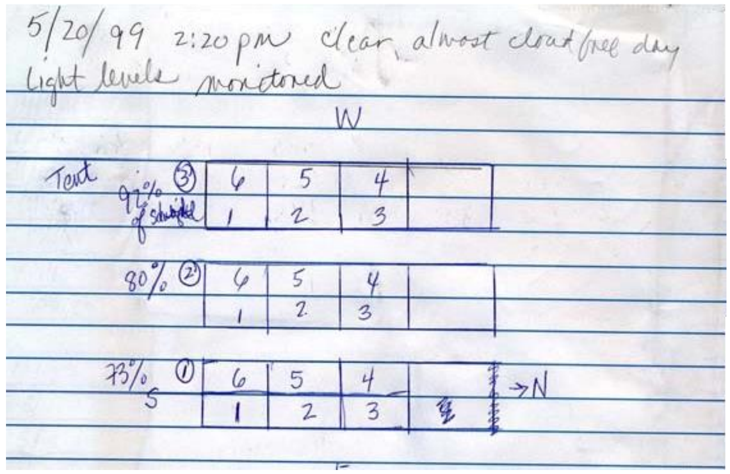

3/19 FRI H_2O pots
Green tray: WO#20 – 1 ✓
3/20 SAT
Green tray WO#6 – 1
3/22/99 MON: Plants have really taken off since SAT.
– Power off ~9:30 – Noon
Fertilized all plants w/ Peters 20-20-20 (?)
200 ml/pot – seedlings
100 ml/pot – unemerged pots
Removed #88 RO-OH-1 Insect feeding?
3/23/99 Lights still 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 H_2O pots ~450 ml w/ plants, ~300 ml for ungerminated acorns
3/29/99 1 CO#6 in Green Tray
3/30/99 Tues H_2O all pots Battery died on datalogger
4/5/99. Some starting 2nd flush Started growth measures
Fertilize seedlings 200 ml/pot
4/6/99 Finished growth measures (Leaf # + QMI)
4/8/99 Thur – Light watering 2 seedlings died probably from H_2O stress

Lab notebook entry of observations made while watering planted oak acorns in greenhouse

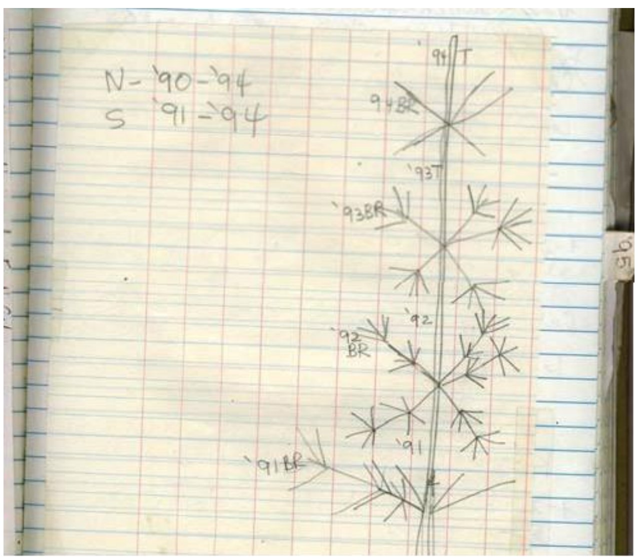
5. **Don't worry about neatness**. It's a personal record of your work. Do not re-do your lab notebook because it looks sloppy. Think of the lab notebook as your

"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



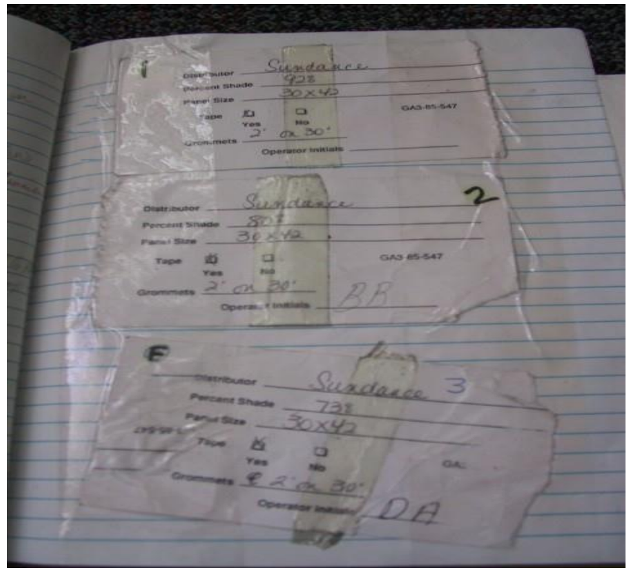
Hand drawing showing different ages of tree branches that were sampled during an experiment

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 lab notebook**. Make a table of contents, index, and create tabs for different sections within your lab notebook. 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.

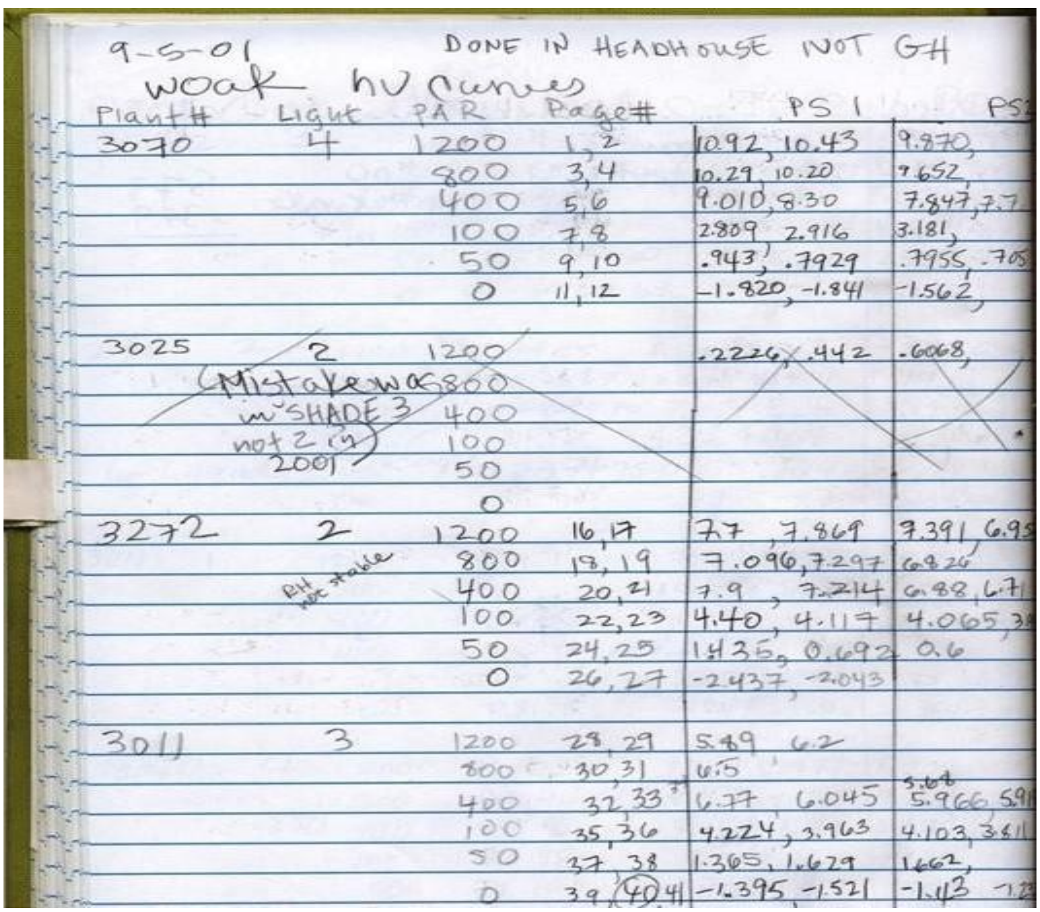
Table of Contents	Tab color	Page #
Deadline Schedule	Red	1
Daily Notes & Reflections	White	2
Background Research Library & Internet	Blue	20
Information Contacts, Supply sources	Green	26
Experimental Setup	Yellow	35
Data collection	Purple	40
Results (pictures, graphs, summary tables)	Orange	50
Reflections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

10. **Include a reflections section in your lab notebook.** 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 lab notebook. If that is not possible, then staple photocopies of data in the lab notebook.

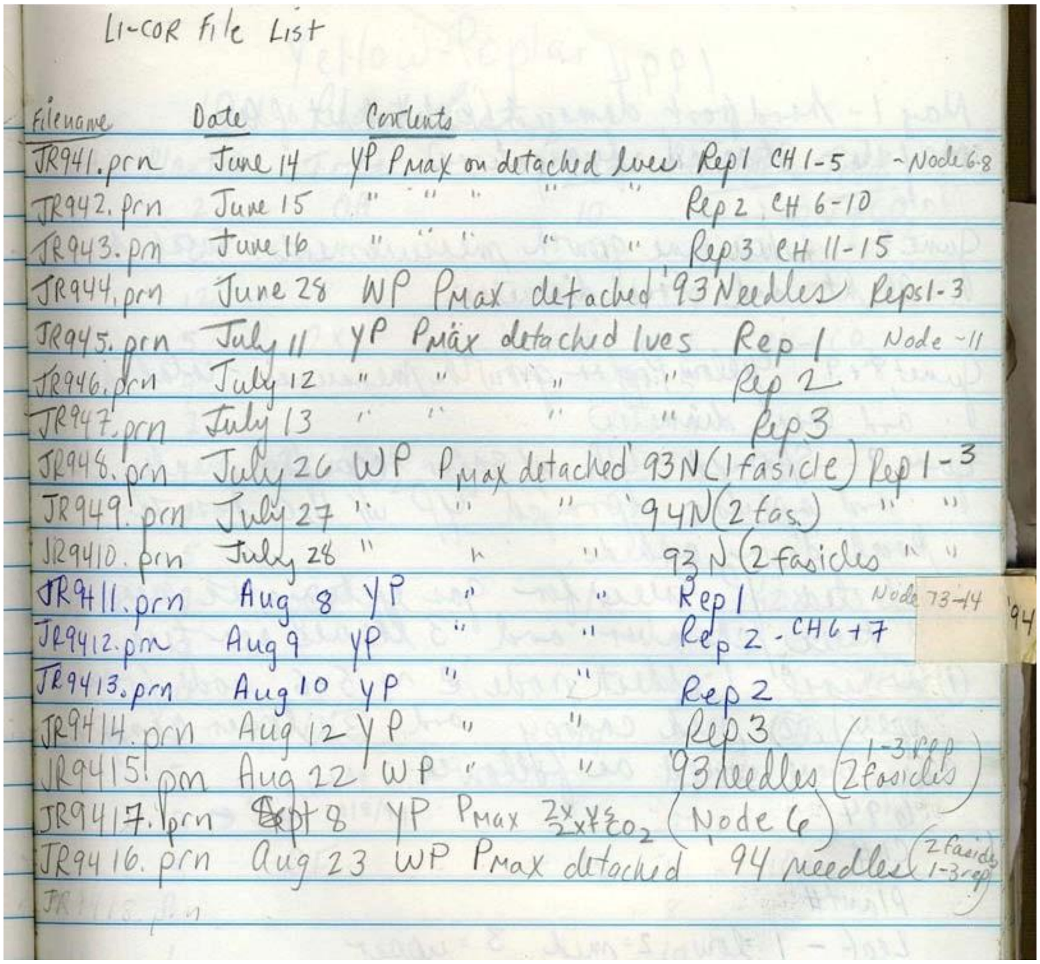


9-5-01 DONE IN HEADHOUSE NOT GH

woak hv curves

Plant#	Light	PAR	Page#	PS1	PS2
3070	4	1200	1,2	10.92, 10.43	9.870,
		800	3,4	10.29, 10.20	7.652,
		400	5,6	9.010, 8.30	7.847, 7.7
		100	7,8	2.809, 2.916	3.181,
		50	9,10	.943, .7929	.7955, .70
		0	11,12	-1.820, -1.841	-1.562,
3025	2	1200		.2226, .442	.6068,
(Mistake was in SHADE 3 not 2 (9) 2001)		800			
		400			
		100			
		50			
		0			
3272	2	1200	16,17	7.7, 7.869	7.391, 6.95
	pH not stable	800	18,19	7.096, 7.297	6.826
		400	20,21	7.9, 7.214	6.88, 6.7
		100	22,23	4.40, 4.117	4.065, 3
		50	24,25	1.435, 0.692	0.6
		0	26,27	-2.437, -2.043	
3011	3	1200	28,29	5.49, 6.2	
		800	30,31	6.5	
		400	32,33	6.77, 6.045	5.64 5.966, 5.9
		100	35,36	4.224, 3.963	4.103, 3.61
		50	37,38	1.365, 1.629	1.662,
		0	39,40,41	-1.395, -1.521	-1.43, -1.2

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


LI-COR File List

Filename	Date	Contents
JR941.prn	June 14	YP PMax on detached lves Rep1 CH 1-5 ~Node 6-8
JR942.prn	June 15	" " " " " Rep 2 CH 6-10
JR943.prn	June 16	" " " " " Rep 3 CH 11-15
JR944.prn	June 28	WP PMax detached 93 Needles Reps 1-3
JR945.prn	July 11	YP PMax detached lves Rep 1 Node ~11
JR946.prn	July 12	" " " " Rep 2
JR947.prn	July 13	" " " " Rep 3
JR948.prn	July 26	WP PMax detached 93N (1 fasicle) Rep 1-3
JR949.prn	July 27	" " " 94N (2 fas.) " "
JR9410.prn	July 28	" " " 93N (2 fasicles " "
JR9411.prn	Aug 8	YP " " Rep 1 Node 73-14
JR9412.prn	Aug 9	YP " " Rep 2 - CH6+7
JR9413.prn	Aug 10	YP " " Rep 2
JR9414.prn	Aug 12	YP " " Rep 3
JR9415.prn	Aug 22	WP " " 93 needles (2 fasicles) (1-3 rep)
JR9417.prn	Sept 8	YP PMax 2x x ... (Node 6)
JR9416.prn	Aug 23	WP PMax detached 94 needles (2 fasicles 1-3 rep)

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

Remember, keeping up a great lab notebook throughout the entire duration of the science project really pays off later! Not only will a nicely maintained lab notebook 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.