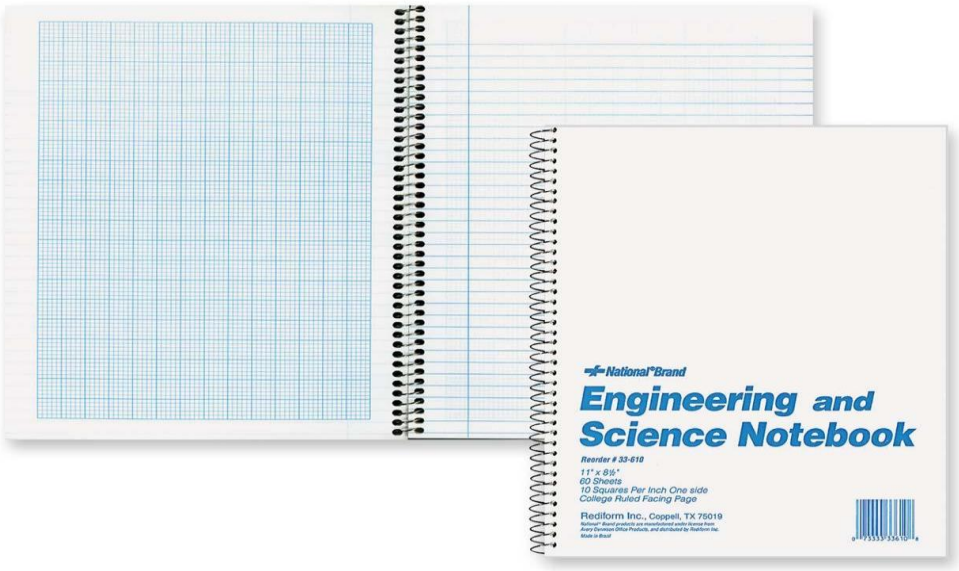
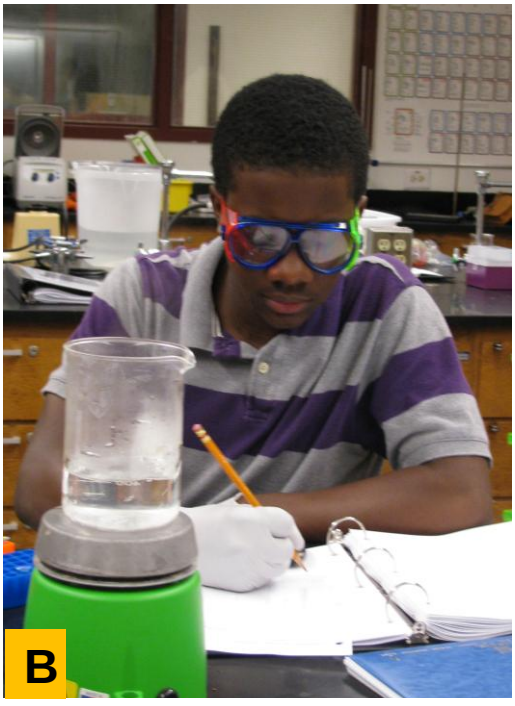
Last Modified July 11, 2012



A

How to Organize a Lab Notebook

Life on the Edge



B

C

Acknowledgements

NASA Astrobiology Institute
Georgia Institute of Technology Center for Ribosomal Origins and Evolution
Georgia Intern Fellowships for Teachers Program
National Science Foundation Research Experiences for Undergraduates Program
Georgia Institute of Technology Center for Education Integrating Science, Mathematics, and Computing

Editors
Dr. Jamila Cola, Georgia Institute of Technology
Dr. Loren Dean Williams, Georgia Institute of Technology School of Chemistry and Biochemistry

Authors
Ms. Aakanksha Angra, Georgia Institute of Technology, Biology Undergraduate Student
Ms. Jannetta Greenwod, Dunwoody High School Teacher

Designers
Mr. Anthony Docal, Orbit Education Inc.
Ms. Aakanksha Angra, Georgia Institute of Technology, Biology Undergraduate Student
Mr. Timothy Whelan, Georgia Institute of Technology, Distance Learning and Professional Education

Photography Credits:

A. Picture of a lab notebook.
B. Picture of a student taking notes.
C. Picture of another student recording data.

National Standards Correlation

Life Science Content Standard C

Picture of a lab notebook.

Understanding Scientific Inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- Scientists review and ask questions about the results of other scientists' work.

Picture of DNA structure

Overview

Purpose: The lab notebook will serve as an organizational tool of ideas for the student's lab experiments.

Key Concepts

- Students will learn how to maintain an up-to-date laboratory notebook with experiments sufficient in detail so that they can be replicated by others.

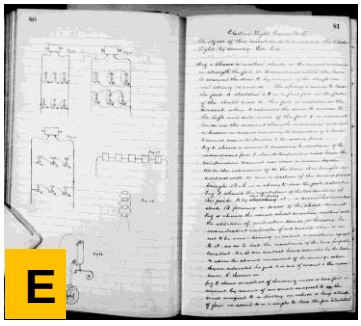
Common Misconceptions

- Taking notes is not necessary.
- Results can be replicated from memory.

Prep Time: 0 minutes
Class Time: 45-60 minutes

Teacher's Note: To make this an exciting, interactive activity, start off by giving students examples of how scientific discoveries happened because of careful notes and observations. Then, tell them that they will be learning to keep a scientific lab notebook. Next, give them the student discussion sheet and allow them to work in small groups to come up with answers. After about 5 minutes of discussion time, give them the student handout, and go over the proper way to organize a notebook.

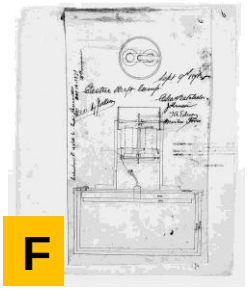
Famous Lab Notebooks



Many great discoveries have been made because scientists in the past kept good notes on their observations, experiments, successes, and failures. Because of their diligence in keeping good records, we have had the privilege of enjoying many modern inventions.
Some of the popular lab notebooks have been by Thomas Edison(See pictures E and F) and Leonardo Da Vinci(Picture G). If it wasn't for their scientific creativity and knowledge, we would not have incandescent light bulbs that burn for countless hours, phonographs to record phone conversations, letter writing and dictation, music boxes, etc. We also have to be thankful for Da Vinci's countless contributions to physics, flight, anatomy, and art.

Additional Resources
Writing the Laboratory Notebook by Howard Kanare
http://www.eric.ed.gov/PDFS/ED344734.pdf

Thomas Edison's Lab Notebook
http://edison.rutgers.edu/NamesSearch/SingleDoc.php3?DocId=NE1695081


F


G

Group Discussion Worksheet (Pre-lecture) with Answer Key

1. What is the importance of having a lab notebook?

   A lab notebook is the main record of research. Scientists in all fields of science and engineering, document their projects by documenting their purpose, hypotheses, experiments, data/observations, results, conclusions and future experiments. Maintaining an organized notebook allows scientists to go back and replicate their experiments, obtain accurate data trials, and allow them to refer back to any notes they took during the experiment so that they can talk about in their final paper and presentations.

   All observations and notes made in the notebook must be honest. Take notes on what you observe and not what you think you will observe in the future. If someone wants to replicate your experiment, they will first look at your lab notebook for details on how to do an experiment. Even if you do not get good data, document it! Science is not about getting the right answers. It is about exploring all the wrong answers first and then finally settling on one answer. If your experiment does not work, do not get discouraged and make up your data! Instead, keep notes on what happens and make improvements to your future experiments.

2. Why should I care about keeping a lab notebook?

   As high school students, participation in science competitions and authentic research are looked favorably upon during college and scholarship application processes. Part of the authentic research process is keeping an excellent lab notebook. During your high school career, you will be assigned to work on an independent inquiry-based group project. You will be required to take good, detailed notes that document every step in your project. Alongside this inquiry-based project you will also be exposed to a variety of different scientific experiments, tools, and techniques. It is in your benefit to make good notes so that you can present your project to your class and maybe even expand upon it for a great science fair project!

3. How should I organize my lab notebook?

Make sure to have a table of contents and everything from 7a-k (see below)

4. What three things should go on the first page of your lab notebook?
    a. Your name
    b. Title of your project
    c. School/Institution's Name
5. How should the Table of Contents be divided?
   Date, title, and page number. See example provided.

6. What is the importance of the following words/concepts? Why do you need to include these?
    a. Date-allows you to organize your notebook by date.

    b. Lab Title- tells you what the lab will be about.

    c. Background Information- Gives you insight on the major concepts covered in the lab. This is also a good place to take notes given by your teacher.

    d. References- It is important to cite sources that you get your information from. Not doing so is known as plagiarism and it can have serious consequences. Use the following website as a reference http://www.easybib.com/

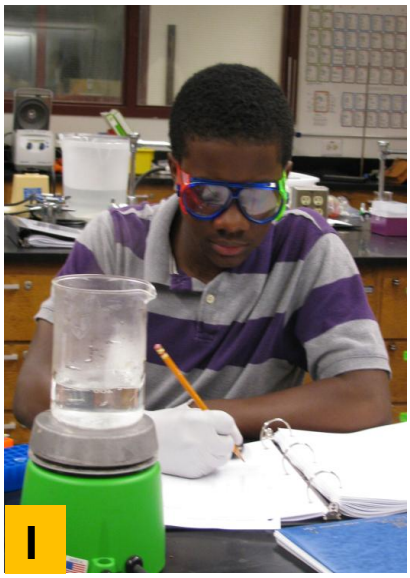
    e. Purpose-This tells you the importance and the reason behind your experiment.
    f. Hypothesis- This is where you write an educated guess predicting the outcome of your experiment.
    g. Experiment- The experimental protocol. This should have all of the steps you followed in a sequential order. In this portion, you should also have your list of materials. That you used in order to carry out your experiment.
    h. Data -Collect qualitative (non-numerical data ex. color, texture, etc.) and quantitative(numerical data ex. height, weight, etc.) data in your lab notebook. You may organize your data into a table. You many also insert any pictures from your experiment here.
    i. Results- Results are displayed in a graphical format. Be sure to include a title, descriptive axes, legend, and a brief caption describing what trends you notice.
    j. Conclusions- Draw any conclusions from your experiment. Also mention possible errors in the data and next steps in your project.
    k. Page Number-Label all of your pages and record them in the table of contents. This keeps all of your data organized.

What is the importance of having a lab notebook?

A lab notebook is the main record of research. Scientists in all fields of science and engineering, document their projects by documenting their purpose, hypotheses, experiments, data/observations, results, conclusions and future experiments. Maintaining an organized notebook allows scientists to go back and replicate their experiments, obtain accurate data trials, and allow them to refer back to any notes they took during the experiment so that they can talk about in their final paper and presentations.

All observations and notes made in the notebook must be honest. Take notes on what you observe and not what you think you will observe in the future. If someone wants to replicate your experiment, they will first look at your lab notebook for details on how to do an experiment. Even if you do not get good data, document it! Science is not about getting the right answers. It is about exploring all the wrong answers first and then finally settling on one answer. If your experiment does not work, do not get discouraged and make up your data! Instead, keep notes on what happens and make improvements to your future experiments.

Why should I care about keeping a lab notebook?



Pictures H and I- Student taking notes and recording their observations.

As high school students, participation in science competitions and authentic research are looked favorably upon during college and scholarship application processes. Part of the authentic research process is keeping an excellent lab notebook. During your high school career, you will be assigned to work on an independent inquiry-based group project. You will be required to take good, detailed notes that document every step in your project. Alongside this inquiry-based project you will also be exposed to a variety of different scientific experiments, tools, and techniques. It is in your benefit to make good notes so that you can present your project to your class and maybe even expand upon it for a great science fair project!

Teacher's Note: For visual learners, you may have to draw this out on the board

How should I organize my lab notebook?

Page 1- Title of the project/camp, your name, institute at which you are conducting the research.

Example:	*NASA Astrobiology Summer Camp, 2011* *John Doe* *Georgia Institute of Technology, Atlanta GA, 30332*

Page 2- Table of Contents at the top of the page. Then sub-divided into 3 columns: Date, Title of lab, Page number.

Example:

Table of Contents

Date	***Title***	***Page Number***
6/24/2011	*What is Life?*	*3*
6/24/2011	*Final Project-Research*	*5*
6/25/2011	*Final Project-Data Collection Day 1*	*12*

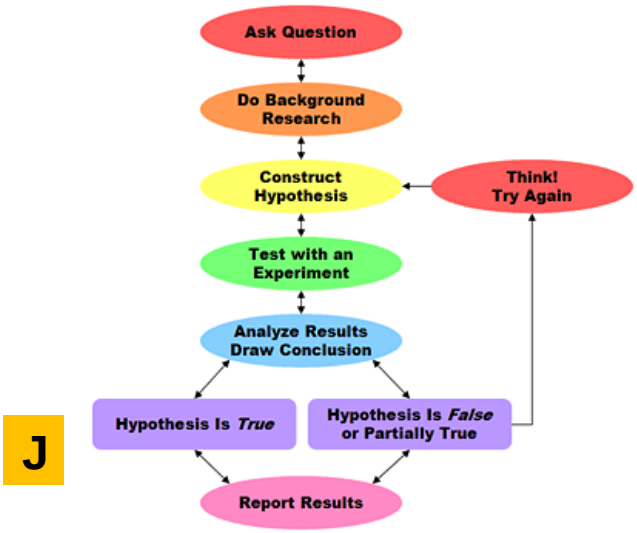
Lab Entries- Each lab entry should have the following:

Date
Lab Title
Background Information- You may take notes on the lectures that the professor gives, or any lab introductions.
References- It is important to cite sources that you get your information from. Use the following website as a reference http://www.easybib.com/
Purpose- Write 1-2 sentences about today's lab and why you think this is important.
Hypothesis- Write 1-2 sentences about what you think will happen. Identify your controls (if any), and your variables. You do not have to write a hypothesis if you feel that it is not appropriate.
Experiment- You may attach the experimental protocol into your notebook.
Data- Collect qualitative (non-numerical data ex. color, texture, etc.) and quantitative(numerical data ex. height, weight, etc.) data in your lab notebook. You may organize your data into a table. You many also insert any pictures from your experiment here.
Results- Display your data in tables or graphs.
Conclusions- Draw any conclusions from your experiment. Also mention possible errors in the data and next steps in your project.
Page Number-Clearly label the page number at the bottom of each page and document it in the table of contents.

Teacher's Note: As you are going through each requirement, it might be a good idea to review with your class what a hypothesis is, variables, experiments etc. See below for details.

Review with your class the scientific method.

Scientific Method



Question: A good question is based on observations. It addresses who, what, which, how, when, and why.

Background Research: Talk to your class about doing a web search by using various computer programs, such as google scholar, local school website, etc. The background research should be very thorough so that a person not in the field of science can easily understand the research topic and the following experiment and results.

Hypothesis: A hypothesis is usually a one-sentence statement that says how the problem will be solved and the expected result. A hypothesis can be written in an "if [I do this] __, then [this will happen]___" format. The statement after "if" is the independent variable, and the statement after "then" is the dependent variable.

An **independent variable** is the one that can be manipulated.
A **dependent variable** is the one that is measured during an experiment. It responds to the independent variable, hence it is "dependent".
A **control variable** is one that remains constant throughout the experiment. It serves as a baseline for comparison with the other treatments.
A **positive control** is one that gives the known desired result. It can be a source of comparison with the other independent variables.

A **negative control** is one that does not give the desired result. In most cases the negative control also serves as the control.

Example: You want to test the effect of different beverages on the activity level (exhibited by the number of jumps) of 5-year old children. In this scenario, your independent variables are the different beverages[water, coffee, coca-cola, sprite, cranberry juice], and your dependent variable is the number of jumps. You can manipulate the type and amount of the drink. Your control can be water. Your positive control can be coffee because you know that it will make the 5-year olds the most active. Your negative control is water since it does not produce any desired results.

An **alternative hypothesis (H_a)** is one that states actually what you will be testing.
A **null hypothesis (H_o)** shows that there is no difference between treatments, and that all differences are due to chance alone.

Example: H_a= If children consume drinks in high amounts of caffeine, then they will exhibit high levels of activity.

H_o= There will be no difference between the variety of drinks consumed and the energy level exhibited by the children.

Teacher's Note: After going through the definitions with your students, you may want to present them with this sample experiment. For an additional exercise, have the students break into groups and come up with their own experiment with variables, alternative and null hypothesis.

Experiment: Conduct an experiment to test your hypothesis. An experiment starts off with a detailed list of materials and methods. Write a detailed step by step process with all your calculations and exactly how your experiment will be carried out.

Example: Test group of 5-year old children: 20 boys and 20 girls.

Observe and monitor the activity of 5-year old children for 30 minutes before administering the treatment. Divide the 40 children into 5 groups of 8 students each. Give each group 8 fl oz. of a different drink. Make sure they all drink everything at the same time and monitor their physical activity level. Record their temperaments every 5 minutes. You may have to break up the groups in order to get accurate observations.

Collect Data: Make a neat and orderly table with all your data. See below.

Example: The table below shows a chart for a sample experimental treatment. The students may use this type of chart organizer when evaluating multiple treatments.

Table 1: Shows the number of jumps displayed by each child in the positive control treatment, coffee. The children were observed over an hour.

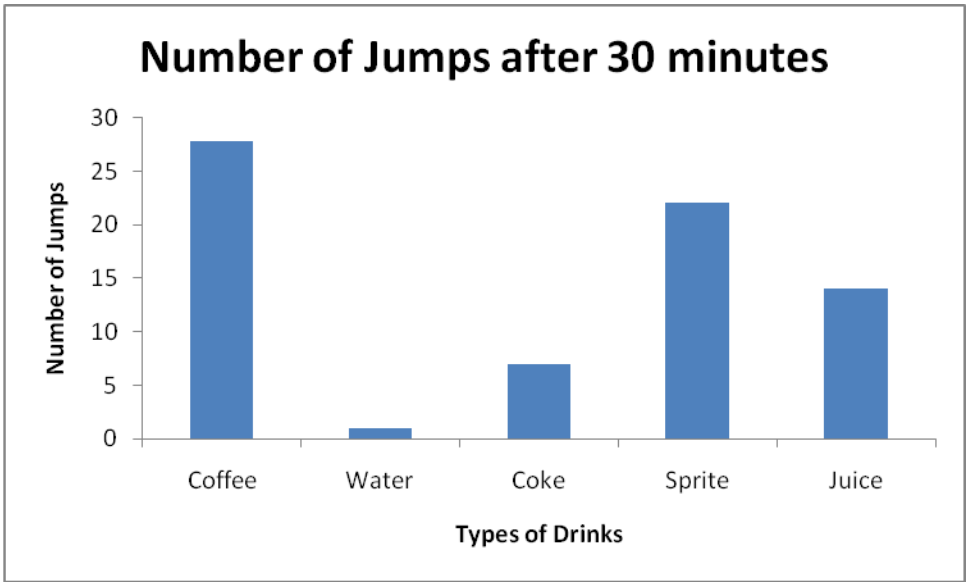
Activity of 8 children when exposed to coffee									
			Number of Jumps Exhibited by 5 different Children						
Time (min)	Child A	Child B	Child C	Child D	Child E	Child F	Child G	Child H	Average
0	2	2	1	0	1	1	0	1	0.888889
5	2	1	3	1	1	4	2	1	2.222222
10	5	6	5	3	5	6	4	3	5.222222
15	10	8	7	10	9	11	10	5	9.444444
20	15	12	15	15	17	14	15	7	14.44444
25	30	15	15	18	35	31	33	36	26.44444
30	28	19	27	29	30	28	29	30	27.77778
35	25	23	23	22	29	25	22	29	25.88889
40	20	19	18	15	26	16	15	26	21.66667
45	18	17	16	10	19	14	13	19	19
50	13	12	11	14	15	10	11	15	16.77778
55	11	9	5	6	10	8	7	9	13.33333
60	9	4	2	1	8	3	5	7	11

Table 2: Shows the average number of jumps across all treatments over an hour of observation.

	Average Number of Jumps				
Time (min)	Coffee	Water	Coke	Sprite	Juice
0	1	0	0	0	1
5	2	0	1	2	3
10	5	0	3	6	5
15	9	0	2	7	9
20	14	0	5	10	11
25	26	1	6	18	12
30	28	1	7	22	14
35	26	0	2	23	10
40	22	1	3	20	9
45	19	0	5	18	2
50	17	0	4	15	1
55	13	0	1	10	0
60	11	0	0	9	0

Teacher's Note: When talking about data charts and graphs, be sure to mention that all charts and graphs need to be followed by a caption. All graphs and charts must have a table number, title, and caption.

Results: Display your data in graphical format.



Graph 1: Graph shows the number of jumps after 30 minutes of administering the treatment. Coffee has the most amount of jumps followed by sprite, juice, coke, and water.

Using this graph as an example, explain to the children the importance of having a title, and labeling axis. The independent variable is placed on the x-axis and the dependent variable is placed on the y-axis. Also see teacher's note for the difference between a graph on a poster vs. in a lab report.

Teacher's Note: If displaying graphs in a poster or presentation, be sure to place the title directly on the graph. However, when writing lab reports, the title of the graph must go in the caption. Also in the caption for the graph, the student must talk about the trend of the data instead of just stating what the axes are labeled as.

Conclusion: Draw conclusions based from your results.
In the conclusion, refer back to the hypotheses and see if the hypotheses were supported by the data or not. Mention to either accept or reject the null hypothesis. Discuss the significance of data. Do a statistical test if needed. Refer to the following websites when deciding which statistical test to pick and directions for performing statistical tests respectively: http://faculty.uca.edu/johnc/statistical%20test.jpg http://www.graphpad.com/quickcalcs/index.cfm. Also mention any sources of error, and things to do differently for next time.