Guide to a Successful Science Project

BPS Science-Engineering Expo

February 2, 2016

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Adapted from: http://www.sciencebuddies.org/science-fair-projects/project_guide_index.shtml

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Bourne Public Schools: Scientific Inquiry Model

The scientific method is a process for experimentation that is used to explore observations and answer questions. Scientists use the scientific method to search for **cause and effect** relationships in nature. Just as it does for a professional scientist, the scientific method will help you to focus your science fair project question, construct a hypothesis, design, execute, and evaluate your experiment.

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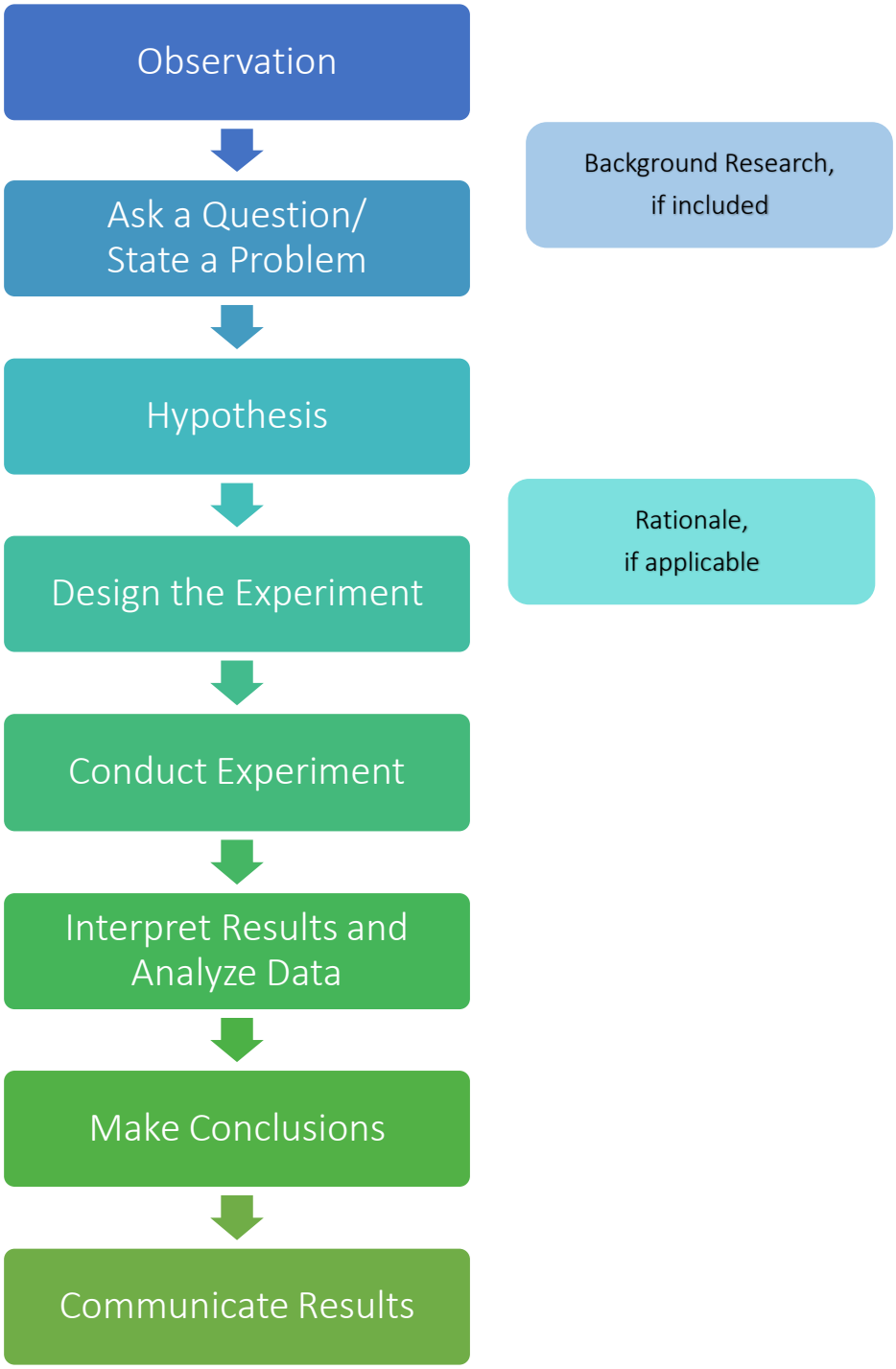


Your Question/Topic

Your topic is probably one of the most important pieces to the science fair puzzle. It should be something that interests you as you will be working on in for several months. The sciencebuddies.org website has a couple tools that can help to select an interesting topic.

- The Topic Selection Wizard
- Project Ideas Index

As you begin to narrow down your ideas, there are several questions to keep in mind. For a good science fair question, you should be able to answer 'yes' to every question below.

What Makes a Good Science Fair Project Question?
Is the topic interesting enough to read about, then work on for the next couple months?
Can you find at least 3 sources of written information on the subject?
Can you 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, are you measuring a factor (variable) that is simply present or not present? For example, • Lights **ON** in one trial, then lights **OFF** in another trial, • **USE** fertilizer in one trial, then **DON'T USE** fertilizer in another trial.
Can you design a "fair test" to answer your question? In other words, can you change only one factor (variable) at a time, and control other factors that might influence your experiment, so that they do not interfere?
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 very low cost?
Do you have enough time to do your experiment more than once before the science fair?
Does your science fair project meet all the rules and requirements for your science fair?
Have you checked to see if your science fair project will require SRC (Scientific Review Committee) approval?
Have you avoided the bad science fair project topic areas listed in the "Science Project Topics to Avoid" table?

Your Science Journal

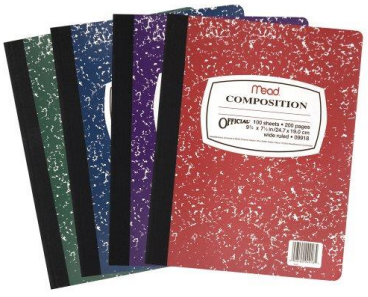
As part of the project, you must also keep a science journal to document your science investigations, experiments, and designs. Your journal is an important as it documents every step of your project. It is also a great way to keep you and your group members organized as you go through the scientific process. This component is required.

The Journal:

There are a variety of notebooks from which to choose, but it is up to you. You will be provided a bound composition notebook from the school. *You may also wish to create a **digital notebook.** That is also fine, but it will need to be printed out and placed into a binder for the final presentations at the Science and Engineering Expo.*

Setting up the Journal:

- Label your Journal: put your name (and group member's names) and your teacher's name in a permanent location. You do not want it on the first page as that may get ripped out. You may want it on the inside front cover.
- Use Ink: Do not use pencil in your journal. If you make an error, ~~cross it out with a single line~~ and re-write the information.
- Number the Pages: This will do wonders in helping keep the journal organized.
- Table of Contents: The Table of Contents will also help in keeping your journal organized. Coupled with the page numbers it will also allow you to find information more easily. You may also want to consider including colored tabs for your journal in order to separate sections.
- Date Journal Entries: Dates are important in tracking **when** you did certain things and/or made certain observations.
- No Skipped Pages: All information and sections should be consecutive. Do not leave any blank pages within the journal. If you do not use all pages at the end of the notebook, that is fine. Just do not skip any between sections.
- Be Brief: You do not want to get too wordy…stick to the point. This is not an exercise in long composition. Say what you mean; mean what you say. Be clear! It is important that you know what you did and it should also be clear to your teacher and the judge that evaluates your project.
- Be Legible: It important that those who look at your journal can read it. Write neatly.
- No Loose Papers: When one picks up your journal, papers should not come flying out of it. All pages must be secured.
- Regular Entries: Work on your journal on a regular basis. It is much easier to track your procedures, findings and conclusions while you are doing it that at the end and trying to remember it all. Do a little each day, and it will prove much easier for you!



1. Background Research
2. Research Plan
3. Bibliography

Background Research

Background research can provide some valuable information in understanding your topic and eventually your experiment. This background essay should be a page in length. Include the following elements:

- INTRODUCTION: briefly describe the connection to the real-world
- GENERAL INFORMATION: What is some information relating to your project?
- IN DEPTH: Explain the scientific concepts and/or theories on which your experiment is based.
- VARIABLES: Information about your independent and dependent variables
- BIBLIOGRAPHY: Citations-from where did you get your information?

Research Plan

If you are selected for the State Science and Engineering Fair, then you will have to complete a Research Plan Form. This is required. That said, it is a good idea to do this anyway as it will help you in organizing your project. A copy of the Research Plan can be found at the end of this document in Appendix A.

Additionally, there are a list of materials that CANNOT be involved in your project/experiment

PROJECT MUST NOT INVOLVE THE FOLLOWING MATERIALS:

Blood products, fresh tissue, teeth and bodily fluids
Nonhuman vertebrate animals or their parts, except eggs
Pathogenic agents
Recombinant DNA
Ingestion or inhalation of any substance by human subject-- *(*no smelling/wafting or eating/chewing of **ANYTHING***)—**NOTHING** in or on parts of mouth—including but not limited to teeth, tongue, lips.*
Controlled substances
Carcinogenic, mutagenic, explosive and toxic chemicals
Composting
Radioactive materials
Compressed gas (exception: helium, air, CO_2)
Hazardous substances or devices (including, but not limited to BB guns, potato cannons, paint ball guns)
High voltage equipment
Lasers (any strength)
Ionizing radiation X-rays or nuclear energy
See MSSEF Middle School Manual for additional information and explanation

Research Plan

You must include the following elements in your Research Plan. There will be a digital form to complete within Google Classroom. See the criteria below. Feel free to use this space as a rough draft.

1. QUESTION/PROBLEM

2. HYPOTHESIS/STATEMENT OF GOALS

3. MATERIALS (be specific) and DIAGRAM of your set-up

4. METHODS OR PROCEDURES

Research Plan-Protocol

Did you complete all required paperwork? YES ☐ NO ☐

All projects are required to have:

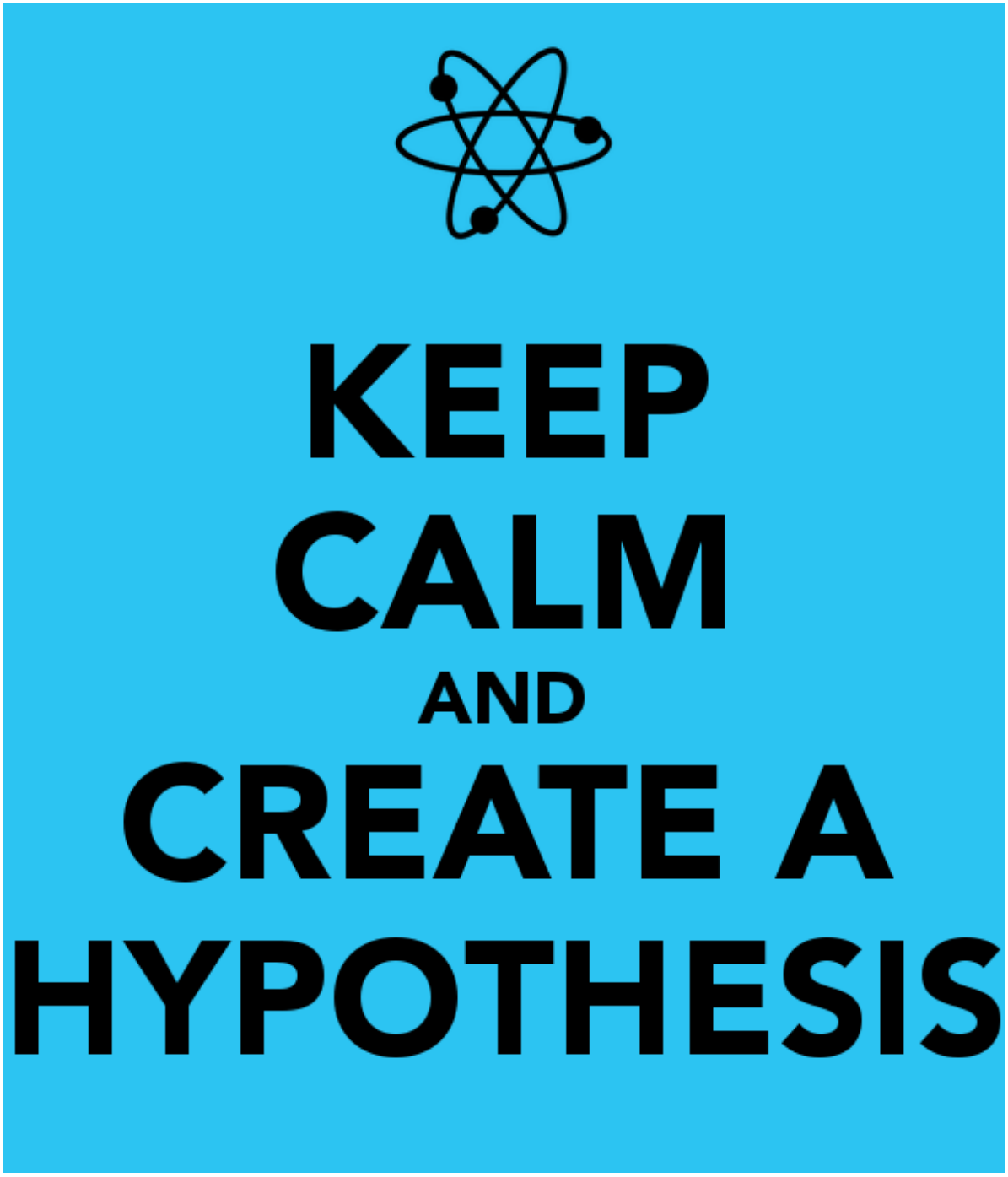
- ☐ A Student Checklist (1A),
- ☐ Research Plan,
- ☐ Form 1, and Form 1B, including dates and signatures, completed before experimentation begins.

Any experiment that involves hazardous chemicals, activities or devices (including controlled substances), potentially hazardous biological agents (including all soil and bacteria projects), and vertebrate animals will need to be performed under supervision at school or in a professional lab under the direction of a supervising scientist. This will require additional paperwork **before experimentation begins.**

Citing Sources: Bibliography

Any time you gather information from another source, you must cite it or give credit to that author/title. You cannot claim work that another has done as your own-that would be considered plagiarism. There are several online tools you can use to cite your sources (use the MLA format). You may have to create a free account in order to save your citations. See below:

- Citefast.com
- BibMe.com
- Easybib.com



1. Variables
2. Hypothesis

The Variables

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.

The **independent variable** is the one that is changed by the scientist. To ensure a fair test, a good experiment has only one independent variable. As the scientist changes the independent variable, he or she observes what happens.

The scientist focuses his or her observations on the **dependent variable** to see how it responds to the change made to the independent variable. The new value of the dependent variable is caused by and depends on the value of the independent variable.

Examples of Variables

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
How much water flows through a faucet at different openings?	Water faucet opening (closed, half open, fully open)	Amount of water flowing measured in liters per minute	• The Faucet • Water pressure, or how much the water is "pushing" "Different water pressure might also cause different amounts of water to flow and different faucets may behave differently, so to ensure a fair test I want to keep the water pressure and the faucet the same for each faucet opening that I test."
Does heating a cup of water allow it to dissolve more sugar?	Temperature of the water measured in degrees Centigrade	Amount of sugar that dissolves completely measured in grams	• Stirring • Type of sugar "More stirring might also increase the amount of sugar that dissolves and different sugars might dissolve in different amounts, so to ensure a fair test I want to keep these variables the same for each cup of water."

The Hypothesis

A hypothesis is an educated guess about how things work. Think of it as an "If/then" statement.

If --- (I do this) ---, then --- (this) --- will happen.

Your hypothesis should be something that you can actually test, what's called a testable hypothesis. In other words, you need to be able to measure both "what you do" and "what will happen."

Examples:

- "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].
- "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]."

1. Experimental Procedure
2. Materials List

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!

Repeating a science experiment is an important step to verify that your results are consistent and not just an accident.

- For a typical experiment, you should plan to repeat it at least ten times).
- If you are doing something like growing plants, then you should do the experiment on at least three plants in separate pots (that's the same as doing the experiment three times).
- If you are doing an experiment that involves testing or surveying different groups, you won't need to repeat the experiment three times, but you will need to test or survey a sufficient number of participants to insure that your results are reliable. You will almost always need many more than three participants!

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! BE SPECIFIC!

A Good Materials List Is Very Specific	A Bad Materials List
500 ml of de-ionized water	Water
Stopwatch with 0.1 sec accuracy	Clock
AA alkaline battery	Battery

1. Recording Data
2. Graphing Data
3. Analysis/Conclusions

Recording Data

Make sure you have a way to measure and collect your results. A data table can help you stay organized and provides a system to chart/graph your results. Google Sheets is a user friendly tool that can assist you in tracking your data. See example below:

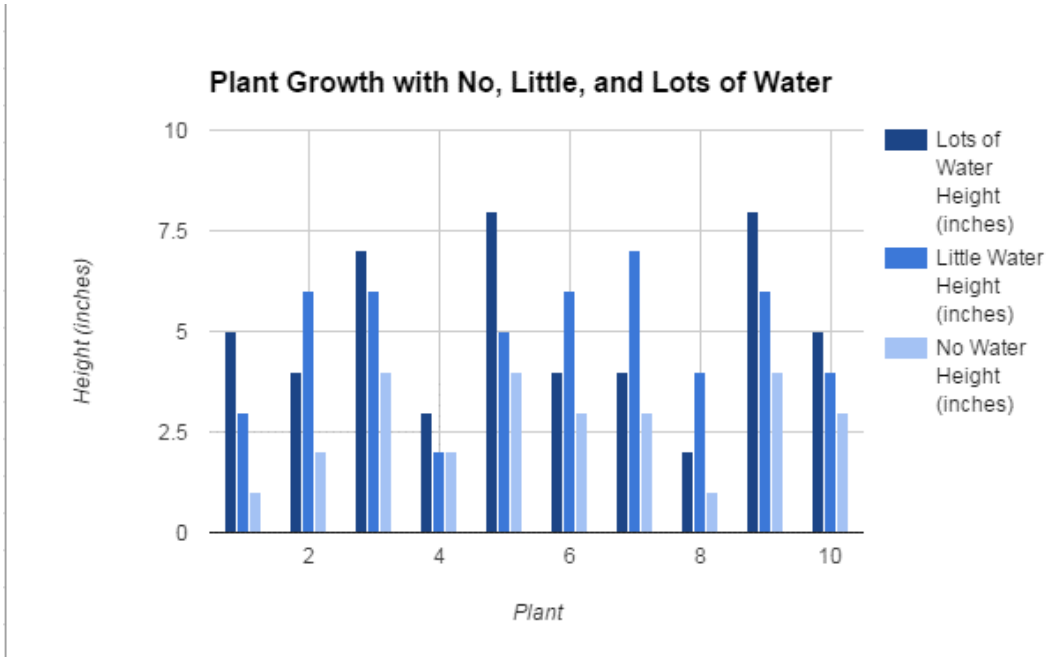
Data Sheet Example

File Edit View Insert Format Data Tools Add-ons Help All changes saved in Drive

	A	B	C	D
1	Plant	Lots of Water	Little Water	No Water
2		Height (inches)	Height (inches)	Height (inches)
3	1	5	3	1
4	2	4	6	2
5	3	7	6	4
6	4	3	2	2
7	5	8	5	4
8	6	4	6	3
9	7	4	7	3
10	8	2	4	1
11	9	8	6	4
12	10	5	4	3
13				

Graphing Data

Graphs make data easy to understand. It is a visual representation of the data you have collected. You can hand-draw your graphs, if you choose, but be neat and legible. If you use Google Sheets, it is very easy to take that data table and transform it into a graph.



Analysis and Conclusions

Use your data to explain the results of the experiment. Answer the following questions:

- Was your hypothesis supported or not supported by your data?
- If yes, what does that mean? If no, how are your results different from what you expected?
- What are some factors that may have contributed to your results?
- What are some factors that could be tested if you tried the experiment again?
- What are some questions you have based on your results?
- What did you learn about your topic?

Conclusions Checklist

What Makes for Good Conclusions?	For Good Conclusions, You Should Answer "Yes" to Every Question
Do you summarize your results and use it to support the findings?	Yes / No
Do your conclusions state that you proved or disproved your hypothesis? (Engineering & programming projects should state whether they met their design criteria.)	Yes / No
If appropriate, do you state the relationship between the independent and dependent variable?	Yes / No
Do you summarize and evaluate your experimental procedure, making comments about its success and effectiveness?	Yes / No
Do you suggest changes in the experimental procedure and/or possibilities for further study?	Yes / No

1. Abstract
2. Display Board
3. Judging Criteria

Abstract

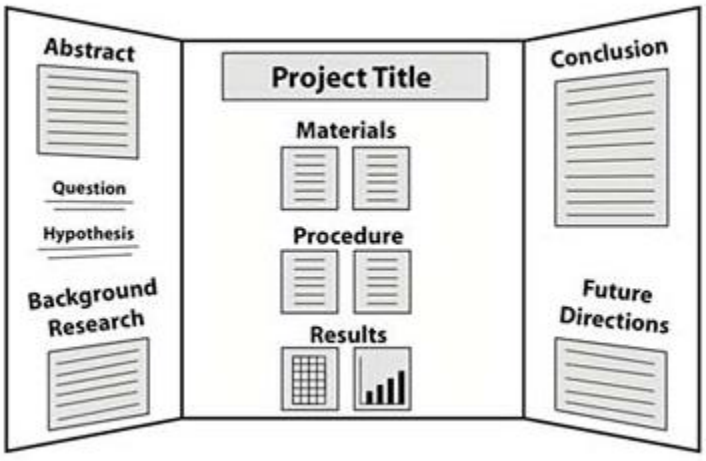
An **abstract** is an abbreviated version of your science fair project final report. For most science fairs it is limited to a maximum of 250 words (check the rules for your competition). The science fair project abstract appears at the beginning of the report as well as on your display board.

Almost all scientists and engineers 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.

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. See example set-up below. You may also want to include a selection of pictures (photographs) of your experiment and place them on the center panel under procedure.



Judging Criteria

Below is a sample scorecard used for judging. It is worth a look and make sure you have included all elements in your presentation.

MSSEF • • • Massachusetts State **Science & Engineering** Fair

JUDGING CRITERIA

1. Scientific Approach (30 points)

Science Project	**Engineering Project**
Clearly Stated Hypothesis	Identified Need or Problem
Logical Experiment with Control	Development of Clear Performance Criteria
Accuracy of Data and Observations	Well-constructed and Tested Prototype
Well-supported Conclusions	Retesting and Redesign
Consideration of Future Research	Feasibility Study

2. Understanding of Science and Engineering (25 points)

Application & Understanding of Scientific Method or Design Process
Conclusions are Consistent with Data
Knowledge of Scientific Literature Relevant to Project
Connections to other Disciplines

3. Innovation/Creativity (20 points)

Originality
Use of Unique Methods, Designs or Materials
Creative Approach to Problem-Solving

4. Presentation (15 points)

Clarity of Auditory Presentation
Effectiveness and Use of Visual Display
Research Paper with Citations
Evidence of Equitable Collaboration (if Team Project)

5. Laboratory Notebook (10 Points)

Well-documented Entries
Dated Records
Evidence of Project Development
Students in a team have their own laboratory notebook

Works Cited

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