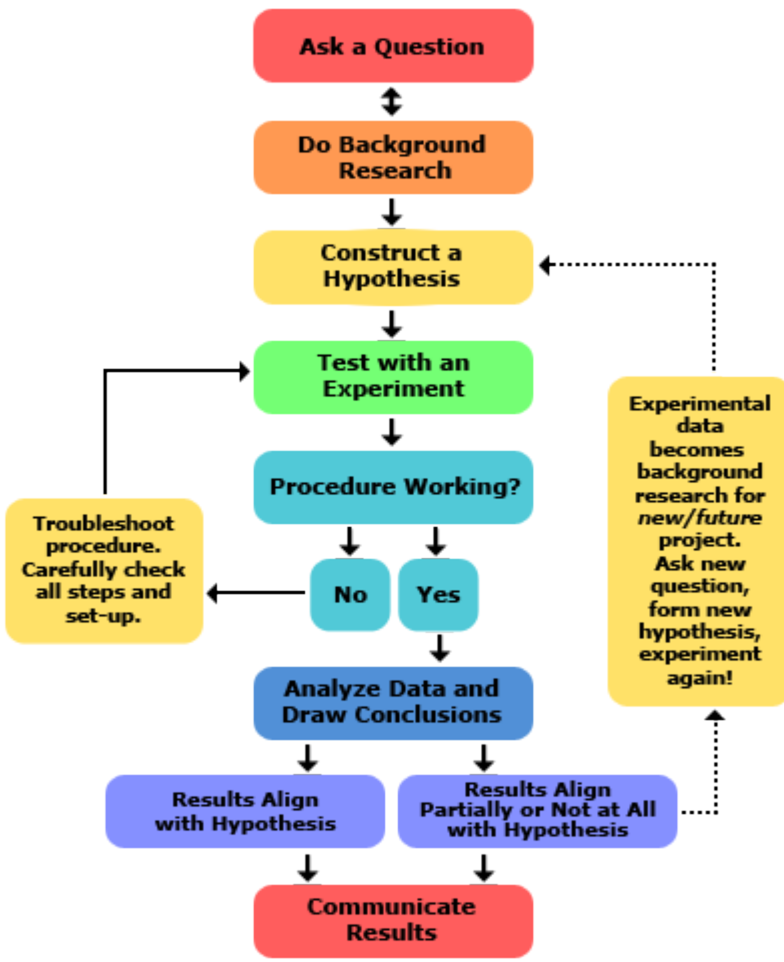
1) Scientific Method

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 other words, they design an experiment so that changes to one item cause something else to vary in a predictable way.

The scientific method starts when you ask a question about something that you observe: How, What, When, Who, Which, Why, or Where? In order for the scientific method to answer the question it must be about something that you can measure, preferably with a number.

Research your question to help find the best way to do things and insure that you don't repeat mistakes from the past.



2) <u>Question</u>

Once you find a topic that interests you, write down the question that you want to answer. A scientific question usually starts with: How, What, When, Who, Which, Why, or Where. One of the most important considerations in picking a topic is to find a subject that you consider interesting. You'll be spending a lot of time on it, so you don't want to select something that is boring.

A lab notebook is an important part of any research or engineering project. Used properly, your lab notebook contains a detailed, permanent account of every step of your project, from the initial brainstorming to the final data analysis and research report. Many science projects require a number of steps and multiple trials. By recording the steps of your procedure, your observations, and any questions that arise as you go, you create a record of the project that documents exactly what you did and when you did it. With a complete record of the project in your lab notebook, you can look back at your notes later if a question arises. Be sure to also document all your information sources (reliable web sites, books, expert).

3) <u>Variables</u>

A good experiment has only one independent variable. As you change the independent variable, you will observe what happens. 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.

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.

However, imagine trying to do an experiment where one of the variables is love. There is no such thing as a "love-meter." You might have a belief that someone is in love, but you cannot really be sure, and you would probably have friends that don't agree with you. So, love is not measurable in a scientific sense; therefore, it would be a poor variable to use in an experiment.

If you can't measure the results of your experiment, you're not doing a science experiment!

4) <u>Hypothesis</u>

A hypothesis is an educated guess about how things work. After having thoroughly researched your question, you should have some educated guess about how things work.

Most of the time, a hypothesis is written like this: "If _____[I do this] _____, then _____[this]_____ will happen, because ____________."

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."

5) <u>Testing</u>

Write your 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!

The first step of designing your experimental procedure involves planning how you will change your independent variable and how you will measure the impact that this change has on the dependent variable. To guarantee a fair test when you are conducting your experiment, you need to make sure that the only thing you change is the independent variable. And, all the controlled variables must remain constant. Only then can you be sure that the change you make to the independent variable actually caused the changes you observe in the dependent variables.

In many experiments it is important to perform a trial with the independent variable at its natural state for comparison with the other trials. This trial is referred to as a control group. An example would be testing something at different temperatures. The control might be room temperature.

In another kind of experiment, many groups of trials are performed at different values of the independent variable. For example, if your question asks whether an electric motor turns faster if you increase the voltage, you might run the experiment at 1.5 volts, 2.0 volts and 2.5 volts. In such an experiment you are comparing the experimental groups to each other, rather than comparing them to a control group.

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 three times (more is better). 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.

6) Experiment

Follow your experimental procedure exactly. If you need to make changes in the procedure, write down the changes exactly as you made them.

Before starting your experiment, prepare a data table so you can quickly write down your measurements as you observe them. Be consistent, careful, and accurate when you take your measurements. Numerical measurements are best.

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.

Don't forget to take pictures of your experiment for use on your display board.

7) Data analysis

Really think about what you have discovered and use your data to help you explain why you think certain things happened. What did your results show? Did you get the results you expected?

Graphs are an excellent way to display your results. In fact, most good science fair projects have at least one graph. For most types of graphs:

•Your independent variable will go on the x-axis of your graph and the dependent variable on the y-axis.

•Be sure to label the axes of your graph— don't forget to include the units of measurement (grams, centimeters, liters, etc.).

•If you have more than one set of data, show each series in a different color or symbol and include a legend with clear labels.

8) Conclusions

Your conclusions summarize how your results support or contradict your original hypothesis (Engineering & programming projects should state whether they met their design criteria).

Summarize your science fair project results in a few sentences. Include key facts from your background research to help explain your results as needed. Briefly review and evaluate your experimental procedure, making comments about its success and effectiveness. Suggest changes in the experimental procedure (or design) and/or possibilities for further study.

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. 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. If you think you need additional experimentation, describe what you think should happen next.

9) <u>Poster and oral presentation to judges</u>

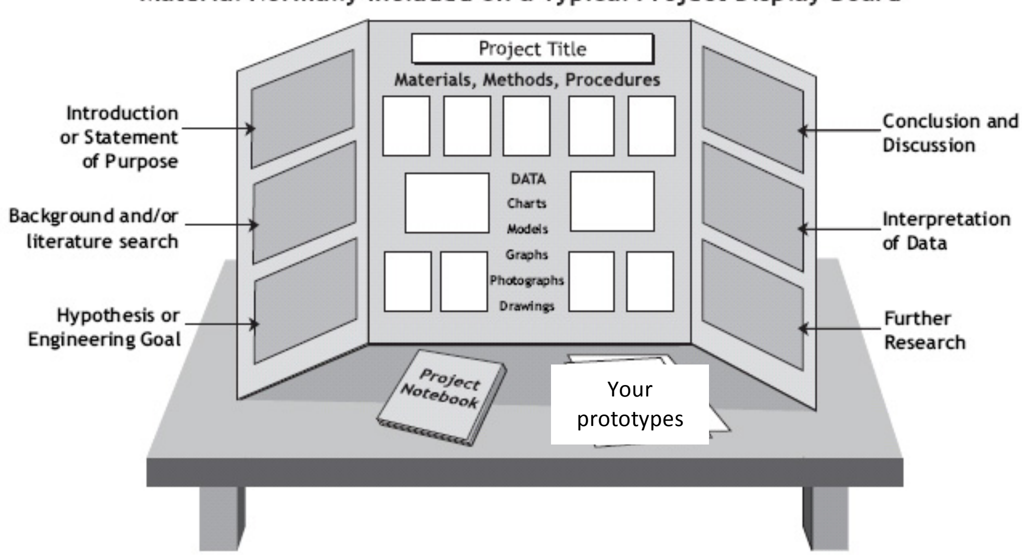
You need to prepare a display board to communicate your work to others. Organize your information so that your audience can quickly follow your experiment by reading from top to bottom, then left to right. Include each step of your project: Abstract, question, hypothesis, variables, background research, and so on. Check out http://www.sciencebuddies.org/science-fair-projects/project_display_board.shtml#samples for more ideas. There are also some sample displays in the library.

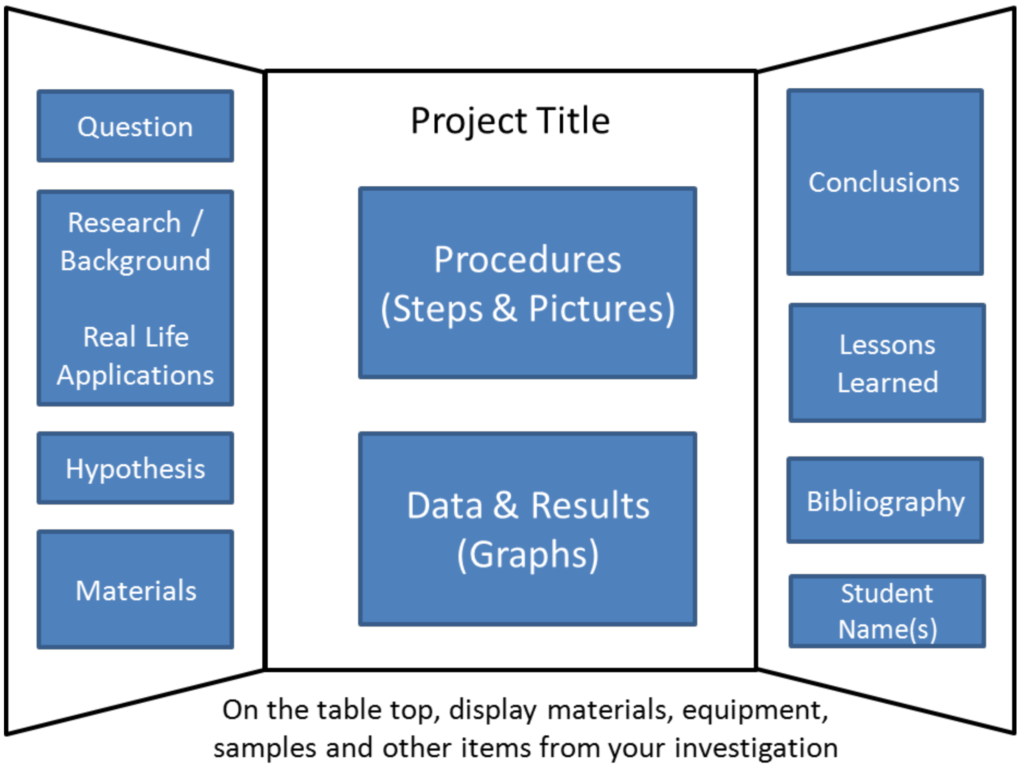
The title should be big and easily read from across the room. Choose one that accurately describes your work, but also grabs peoples' attention.

Use a font size of at least 16 points for the text on your display board, so that it is easy to read from a few feet away. It's OK to use slightly smaller fonts for captions on picture and tables.

Remember: A picture speaks a thousand words! Use photos or draw diagrams to present non-numerical data, to propose models that explain your results, or just to show your experimental setup.

Material Normally Included on a Typical Project Display Board





- Prepare to present to the judges for approximately 5 minutes
- Be ready to answer questions
- Know your project and show your enthusiasm
- Look the judge in the eye and speak clearly
- Use props to demonstrate your experiment, if possible
- Reference results, tables and graphs
- Don't just read from the poster
- Practice your presentation in front of someone before the fair