SCIENCE FAIR

A guide for students and parents

Table of Contents

Starting with the right goal.

Why do people do science experiments? Do they do them because they're fun? Yes, sometimes. But that's not really the most important thing about doing science experiments. The important thing is that scientists do experiments because they want to know how the world works, and what causes things to happen as they do.

Doing a science experiment or an engineering project is not about proving that you're right about something. It's about learning something you didn't already know or making progress toward solving problems.

A very famous scientist named Thomas Edison invented the first electric light bulb. You probably already know that. But did you know that he did THOUSANDS of experiments that FAILED before he did the experiment that worked?

Someone once asked Edison if he felt like a failure because he hadn't been able to figure out how to make a light bulb yet. We don't know exactly what he said because people who heard his answer remembered it differently. But it was something like this: "I haven't failed. I've found 10,000 things that don't work."

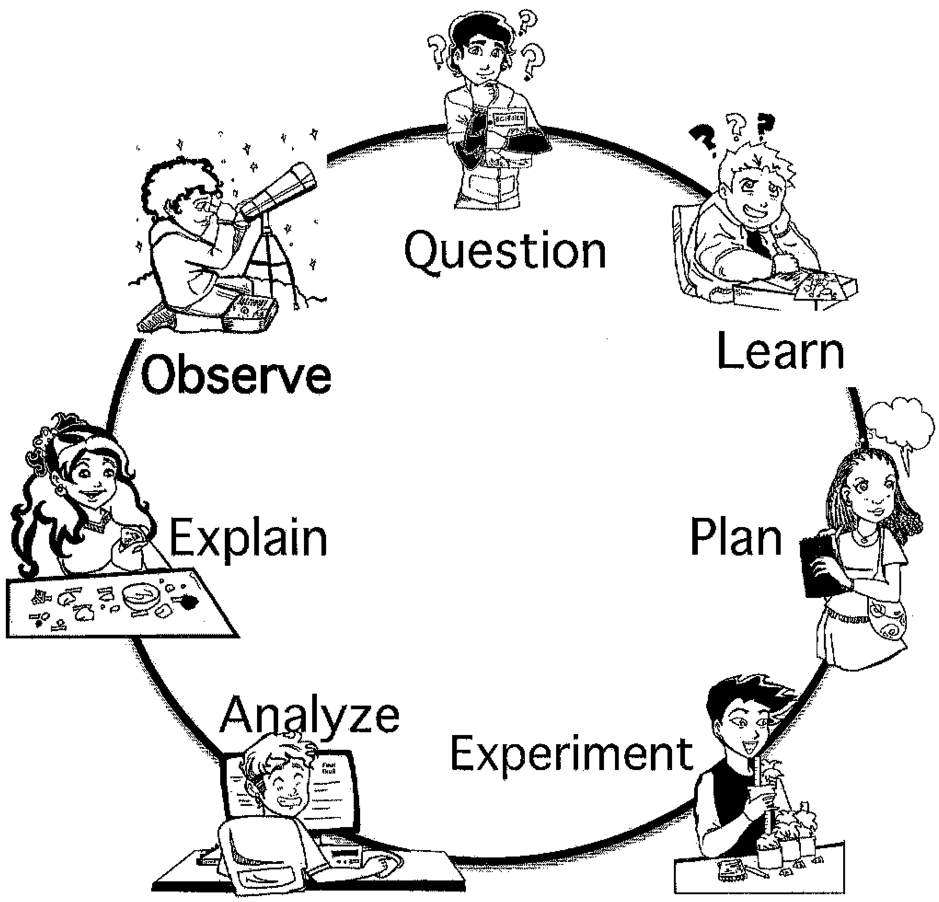
You see, what mattered to Edison was that every experiment taught him something. Sometimes the experiment taught him that he was wrong again. But each experiment got him closer to finding out how to make a light bulb.

Starting with the right goal.

Doing science isn't about being right or wrong the first time. It's about learning something new. It's about finding out the truth or solving a problem.

When you decide to do a science experiment or an engineering project, you're trying to add to the knowledge we have about the world and solve big problems. We need people like you. You're still young, but by starting to do experiments when you are young, you are preparing to make a real difference in the world when you get older.

If you read and follow the suggestions in this guide, you will be able to create a great project.



Choosing a good topic.

Observe

Use your senses. Notice the world around you. What are you curious about? What do you enjoy doing? Do you dream about designing cars or buildings? Do you have an idea for an invention? Anything that you're curious about or that you dream of doing can become a science fair project.

Think of a topic you're curious about, like wind turbines, earthquakes, or dog behavior. Got it? OK now try this: Finish the questions below.

How do ________________________________?

Why do ________________________________?

When do _______________________________?

What makes ____________________________?

Where do ______________________________?

How could _____________________________?

What if _______________________________?

Question

If you were able to add to most of those questions, that topic might be a good one for your project. A good question is the place to start. It can lead you to create a good science experiment, or it can lead you to invent a solution to a problem.

What makes a good project.

Learn

You probably already know a lot about the subject of your question. You might be a real expert on it someday. Right now, there is probably a lot you could still learn. Read some books. Talk to an expert on the subject. Watch a video. Go to work with someone whose job has something to do with your topic. Or go to a website that's all about your topic. While you learn, remember to look for answers to the questions you wrote, and remember to write down what you find out.

After you've learned all you can about the topic you're interested in, you can start thinking about an experiment that will help you (and everyone else) know more.

It's really important that, if you want to win the science fair, you do not do a demonstration of something that everyone already knows. Don't make a model volcano, or a display of your rock collection. Those projects might be fun, but they aren't the kind of project that will win the science fair, or contribute to what we know about the world.

You should start with an idea for an experiment, or an idea for an invention that you think will answer a question or solve a problem. Answering questions and solving problems both involve being able to count or measure things. If you are thinking of an experiment, but you can't figure out what you would measure, *it's not a good idea for an experiment.*

It wouldn't be a good idea, for example, to do an experiment on whether chocolate ice cream tastes better than vanilla, because you can't measure "tastes better". You *could* do a survey to see if chocolate ice cream is more *popular* than vanilla ice cream, because you can ***count or measure*** how many people say they like like chocolate or vanilla best. But it still wouldn't be a very good science experiment, because...

A good experiment answers a question that hasn't already been answered!

The companies that make ice cream already know if more people like chocolate or vanilla best. That's how they know how much of each kind of ice cream to make. So when you design an experiment, make sure you're answering a question that hasn't already been answered or that you are trying to solve a problem that hasn't already been solved!

But what if you're really stuck and want to do a project but have no idea what to do?

Go to www.sciencebuddies.com and go through their survey. It will help you get some good ideas for projects. Pay attention to how they rate the project difficulty, and don't pick one that would take more equipment or materials than you can get. Don't do one that is rated as "difficult" if this is your very first science fair project.

When you think you have a good question that can be answered with an experiment, or you have idea for making something that would solve a problem, you need to plan. You need to plan what materials you need. You need to plan what you'll do. You need to plan how you'll keep a record of what you're doing. You need to plan how you'll measure or count what happens. You need to plan a lot of stuff before you get to start experimenting!

Plan

Let's pretend that you've noticed that if plants don't get watered enough, they die.

You're curious about the best way to water cactus plants. You've done some reading and talked to a person at a store where plants are sold. You have also watched a video about plants in different places like deserts and jungles. But you have not been able to find out if cactus plants grow more if they get water every day than they grow if they don't get watered every day.

You might have learned that cactus plants are especially adapted for deserts. So you know that they can grow with very little water, but you wonder if they'd grow better with more water. So you decide to do an experiment. Is it a good experiment? Well that depends. It might be a good experiment if:

1) You haven't been able to find an answer for the question, and you don't think anyone has found out the answer to that question.
2) You know how to measure the growth of the cactus.

Credible sources of information.

So, let's say you have a question that you think has not been answered before. In the science fair, the judges will ask you how you know that it hasn't been answered before. You need to be able to show them that you did your research, and that you looked for information from what are called **credible sources**. Credible sources can be scientists, scientific magazines, some websites, etc. They are sources that can be trusted to be accurate and thorough. Be careful. Just because something is on the internet, doesn't make it true or accurate. It certainly doesn't guarantee that the source is credible.

Let's talk about Wikipedia for a minute. Wikipedia is OK as a beginning place to look for information. But anybody can add to a Wikipedia article, and that person might not have a clue what they're talking about. So Wikipedia will not be considered a credible source for your research. You can *start* with Wikipedia for information, but you should also look at books, websites, and articles from newspapers and magazines that have a good reputation for being accurate. Ask your school librarian, public librarian, or your science teacher for some suggestions of credible sources.

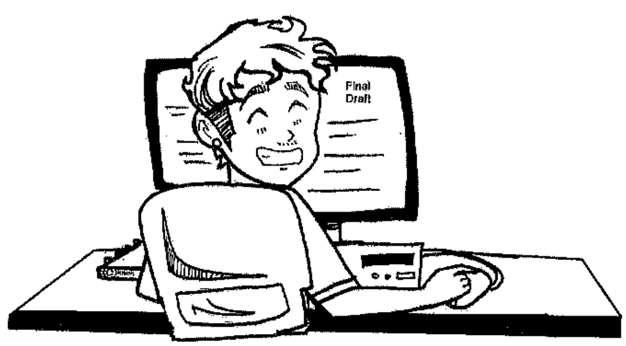
Here are some credible internet sources that are meant for students your age:

http://www.chem4kids.com/

http://discoverykids.com/

http://www.geography4kids.com/

http://www.sciencekids.co.nz/



The importance of being fair.

If you were going to be in a race with other kids and they got a head start, would it be fair? What if they were three years older and had longer legs than you? What if you were barefoot and they had shoes? Would you think that was fair? Would you think that it was OK for people to say that you were not as good a runner as the other kids? Probably not. Because it wouldn't be a fair race. Being fair is important. Being fair is important in science experiments too.

Being fair in science experiments means that you have to be willing to accept that you might be wrong. It means you have to give every possibility a chance, so that you can find the truth. Finding the truth means that in the cactus experiment you would have to think about *everything* that might cause cactus plants to grow more. Maybe sunlight is more important than water. Maybe the soil they're in is more important than the water they get. Maybe the kind of pot they are in makes a difference. You need to do a fair experiment to find out. Don't start off trying to prove that you're right. Start off *wanting to know the truth.* Finding the truth means being fair and being careful. Science fair judges look to see if you were careful to be fair. It's the most important part of doing a good project.

Controlling the variables.

Keeping your experiment 'fair' is usually called "controlling" the experiment. Controlling the experiment depends on several things.

1. **The control group and the experimental group.** In the cactus experiment the **control group** is the cacti (plural for cactus) that you **don't** water daily. The control group in an experiment gives you something to compare to. Your **experimental group** is the group you are experimenting on. You measure the growth of your experimental cacti by comparing them to the control group cacti. The control group is how you know that what happens to the experimental group wouldn't be happening if it wasn't for what you were doing. Let's say your experimental cacti grew two centimeters during the experiment. How do you know that two centimeters is a lot? Because you have a control group to compare it to, and the control group cacti might grow ½ cm in the same time. *The control group is the standard you measure against.*

2. **The Constants** – The constants are the things that never change during the experiment. In your cactus experiment you would make sure that every cactus gets treated the same way, just as you would want every runner in a race to be treated the same way. You don't change the distance of a race for some runners, or take their shoes away in the middle of the race. That wouldn't be fair. In a good science fair experiment, you don't change things in the middle of the experiment. You wouldn't move some cacti to a place with less light in the middle of the experiment.

Controlling the variables.

The Independent Variable – This is the one thing you are changing or testing. In the cactus experiment you would be changing how often the experimental cacti get watered. The watering is the **independent variable**. A good science experiment only has one independent variable. If you have more than one, it's not fair. You can't give some cacti daily water AND better soil. Because then you wouldn't know if it was the water or the soil that made them grow more. It wouldn't be fair to say the water made the difference. You can't know for sure what made a difference in the growth of the cacti if there are a lot of things that could have made a difference. Make sure you have only ONE independent variable.

Your independent variable might have some other variables within it. For example, in the cactus experiment the independent variable "daily watering" has smaller variables within it, such as how much water is provided daily, how cold or warm the water is, whether the water is poured over the top of the cacti, or put into a saucer underneath the cacti. Even within your independent variable there are smaller variables you need to think about and keep constant during the experiment. Think about, and control, every variable that you can - so that the independent variable is, as much as possible, the only difference between the control group and the experimental group.

The Dependent Variable – The dependent variable is what you measure to determine the effect of the independent variable. In your cactus experiment you measure growth, because you think growth depends on watering. Growth is the dependent variable, and is how you measure the effect of daily watering (the independent variable).

A chart like this one will help you plan a good experiment.

It's possible that..	So I will do this:
The cacti would have grown just as much without daily watering.	I will have both an experimental group of cacti and a control group of cacti. If the experimental group cacti grow more, I'll have a way to compare how much they grew to how much they would grow without daily water.
Getting more sunlight might make a cactus grow more.	I will make sure all the cacti get the same amount of sunlight. If those I water daily grow more than the others, I'll know it wasn't because they got a different amount of sunlight.
The temperature of the water the cacti get might make a difference in their growth.	I will make sure that the temperature of the water I use is the same for all the cacti. If the experimental cacti grow more I'll know the temperature of the water wasn't the reason for it.
The kind of soil the cacti are in might make a difference in the growth.	I will put all the cacti in the same kind of soil. If the experimental group cacti grow more, I'll know it wasn't the soil that made the difference.
The kind or size of pot they are in might make cacti grow more.	I will put all my cacti in identical pots. If the experimental group grows more, I'll know it wasn't because they were in better pots.

Know the rules BEFORE you start experimenting.

Your school science fair might have rules that seem ridiculous to you. Finding out about them after you are finished experimenting and then being disqualified from a science fair or being disqualified from going on after you WON the school science fair would be really sad!

Some science fairs are only for individual schools. There might be winners of the fair, but there is no state or regional fair for the winners to go to next. But some school science fairs have winners who go on to district, state, or regional science fairs and possibly even to international science fairs. A student who is hoping to win at the international science fair level has rules to follow. And they can't enter the international fair unless their experiment follows those rules. Which means the state fair before the international fair must have those same rules. Which means the district science fair must have the same rules. Which means the school fair must have the same rules.

And that's why your school science fair might have rules that seem ridiculous. The rules are there because students entering the international fairs are often doing truly ground-breaking scientific research at nearly professional levels, and have to be doing their research in professional level ways. In 2014, the first and second place winners in the INTEL International Science Fair competition were both fifteen years old. If they can do it, you can. Don't disqualify yourself before you even start. Follow the rules.

Know the rules BEFORE you start experimenting.

If you are entering a science fair from which you can move on to a higher level, you need to know what kinds of experiments need approval and which ones don't.

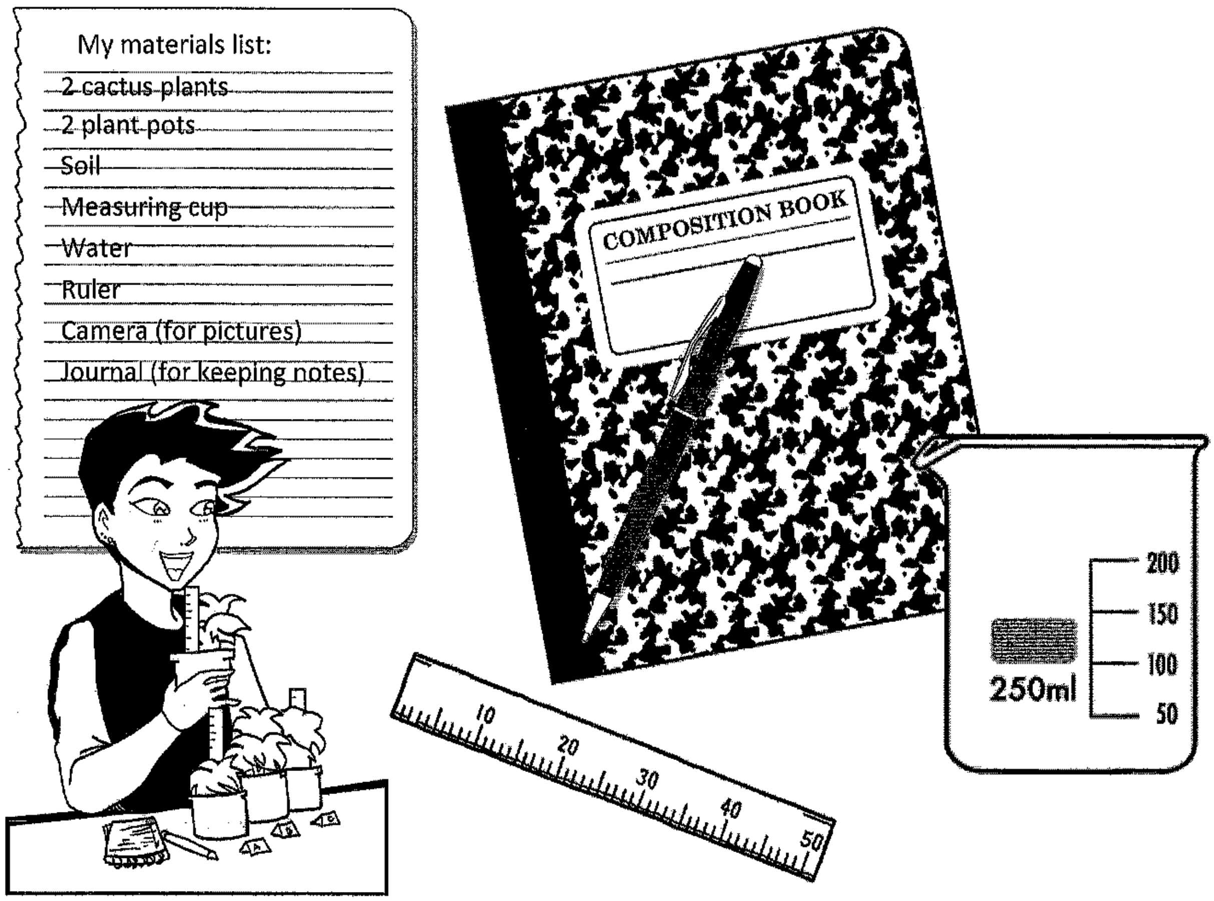
As a general rule, you need approval from a vet before you do any experiment with a vertebrate animal (animal with a backbone).

And, as a general rule, you need approval from a doctor before you do any experiment that involves testing people. Even things like surveying people require a doctor's permission. Seems ridiculous, right? But the rules are the rules and if you want to go on to state, regional, or international fairs, you have to follow the rules.

You definitely are going to need approval from a doctor, and probably some help from a scientist with a lab before you do any experiment that involves growing bacteria or fungi (mold etc.). Those things can kill people, and they need to be grown with supervision under carefully controlled conditions.

So before you go any further with planning your experiment, talk to your science teacher and make sure that you have all the permission forms you need **before** you start doing your experiments.

NOW, you're ready to start experimenting!



You'll need to keep good records. Take lots of pictures. You'll be really glad you did when it's time to make your display. You probably won't be allowed to take any part of your actual experiment into the science fair. You probably will not be allowed to bring liquids of any kind or any living thing. That's because some people who come to the fair might be allergic to something you've brought in, or the chemicals might be dangerous. So it's really important that you take pictures. Make sure you take good notes about what you do. Write down your mistakes too. If you forgot to do something one day, write that down. Every picture, every note and every measurement will help you.

A UtahRoots Publication

Write a good hypothesis.

You thought of a good idea. You did research. You've got a question that you want to answer or you have identified a problem that needs to be solved.

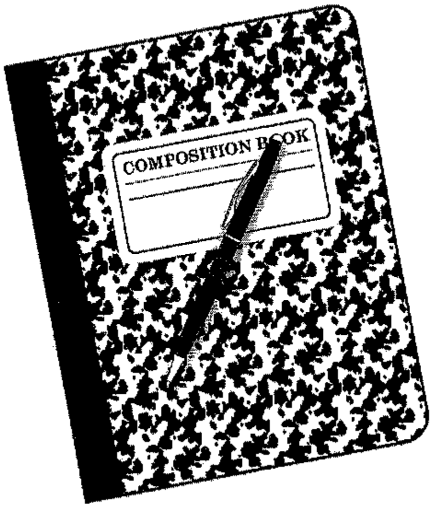
The next important step is writing a good hypothesis. A hypothesis is not just a guess. It's an idea based on good information, that describes what you think is going to happen.

A good hypothesis is usually worded in a certain way. It's called an "if – then statement". It can also be in the form of "If..and I…then"
Here's what that looks like:

> "**If** water is important for cactus growth **and I** water a cactus daily, **then** it will grow more than cactus plants that receive water once a week."

You need to write a hypothesis like that before you start your experiment. It guides your work. It shows exactly what you were trying to find out by doing your experiment. It's the format that is expected in state or regional science fairs.

Keep a log book.



Keeping a log is an important part of your experiment. Your log will be part of your display. It will contain all the information about what you did every day. All of your data will be in your log.

Here are some hints for keeping a good log.

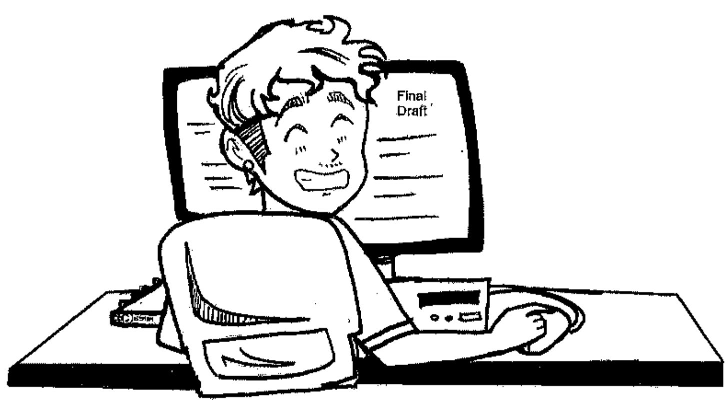
1. If you can, use a notebook where the pages are permanently fastened in. Try not to use a spiral notebook or a binder. That will prove that you didn't replace, add, or tear out pages to try to 'fake' your results.
2. Make a table of contents page, but don't fill it out until the end. You're just saving a page that you can come back to and complete later.
3. Write your name and your science teacher's name on the inside.
4. Number the pages of the notebook (for the same reason as #1).
5. Write something in your log every day. Even if you think the information isn't important, it might turn out to be. Describe everything you do.
6. As you work, glue or tape any loose papers, etc. into the notebook. (But you might want to make sure you can remove the photos to use on your display.)
7. Don't worry about being neat and don't erase or re-do pages to make them look better. No scientist ever has totally neat notes! Not even Einstein!
8. Use your notebook from the start. Use it for everything that you might possibly need to remember or use again.

Collect and analyze your data.

At the end of your experiment, your log book should be full of measurements or other data that you have taken regularly during the days or weeks that you've been working on your experiment. It is time to analyze the data.

Analyzing the data involves making charts or graphs that help people understand what happened during your experiment. Your charts and graphs must go on your display board for the science fair. The science fair judges will want to talk to you about your graphs and charts and will ask you what the graphs and charts mean.

If you're not quite sure how to make a good graph, here's a website that might help you: http://nces.ed.gov/nceskids/createagraph/



Get ready to show what you know!

Good scientists do careful experiments, and they tell the truth about what happened. But good scientists also try to **communicate** what they did and what happened during the experiment. Your display is how you communicate what happened in your experiment. There are rules in science fairs about what you have to have on your display, and about how big your display can be. Make sure you know the rules and follow them.

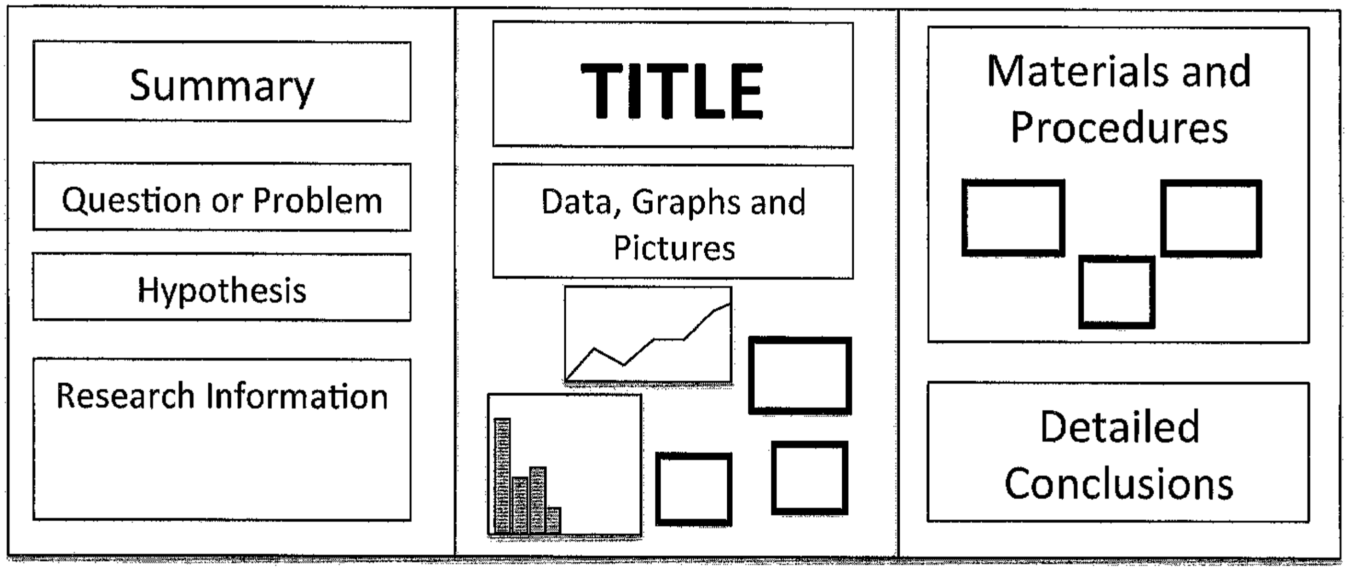
You'll need to make a display that stands up by itself and has some required information on it. There will be a size limit. Find out what it is.

It's OK to get *some* helping making your display. But the information on the display should be done by you, not your mom or your dad or some other person. Science fair judges are good at spotting the displays that were done by somebody's mom instead of being done by the kid. Do your own work. Judges don't want to see what your mom can do. They want to see what you can do.

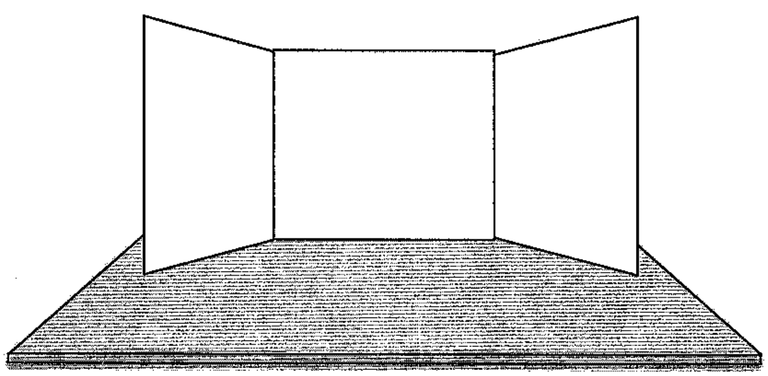
On the next page is a picture that will help you design your display.

Preparing your display.

Most science fairs require a display that looks something like the picture below. The exact information you need to include and where it goes on the display might be different than the picture below. This is just an example.

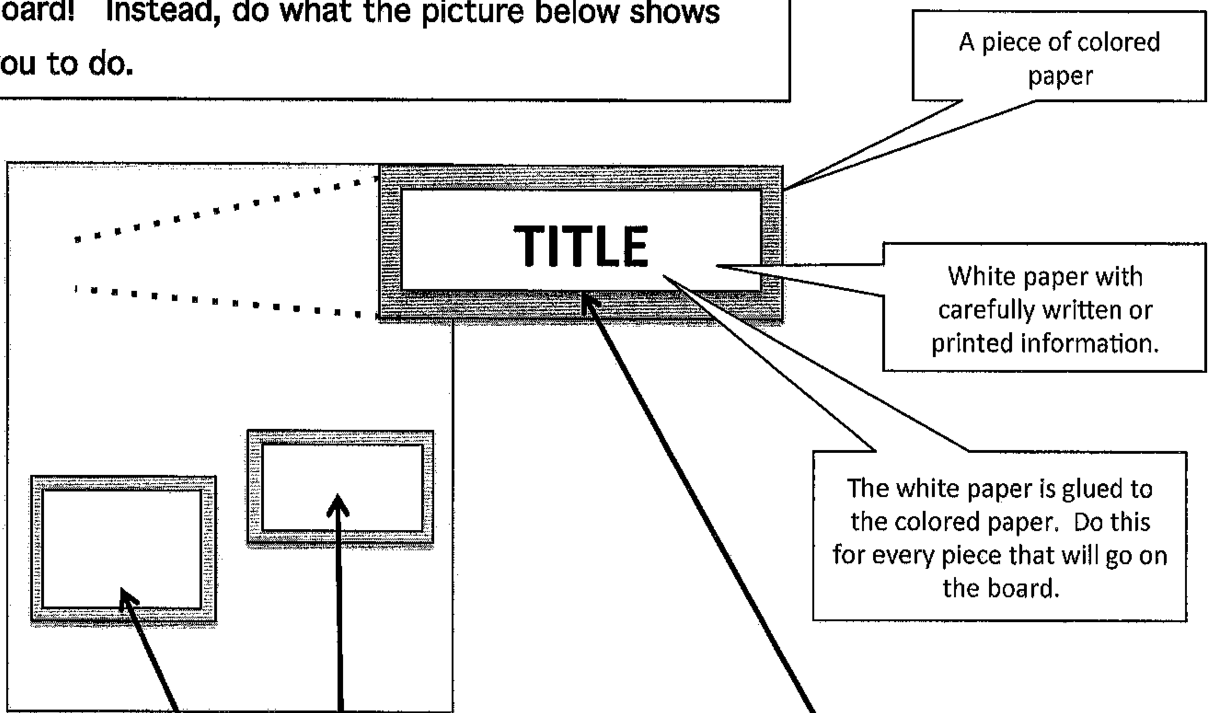


Your display has to be able to stand up by itself. It's recommended that you use specially designed display boards. But check the rules for the fair you are entering.



Tips for a good display board.

1. Don't write or draw on the display board. If you make a mistake you'd have to buy a new display board! Instead, do what the picture below shows you to do.



2. Your main title should be at least 3 inches tall. Smaller headings should be at least 1 ½ inches tall. The font on your typed information should be at least size 12 font.

3. Lay all the pieces on the board and move them around until the layout looks good. When each piece is where you want it, put a DOT of glue in each corner, on the back of the colored paper and attach the piece to the display board.

The day of the fair.

Here are some tips to help you be prepared for the day of the science fair.

1. Dress nicely. You will be meeting people who don't know you. Make a good first impression by being well-groomed and wearing clean clothes.

2. Take something to do while you're waiting to be judged. It usually takes about ten to fifteen minutes for a judge to talk with each student, so you might be sitting around for a long time waiting for a judge. You might not be allowed to have electronic games, so plan on taking a book or a sketchbook so you have something to do.

3. You probably won't be allowed to bring a backpack. Check the rules to make sure.

4. Stay with your project. If you are not with your project when the judges get to it, they may leave. And it makes a bad impression on judges if you're playing around or being disruptive during the fair.

5. Eat before you go. Usually, you will not be allowed to bring food or any kind of liquid into the fair, but in some cases you may be allowed to bring a bottle of water or a snack.

6. You are responsible for your project. Make sure you know when you are supposed to set it up and take it down. Nobody is going to do that for you. If your project is left behind after the fair closes, it might be thrown away. Be sure you find out when you are supposed to pick it up.

7. Don't leave valuable items or things that are critical to your display unattended. Plan on not being able to take anything living, any liquids, or any hazardous materials such as cleaners or household chemicals into the fair. Instead, take a lot of pictures that you can attach to your display board. Check to find out what you can and cannot bring with you on the day of the fair.

Practice what you'll say to the judges!

Here are some questions that judges might ask you. It's a good idea to practice how you will answer them. Remember that your display **and your log** are there to help you and to help the judges understand what you did.

Question: What gave you the idea for your project?

Your answer should include:

Why you are interested in the topic.

What you wanted to learn.

Question: How did you learn more about your topic?

Your answer should include:

What books you read, what research you did online, what experts you talked to, and anything else you did to learn about your topic.

Question: What question did you have? (Or, what problem were you trying to solve?)

Your answer might start with "I wondered about..." or "I wanted to find a solution to the problem of..."

Question: What was your hypothesis? ("What did you think was going to happen?")

Your answer should include what you expected and why you expected that to happen. Even if it didn't turn out the way you expected, you should be ready to say what you expected.

Question: How did you set up your experiment?

Your answer to this question is really important. It's probably the most important question you'll be asked. Carefully describe how you set up the experiment so that it was fair. Talk about the control group, the constants, the independent variable and the dependent variable. Explain to the judge how you know that your experiment was fair. It would be really good to have your planning chart glued into your log! And don't forget to bring your log to the fair!

Question: How did you control your experiment?

If the judge asks this, it's pretty much the same as asking how you set up your experiment. If you are asked this question, the judge is especially interested in your control group, your constants, and your independent variable. The judge is listening to see if you had more than one independent variable. If it seems to the judge that you might have had more than one independent variable, or if they think you didn't pay attention to the constants, they'll ask a lot of questions about your data and how you collected it and whether you changed anything in the middle of the experiment.

Question: What was your procedure?

Your answer should include:

How you set up the experiment with constants and only one independent variable.

What you did when you were experimenting.

How you made measurements or collected data.

Question: If you did this project again, what changes would you make?

The judge is trying to find out if you recognize mistakes that you made. Be honest. If you know you made mistakes or if something unexpected happened and you had to do your best to recover from it, say so. Tell what you would suggest to anybody else who wanted to repeat your experiment, or who wanted to start where you left off and keep going with the experiment or the invention.

Question: What were the results?

Your answer should include the data (numbers) that you gathered. Point to your graph and explain what that graph shows. The judge wants to see that you know how to make a graph and that you can explain what it shows. This is the first time you need to explain whether your data supported your hypothesis or not, by using the data you collected. You should expect the judge to ask about any measurements that don't seem to support your original idea. (For example, what if the cactus stopped growing for a few days and then started growing again? You might be asked to explain why you thought that happened.

Question: What was your conclusion?

Your answer to this question needs to tell what you learned. Remember that scientists learn as much from mistakes as they do from experiments that turn out the way the scientist expected. When you talk about your conclusions, be honest about what didn't work, as well as what did work. The best way to phrase your conclusion is to say "My hypothesis was supported…", or "My hypothesis was partially supported…" But don't say "I was right." or "My hypothesis was right." A hypothesis can't be proven right with *one* experiment. It just can't. So don't say it was. Say it was **supported** or **partially supported** or **refuted** (refuted is the opposite of supported. It is pronounced re-**FEW**-ted).

You'll probably be pretty nervous when you start talking to the judges. They will do their best to calm you down. They're judges because they love science and want you to love science too. They are there to help you do good work. Try not to be nervous about talking to them. They ask you questions so that they can make suggestions, not so they can catch you doing something wrong. If you follow the suggestion in this guide, you'll do a great job and will impress those judges!

Hopefully you have realized by now that science fair projects are not something you can plan and do over a weekend. You need to think ahead, plan, and be careful. But if you do plan carefully, your science project will also be FUN and will help all of us know more about the world. Even at a very young age, you can do real scientific work. Go do it!

My Plan

Name ______________________

It's possible that..	So I will do this:

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