Science Fair Guide

Resources for Students

What Is a Science Project?

Scientists all over the world make new discoveries by using the scientific method. Now, you can join their ranks! A science project is your chance to choose a subject of interest to you and study it in the exact same way that a professional scientific researcher would.

You may choose to study a topic such as how lighting affects plants or how much of the air is oxygen. Whatever you choose to do, the worksheets on pp. 35–60 will lead you through each step of the scientific method and through each phase of the project. The worksheets will even help you choose your subject if you can't decide what to do. So, don't worry! The project is entirely yours. Your parents and teachers will be around to help you if you need it. You'll also have plenty of tools such as timelines and progress reports to help keep you on track.

Explore Your World The whole point of a science fair is to give you a chance to explore on your own. Exploration can be a lot of fun. Instead of reading about composting in a book, you can do experiments comparing store-bought fertilizer to compost that you have made. You may try to figure out what weather patterns would be like if the Earth were square. Or, you can discover what types of plants attract butterflies. Maybe you'll build a machine to test the difference between old golf balls and new golf balls. The fact is that your science project presents *your* creative solution to a question or problem. So good luck, and have a blast!

SCIENTIFIC METHOD

THE SCIENTIFIC METHOD

The steps of the scientific method that you'll be using appear below. Each step is explained in Phases 1–5 of this packet.*

Purpose: developing an investigative question

Hypothesis: making an educated guess about the answer to the investigative question based on research

Experiment: testing the hypothesis, collecting data, and making observations

Analysis: organizing data from the research and experimentation and looking for patterns

Conclusion: determining if the hypothesis is supported or disproved by the experimental results

Communicating the Results: sharing the conclusion with others

*In Chapter 1 of your textbook, these steps are called Ask a Question, Form a Hypothesis, Test the Hypothesis, Analyze the Results, Draw Conclusions, and Communicate Results.

Safety Guide

Science is a lot of fun, and you'll have the most fun if you avoid accidents. Some simple precautions can go a long way to ensure the safe and successful completion of your project.

The major causes of laboratory accidents are carelessness, lack of attention, and inappropriate behavior. Following the safety guidelines below will greatly reduce your chances of having an accident. While you are working on a science experiment at home, even a minor accident can cause serious injuries, so be very careful.

- Know the locations of the fire extinguisher, telephone, and first-aid kit in the event of an emergency.
- Always have an adult (parent or teacher) supervising the data collection phase of your science experiment.
- Wear safety goggles and tie back loose hair and clothing when working with any chemical, flame, or heating device.
- Wear an apron and gloves when using acids and bases.
- Never smell or taste a chemical unless instructed to do so by your teacher.
- Never use an electrical device with a frayed cord. Never use an electrical appliance with wet hands or with water nearby.
- Never eat any part of a plant used in an experiment.
- Whenever possible, use plastic test tubes, beakers, and flasks. Check all glassware for chips and cracks. Glass containers used for heating should be made of heat-resistant glass.
- Whenever possible, use a hot plate rather than an open flame or burner. Make sure to turn off and unplug a heating device when you are through with it.
- Check with your state board of education before experimenting with and exhibiting animals. Permits and/or veterinarian supervision may be required. Also, wash your hands with hot water and soap after touching any animal.
- Students and adults should wear ultraviolet safety goggles during operation of UV light.
- Do not use cultures from any warm-blooded animal.
- If you are planning on using X rays, cathode ray tubes, or radioactive substances, you must get information on federal guidelines for their use. Consult the Consumer Affairs Office of the Center for Devices and Radiological Health, a division of the Department of Health and Human Services.
- Many states require registration of lasers. Check with the state board of education for tips on how to register.
- Discuss the safety of your materials with your teacher or another scientist.

Safety Contract

I, __________________________, hereby certify that on this day of ____________________, I have successfully completed a review of safety procedures for a science project. I agree to follow the safety guidelines listed below, and I will take every necessary precaution to operate safely throughout my experiment.

- I will follow the safety guidelines of my teacher and my school.
- I will keep my work area neat and free of unnecessary papers, books, and materials. I will keep my clothing and hair neat and out of the way, and I will wear a safety apron and/or gloves if necessary.
- I know the location of all safety equipment (such as the fire extinguisher and first-aid kit) and the nearest telephone.
- I will wear safety goggles when handling chemicals, working with a flame, or performing any other activity that may cause harm to my eyes.
- I will not use chemicals, heat, electricity, or sharp objects until my teacher or parent instructs me to do so, and I will follow the adult's instructions carefully.
- I will be especially careful when using glassware. Before heating glassware, I will make sure that it is made of heat-resistant material, and I will never use cracked or chipped glassware.
- I will wash my hands immediately after handling hazardous materials. I will clean up all work areas before I leave the laboratory, put away all equipment and supplies, and turn off all water faucets, gas outlets, burners, and electric hot plates.

I understand and agree to the above and all other safety precautions presented to me in class. I am hereby ready to undertake my science project with safety from this day forward.

____
Student's signature

____
Teacher's signature

____
Parent's/guardian's signature

Name ______________________________ Date ______________ Class ____________

Student's Progress Report

For each step of each phase of the science project, mark the date it is due and the date you completed your work. Reward yourself for your hard work!

Phase 1—Generating an Idea	Date due	Date accomplished
I brainstormed five possible topics.		
I came up with two investigative questions for each topic.		
I consulted with my teacher and parents about project possibilities.		
I chose a suitable topic.		
I formed a hypothesis.		
I discussed topic and hypothesis with my teacher and gained approval.		
I recorded ideas in my science project journal.		

HOORAY! You've completed Phase 1—now you're on your way!

Phase 2—Researching and Planning	Date due	Date accomplished
I researched my hypothesis.		
I reconfirmed or changed my hypothesis based on further research and then gained teacher approval.		
I contacted all appropriate people before beginning data collection.		
I recorded all details of research so far in a bibliography in my science project journal.		
I filled out the Procedural Plan for Action and obtained necessary signatures.		
I developed the initial plan for display materials.		

WAY TO GO! You've completed Phase 2—give yourself a pat on the back!

Comments: ____

____

____

____

Student's Progress Report, continued

Phase 3—Data Collection and Analysis	Date due	Date accomplished
I conducted the experiment safely.		
I chose an appropriate sample size.		
I performed several trials of my experiment.		
I collected data accurately.		
I recorded all data and observations in my science project journal.		
I graphed or charted data and looked for trends.		
I prepared a written conclusion supported by the data.		

ALL RIGHT! You've completed Phase 3—you're halfway there!

Phase 4—Writing a Report	Date due	Date accomplished
I answered the questions on page 55.		
I prepared an outline and discussed it with my teacher.		
I prepared a draft and discussed it with my teacher.		
I revised the draft according to my teacher's feedback.		
I turned in the final draft of my written report.		

FANTASTIC! You've completed Phase 4—you're almost done!

Phase 5—Creating and Exhibiting a Display	Date due	Date accomplished
I sketched possible designs for my display.		
I created a display board within the appropriate parameters.		
I displayed the results in a clear and interesting manner.		
I gave an oral presentation as practice for the science fair interview.		

CONGRATULATIONS! You've completed your science project!

Phase 1—Generating an Idea: Science Fair Success

DURING THIS PHASE, YOU WILL

1. brainstorm five possible subjects
2. come up with two investigative questions per topic
3. consult with your teacher and parents about project possibilities
4. choose a suitable topic and investigative question
5. form a hypothesis
6. discuss topic and hypothesis with your teacher and gain approval
7. record ideas in your science project journal

Remember to update your Student's Progress Report as you go along. You will have until ______________ to finish Phase 1.

Your Journal: The Most Important Tool You'll Use
The first thing you'll need to do is sit down with your science project journal and brainstorm a list of possible science project topics. Keep all notes that you take and data that you collect in this journal. The point of having a science project journal is simple: if you write everything down in one place, you'll know where all of your information is during the entire project. It will also be much easier for you to show your progress to your teacher and parents. Because all of your project information will be in your journal, be sure to keep it in a safe place.

Brainstorming for Topics

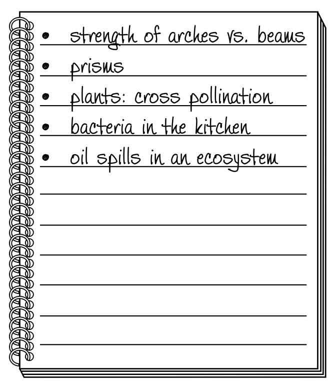
Here's where it all begins. By following the steps outlined in this section, you will take a general idea and narrow it down into a working science project. You will start with a general topic, choose a specific research question, and then develop the hypothesis that your experiment will test.

Ideas Galore! Brainstorming means coming up with as many interesting ideas as possible and writing them down in a list. Don't worry about how your ideas sound or whether you will actually pursue each topic. The important thing at this stage is to come up with a lot of ideas to choose from. The more ideas you have, the more likely it is that you will find one that is interesting and one that you'll enjoy working on for the entire length of the project.

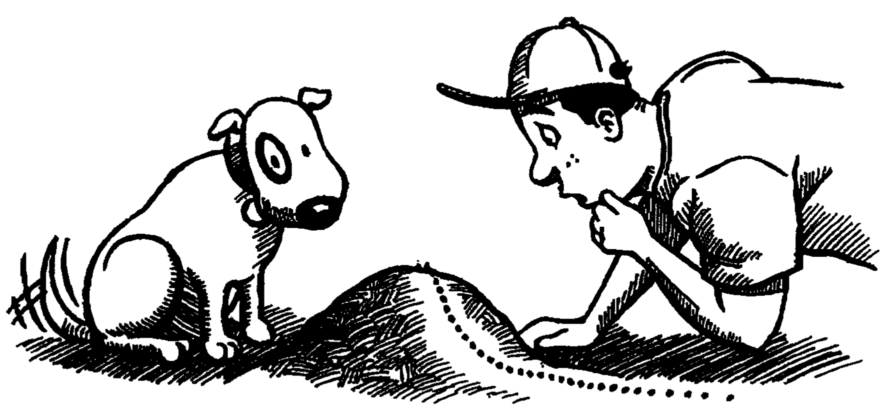
Make It Fun Since you'll be spending weeks or months preparing for the science fair, you really want to be sure that you have a true interest in finding out about your topic. Even though all of what you learn in school is worthwhile, most of the topics have been chosen by someone else. Take full advantage of the chance to choose something you're really interested in for your science project.

Getting Started

Find Out More To begin the brainstorming process, think about scientific topics you've always wanted to know more about. Maybe you've always been interested in the way mirrors work or the way light waves travel. Have you been on a field trip recently that sparked your interest or brought up some interesting questions? Now is your chance to find out more about your favorite science topics.



Solve a Mystery Another way to begin is to make a list of things that have mystified you. What makes a microwave oven cook some foods more quickly than a conventional oven? How do ants know to travel in a single line? Why are some bicycles faster than others? If the idea involves a mystery, chances are good that it would make an excellent topic for a science project.



The Library: Where the Topics Are Many kids get ideas from library books or even from the Internet. If you start researching early on in the process, you can get an idea of how much information has been written about your topic. Even though your goal is to design your own experiment, you're still going to have to research the topic. You will want to get some background information and determine how to go about testing your hypothesis. So don't be afraid of research. In the long run, it will actually make your project much easier for you.

TIP

An adult can help you think of an idea, but it is very important that your science project is clearly your own. At the science fair, your work will be compared only with that of other students close to your age.

From the list of topics that you brainstormed, choose five subjects that interest you most. Not all of these subjects have to be developed into an experiment; this is just a list of ideas of things that you may like to learn more about.

Investigative Question

When you've chosen five possible topics, you'll want to figure out what you want to know about each topic. Your investigative question is what you intend to find out during the course of your experiment. Using the topics you brainstormed earlier, you will choose a related question that your experiment will answer.

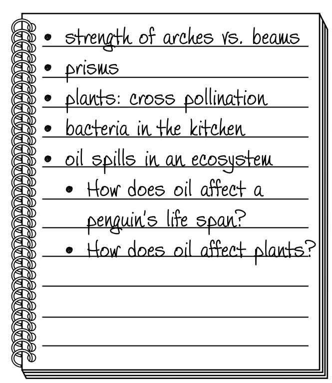
The Search Continues At the library, start by searching through the card catalog. (If you need help, ask your teacher or librarian. The faster you understand how to use the library's resources, the easier your research will be.) Look up key words from the subject that you are interested in. Looking up "oil spills" in the card catalog or *Reader's Guide to Periodical Literature* will lead you to a number of articles. If you have Internet access, you could try a search on "oil spills." You may include the word "penguin" in your search to find articles about how oil spills have affected penguins.

While you're at the library, try to think of two investigative questions that go with each topic you brainstormed. Record these ideas in your science project journal.

Here's an Example Let's say you decide to pursue the topic *oil spills*. You probably already know that large amounts of oil spilled into water can hurt the animals in an environment, but you want to know more. Maybe you want to know how an oil spill would affect a penguin's life span. Two investigative questions for this topic would be "How does oil in the water affect a marine ecosystem?" and "How do oil spills affect the life span of penguins?"

Choosing the *Best* Investigative Question The question "How does oil in the water affect a marine ecosystem?" is too broad to study in a short-term science experiment. Now consider the next question: "How do oil spills affect the life span of penguins?" The chances that you'll be able to do tests using penguins are very slim. You'll have to think of experiments that use resources available to you.

You don't have to throw out the topic if a particular experiment is not workable. Instead, think of a different testable question related to the same topic. For instance, you may want to learn more about how the ecosystem or food web of an area is affected when a large quantity of oil is introduced. This food web probably includes plant matter. Therefore, "How does oil affect plants?" is an example of a reasonable investigative question that you can test.



Consult with Your Teacher

Now you have ten investigative questions, two for each of five topics. It will become very clear that some of the possible experiments you are interested in would be too involved to do in a science project that lasts only 6 or 8 weeks. Or, you may be able to think of a way to do an experiment but realize that the materials you would want to use would be too expensive. At this stage, you'll have a conference with your teacher about the investigative questions that you have. He or she will help you settle on one investigative question to use for your science project.

Avoiding Problems

Keep in mind the limitations of the science project. Ask yourself the following questions about your topic:

- Are the materials you need affordable?
- Are the materials you need available?

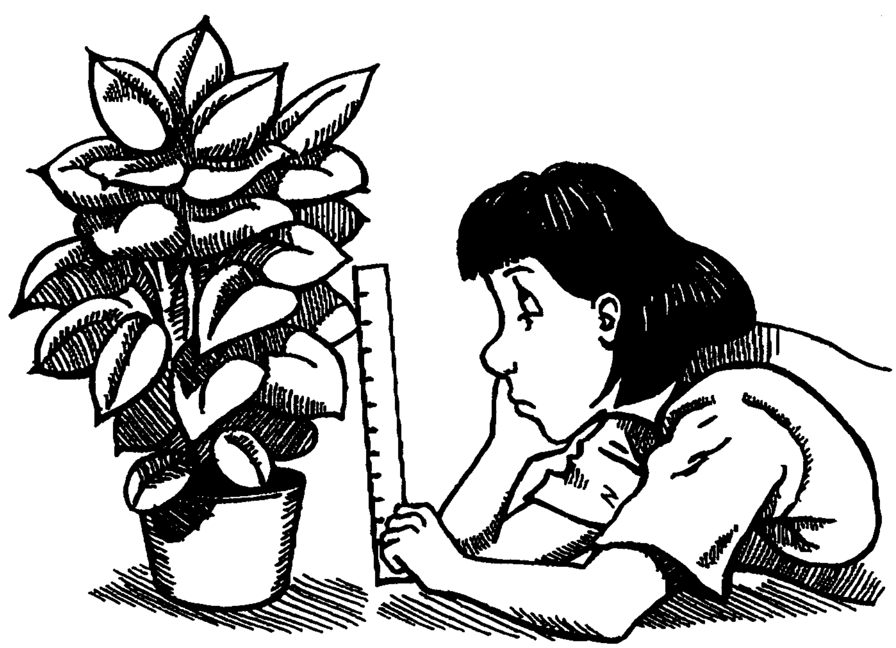
Consider the expense and availability of materials that you need for your project. For instance, unless you have access to an X-ray machine, you don't want to study how different materials affect the path of X rays.

- Does the science fair you are entering prohibit materials or specimens that you will need for your experiment?

Find out the limitations of the science fair itself. Ask your teacher about any restrictions on qualified science projects.

- How long will it take you to gather the necessary data?
- How much time do you have for data collection?

Be careful not to choose a topic that will take more time to investigate than you have to carry out the science project. For instance, you don't want to study the growth of a plant that grows only 2 cm a month.



Creativity Is the Key There are many ways to develop a workable project that is within your budget and still study a topic that interests you; it will just take a lot of creativity—and that's the key to a winning science project.

Forming a Hypothesis

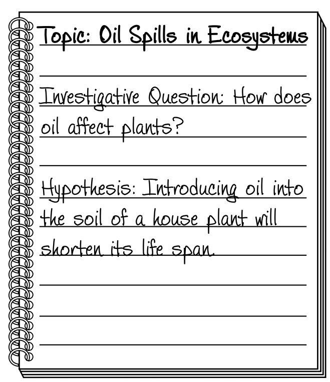
What Do You Think the Answer Is? Before you begin an experiment about oil spills, you would read about oil spills and guess that oil affects the health of plants in a negative way. It's typical scientific procedure to have an idea of the answer to your investigative question before you begin. In fact, the scientific method requires that you state a possible answer to the investigative question before you begin. This statement is called the hypothesis.

Some possible hypotheses for the investigative question "How does oil affect plants?" are

- "Oil does not affect the health of plants."
- "Oil negatively affects the health of plants."
- "Oil improves the health of plants."

What if the Hypothesis Is Inaccurate? It doesn't actually matter whether your hypothesis is accurate. The objective of a science project is to develop a hypothesis and then design a way to test it. In fact, few people will be concerned if the results of your experiment do not support your hypothesis. It is just as acceptable to have an inaccurate hypothesis as it is to have an accurate hypothesis—the challenge is in designing an effective experiment.

So take the plunge, and write down what you think will happen. After researching the example that we are using, you may come up with the following hypothesis:



✓ Make sure to check off the Phase 1 steps on your Student's Progress Report as you complete each one.

Phase 2—Research and Planning: Science Fair Success

DURING THIS PHASE, YOU WILL

1. research the hypothesis

2. change or reconfirm the hypothesis with the teacher

3. contact all appropriate people

4. record all research sources in the science project journal

5. fill out the Procedural Plan for Action and obtain signatures

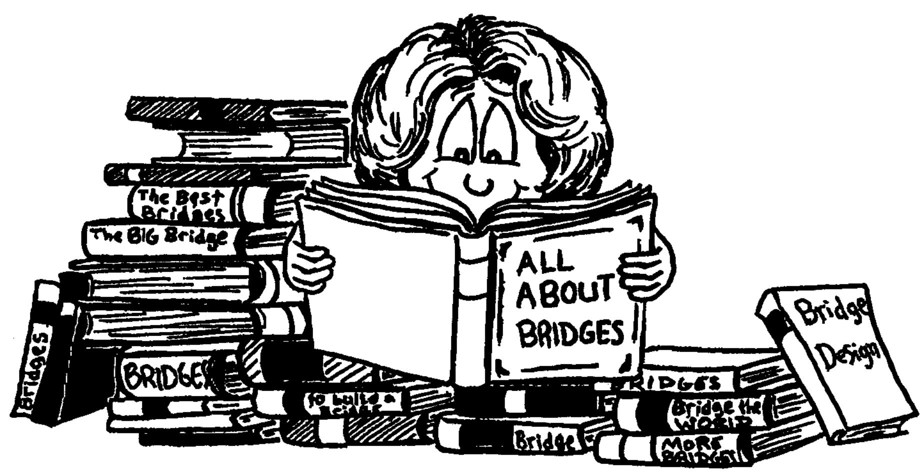
6. develop the initial plan for display materials

Remember to update your Student's Progress Report as you go along. You will have until ______________ to finish Phase 2.

Researching and Planning

Doing further research will help you decide what your experiment will be. Remember to write all of your research notes in your science project journal.

Imagine for a moment that your hypothesis is "Bridges with arches provide more support than simple beam bridges." For your project, you want to build two models: one testing the forces that bridges with beams can withstand and another testing the forces that bridges with beams *and* arches can withstand. Before you can really do this, you will have to read about the design of bridges.



Ensuring Success By thinking ahead, you can prevent problems from popping up later. So start planning now, and you'll be much more likely to end up with a successful project. Now's the time to

- make sure you have enough time to complete your experiment.
- make sure you can cover the costs involved.
- start thinking about the science fair display.
- ask others for any information or help you may need.

Is This the Project for You?

After additional library research, you'll check in with your teacher to reconfirm your hypothesis. By now, you probably have a good feel for how much information has been written on your topic. You may also have some good ideas about what you can do to test your hypothesis. If you need to change your topic at this point, you can still do so. If you feel that you won't have enough time or money to complete your experiment, speak to your teacher. Remember, this is your last chance to change topics! After this point you will be too far along in the timeline to safely change your plan of action.

Further Research

You have already begun researching your topic by the usual means, such as reading books and checking out the Internet. Perhaps you haven't thought about the following ways of gathering information:

Interview an Expert You might want to interview an expert in the field you're studying. If you are interested in studying sedimentary rocks, for example, you could talk to a geologist. A geologist could probably give you some good tips on where to find the materials you need. Remember to record the details of the interview in the bibliography section of your journal. You'll need to give the expert credit for the information that he or she has given you.

Let the Letter Ask Writing a letter is one of the best ways to get information. It sometimes takes a while to receive a response, though, so write as early as possible. Let's say you were interested in finding out how to dispose of paint and other chemical wastes without hurting the environment. You might write to someone at a paint company. You can ask for information in a letter like this one:

> Green Paint Company
> 4500 East South Street
> Detroit, Michigan 70555
>
> Dear Sir or Madam:
>
> I am a seventh grader preparing for the Springfield School District Annual Seventh-Grade Science Fair. The purpose of my experiment is to see how proper disposal of leftover paint can prevent heavy metals from contaminating drinking water supplies.
>
> Could your company provide me with a list of chemical ingredients contained in your product? I would also appreciate some guidelines on how to safely dispose of leftover paint.
>
> I hope you will be able to help. Thank you for your time and effort.
>
> Sincerely,
>
> *Meredith Phillips*

Thank Others for Their Help When you receive a response from a company, transfer any useful information into your science project journal. It's also a good idea to keep the actual letter in a safe place so that you can refer to it again later. Remember to thank anyone who helps you by supplying information or materials.

Citing All Your Sources

Your sources may include books, magazines, newspapers, Web sites, television programs, videos, or even interviews with live people. You will need to include all of these sources in the bibliography for your research paper. Your science project journal is the perfect place to keep track of this information.

How to Cite a Reference In your science project journal, record the title, author, publisher, and copyright date of each source that you use. If you perform an interview, record who you spoke to, what you discussed, and when and where the interview took place. You can keep all this information organized by devoting a few journal pages to your notes on information sources.

Preparing to Conduct the Experiment

You have a hypothesis that you are happy with, and you are learning more about your topic. Now it's time to consider a procedural plan for your experiment. Most scientific experiments follow the same basic rules, which are explained below.

Being in Control When testing your hypothesis, you'll want to establish a *control group* and one or more *experimental groups*. The control group and the experimental groups are exactly the same except for one factor, which varies in the experimental groups. The factor that differs is called the *variable*. Because the variable is the only factor that differs between the control group and the experimental group, scientists know that this factor is responsible for the results of the experiment.

If you were planning to test the effects of an arch on the strength of a bridge made of beams, you must test the strength of a bridge that doesn't have an arch and the strength of the same bridge with an arch. Bridges that have no arch (beam bridges) are in the control group. Bridges that have beams *and* arches are the experimental group. The variable is whether the bridge has an arch.

Then if you wanted to test the effects of suspension cables on the strength of a bridge, you'd use the same control group as before—beam bridges. Your experimental group would include beam bridges with suspension cables. The new variable is whether the bridge has suspension cables.

It Depends The physical structure of a bridge—whether it has an arch—can differ from one bridge to the next. Since the bridge's physical structure does not depend on any other characteristic, it is called the *independent variable*. The independent variable can be changed by the researcher.

The strength of the bridge *depends* on whether the bridge has an arch, so the strength of the bridge is the *dependent variable.* When you measure the dependent variable you are measuring the result that occurs when the researcher changes the independent variable. The dependent variable is what the experiment is actually measuring.

There Can Be Only One It is very important that you have only one variable. Otherwise you are not effectively testing your hypothesis. For instance, your test of the bridges' strengths would be influenced by the materials from which the bridges were made, so all bridges in your experiment must be made of the same materials. *All factors of the control group and the experimental group(s) must be exactly the same except for one variable.*

Experiments Versus Demonstrations When you don't know what you want to do for an experiment, it can be tempting to demonstrate a concept that scientists have already figured out. As a researcher, you will focus on performing an experiment instead of a demonstration. Though modeling a volcano's eruption is an interesting demonstration, it is *not* an experiment. Figuring out how altitude affects the boiling point of water *is* an experiment. Ask your teacher if you need help developing an experiment that tests your hypothesis.

The Procedural Plan

Look on the next page to find a blank form for your Procedural Plan for Action. You can use this worksheet to write down your ideas for your experiment. It can help you think through the details of your science fair project.

When completing the procedural plan, it is important to begin planning for the display. Your teacher will provide you with a list of rules for the science fair you are going to enter. The rules will include important information about display sizes and materials. You will also need to begin gathering the materials that you will need for the experiment and the science fair.

Put Your Ducks in a Row Some students find it helpful to use a schedule or a list to organize all the work that they need to do. You can use the Task List (page 48) to create your own personal schedule. Fill out your task list however you like. You can use it as a personal to-do list or as a place to write down which days you want to go to the library or meet with your teacher.

✓ Make sure to check off the Phase 2 steps on your Student's Progress Report as you complete each one.

Name ______________________________ Date ______________ Class ____________

Procedural Plan for Action

Describe your experiment's procedure.	
What will be your control group?	
What will be your experimental group?	
What is your dependent variable?	What is your independent variable?
What kind of location or setting will you need for your experiment?	
What kind of materials will you need for your experiment?	
What costs do you expect?	

Parent Signature ______________________________ Date ______________

Teacher Signature ______________________________ Date ______________

Name ____ Date ________________ Class _____________

Task List

Task to be accomplished	Goal date	Date accomplished

Phase 3—Data Collection and Analysis: Science Fair Success

DURING THIS PHASE, YOU WILL

1. conduct the experiment safely
2. choose an appropriate sample size
3. perform several trials of the experiment
4. collect data accurately
5. record all data and observations in your science project journal
6. graph or chart the data and look for trends
7. prepare a written conclusion supported by the data

Before You Begin

- **Have your teacher or parent approve your experiment.**
- **Read over your Safety Contract.**
- **During the data collection, make sure that there is an adult present.**

Your teacher will schedule some in-class data collection days, so remember to take the necessary materials to class. Don't forget to update your Student's Progress Report as you go along. You will have until _______________ to complete Phase 3.

Types of Data

Data can take two different forms: data can be *quantitative* (a value that can be measured or counted) or *qualitative* (a value that can be described but cannot be measured or counted). Some projects may combine both forms of data.

Quantitative Data: Count It Up *Quantity* and *quantitative* have the same word root. Just remember that quantitative data have to do with numbers or quantities that you can measure. Examples of quantitative data are the number of bird chirps that you hear on a cold day or the width of a layer of rock in a cliff wall.

Qualitative Data: Spell It Out The word *quality* is related to the word *qualitative.* Taking qualitative data means that you will be describing your observations with adjectives instead of numbers. Examples of qualitative data are descriptions of the color and shape of the rock in each layer of a cliff wall. Drawings and photographs are also qualitative data.

Whichever kind of data you have decided to collect, *remember to write it down.* Be certain to record *all* results of your tests in your science project journal. Recording everything as it happens not only will help you keep your information in one place but also will make it easier for you to avoid errors.

Sample Size and Multiple Trials

Test More Than One Subject *Sample size* is the number of subjects you test. Your sample size must be large enough to allow you to draw accurate conclusions from your data.

For example, if you were comparing the differences in hand-eye coordination between 20-year-old and 40-year-old women, the data taken from just one woman in her 20s may not give you accurate results. She could be the fastest woman in the world! Testing only her, you would conclude—possibly incorrectly—that all women in their 20s are faster than all women in their 40s. If you tested several other women in their 20s and compared this data to the data taken from several 40-year-old women, you would have a more realistic picture of the actual trends among 40-year-olds and 20-year-olds.

Record in your journal the number of subjects that you tested. Also record any details that might affect your results. For instance, in the example above, you would record each subject's age, sex, height, weight, the time of day the subject was tested, the number of times you tested each subject, etc.

Play It Again, Sam! When you are conducting an experiment, it is necessary to do *multiple trials*. This means you should perform each test several times. For instance, if you are going to compare your body temperature in the morning with your body temperature in the evening as part of your project, make sure that you test your temperature on several days before you try to draw any conclusions. And if one day's temperature differs wildly from the rest, you might consider that there was an error and try to figure out what went wrong.

Taking Accurate Measurements

Scientists need to be as exact as possible in taking measurements. It's almost impossible to measure something exactly, so scientists usually measure something more than once and then use the average of the results. This approach helps to account for the uncertainty of each individual measurement.

Always double-check the measurements you take before you record them in your journal. Measure carefully and make each measurement level. For instance, if your experiment requires the use of measuring spoons or cups, be consistent: don't fill some of them so that they are heaping and others so that they are not quite full.

Go Global Most scientists use the International System of Units (SI) in all their work. The International System of Units is a global measurement system that helps scientists share and compare their observations and results. It is usually best to use this system, and some science fairs require that all measurements be expressed in SI units. Your teacher has a unit conversion chart for common measurements of length, mass, volume, and temperature that may be useful.

Creating Charts and Graphs

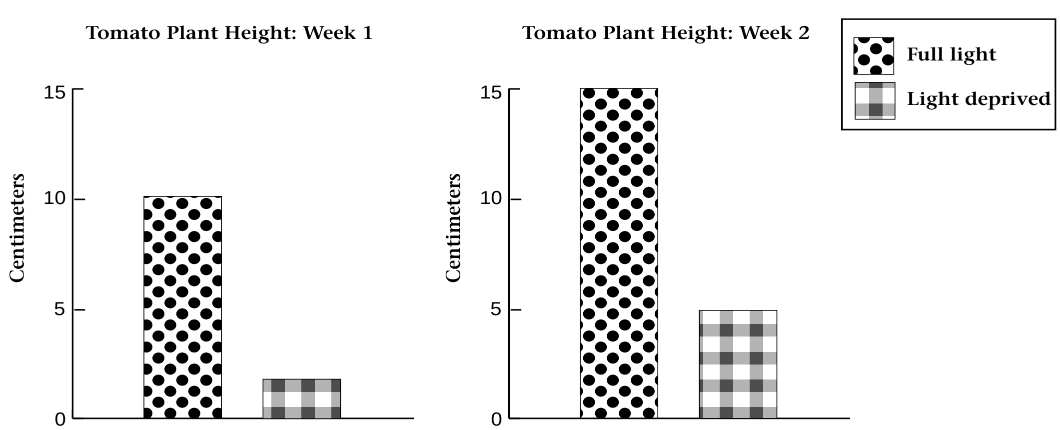
As you are collecting your data, you may want to keep in mind that you will be required to display your results and conclusions at the science fair. You can make it easy for people to understand the relationship between your variables by displaying your data in a chart or graph. It may be useful for you to make the first drafts of your graphs in your journal. This will let you decide the best way to illustrate your data before you make the final graphs for your display.

> **TIP**
>
> When you create a graph, make sure that you leave equal spaces between the numbers on the axes and that you number the axes consistently. For instance, if you start with the number 0 and the next values are 5 and 10, you can't skip to 20. The next number would have to be 15.

Bar Graphs

Use a *bar graph* if you want to compare different types of data. In the case of a bar graph, each bar represents a group of data.

- It is important to make it easy to identify each bar. For example, you could choose to use polka-dotted bars for one group of data and striped bars for another.
- Every graph always needs a key so that people can easily tell what each color or pattern represents.
- Make each key the same so that graphs are easy to compare. That way, if you had measured data on three different days, a person could quickly distinguish between the groups of data.

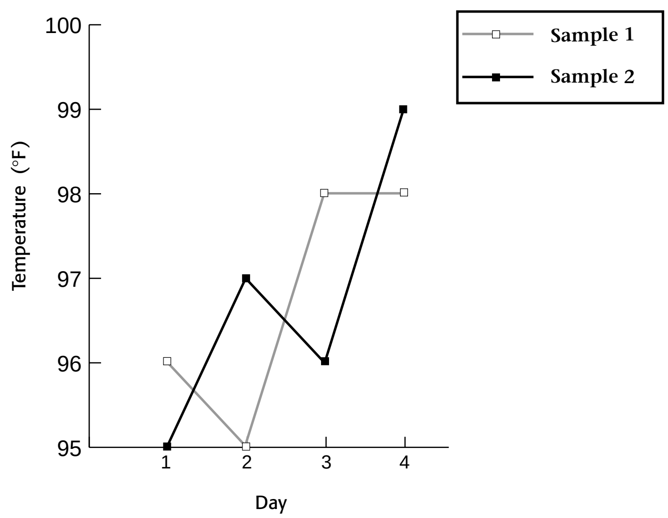


Line Graphs

Use a *line graph* if you want to show how the dependent variable is affected by changes in the independent variable or if you want to show how data change over time.

- In a line graph, place the dependent variable on the vertical (up-and-down) axis, or the *y*-axis. The independent variable should be on the horizontal (left-to-right) axis, or the *x*-axis.
- Plot your data as carefully as possible. Then connect the points.
- If you decide to record the results of more than one experiment on one line graph, you may choose to use a different color of ink for each set of points (and the connecting line). Be sure to include a key explaining the colors.

Temperature Variation over 4 Days



> **TIPS**
>
> This is where graph paper will come in handy. Your graph will be much neater and easier to draw if you use graph paper. You will find a sheet of graph paper on page 54.

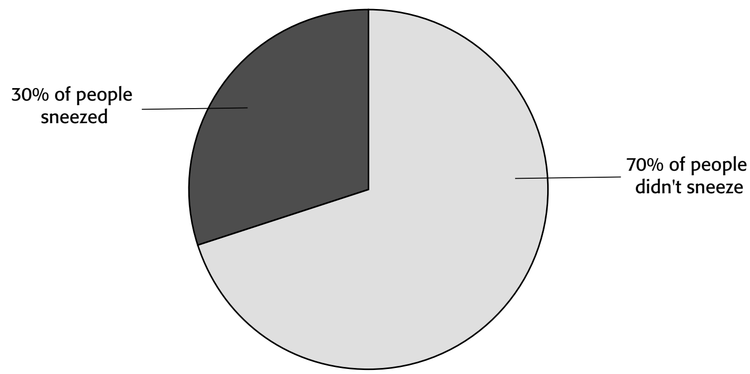
Pie Charts

Showing percentages is easy to do with a *pie chart,* a round chart that looks like a sliced pie. You can quickly see which group has the biggest slice and therefore contains the most data.

- The size of a group's slice indicates the proportion of the whole that the group represents. Say you want to show that 30 percent of people in an experiment sneezed when exposed to a bright light and 70 percent of people didn't sneeze. You would use 30 percent of the circle to represent the sneezers.
- A circle has 360°, so you would multiply 0.30 by 360° to get the number of degrees that should be used to represent the sneezers.

$$\mathbf{0.30 \times 360° = 108°}$$

Sneezing After Exposure to 10 Minutes of Bright Light



- Using a protractor, you would measure out 108° of the circle for the sneezers. The other part of the pie chart (252°) would be reserved for the nonsneezers.
- Make each section of the chart a different color and include a key or labels to make the graph easy to understand.

Analyzing Data and Drawing a Conclusion

After you've gathered all of your data, you'll want to analyze your results. In the analysis, ask yourself, "What are the data telling me? What trends do I see in my graphs? Are the data for the control group different than the data for the experimental group?" Write your analysis in your science project journal.

What Does It All *Mean*? If your results are mathematical, it will help you to understand the concepts of *mean* and *median.* Mean is the average of your data, and median is the middle-most value when all measurements are listed in order from smallest to largest. Two experiments may have the same average result but differ in how the results are distributed. Compare the means and medians and see how they differ. Ask your teacher or your parents for help with mathematical concepts that you aren't sure about.

Drawing Conclusions

The main question you should ask yourself when drawing a conclusion is, "Do my results agree with my hypothesis?" If they do, why do you think they do? If they don't, how are they different? And, why do you think they differ? Remember that it is *not* important for the hypothesis to be correct. It is important, however, that you explain *why* you got the results you did. Write your conclusions in your science project journal.

Be sure to mention in your conclusion what factors you believe contributed to your results. Then, briefly explain possibilities for new experiments that would control these factors. Also, mention any investigative questions that came up during the experiment. These questions will guide other researchers who find your results interesting and want to study the topic more.

✓ Make sure to check off the Phase 3 steps on your Student's Progress Report as you complete each one.

Name ______________________________ Date ______________ Class ____________

Phase 4—Writing a Report: Science Fair Success

DURING THIS PHASE, YOU WILL

1. answer the questions on this page
2. prepare an outline and discuss it with your teacher
3. prepare a draft and discuss it with your teacher
4. revise the draft according to your teacher's feedback
5. turn in a completed draft

All of the time you've spent recording every little detail in your science project journal is about to pay off. Your written report will represent your ideas and conclusions about your project, so you'll want to make sure that it is well thought out and neatly prepared. Don't forget to update your Student's Progress Report as you go along. You will have until ______________ to complete Phase 4.

Putting Your Ideas on Paper

Before you begin, answer the following questions in your science project journal. When you are through, you may have a better idea of how to start on your written report.

1. *How did you first decide on your idea?*
2. *What was your favorite aspect of the experiment?*
3. *What was something new that you learned?*
4. *What was something unexpected that happened?*
5. *What were the ups and downs of the whole process?*
6. *What did your data show?*
7. *What would you do differently next time?*

TIP

Have fun with your report. You've already done most of the work. Now, just carefully describe what you did in each phase, and explain every detail of your experience.

Creating an Outline

Now that you've answered the questions on this page, you are ready to make an outline of your report. An outline is a framework of what is going to go inside a report. Most scientific reports follow the same order as the steps of the scientific method, explaining the entire process from beginning to end. Using index cards for each idea will allow you to make sure that all the information makes sense in the order that you are going to tell it.

Making a List Include at the beginning of the report any background information that a reader would need to understand your project. Then you will state the purpose and hypothesis of your project. Briefly describe your procedure and the data that you acquired. Finally, you'll want to illustrate your conclusion using charts, graphs, or photographs of your data. You may want to include your answers to the questions on page 55.

TIP

You may choose to use some of your charts or graphs in your report. The best figures to use are those that clearly show the trends you found in your data. Always title and label your figures, and, if possible, write a sentence telling what they illustrate.

Checking It Twice When you are done, have your teacher check your outline. Your teacher will make some suggestions about how to improve your report. Pretend the report is not your own, and try to see how your teacher's suggestions could make it even better. Professional scientists and writers get constructive criticism about everything they do before they show their results to the world. It is an important part of the writing process, and it will help you improve your report so that it is ready to impress the science fair judges.

Writing the Draft

After you've thought about your teacher's suggestions, you may want to change your outline. When you are happy with your outline, you can start a draft of the written report.

TIPS

The following are some helpful writing tips:

- Before you begin, make sure that you know how many pages your report should be.
- As you write, you may ask your parents to read sections to make sure that you are on the right track.
- Show your finished draft to your teacher. Your teacher will make comments to help you create the best project that you possibly can.
- Don't forget about neatness and spelling! Judges will notice if you have not been careful in your work.
- Finally, remember to complete a bibliography of the sources you used. Be sure to give credit to the people who helped you in your project—your teacher, your parents, professional scientists, or others.

✓ Make sure to check off the Phase 4 steps on your Student's Progress Report as you complete each one.

Phase 5—Creating and Exhibiting a Display: Science Fair Success

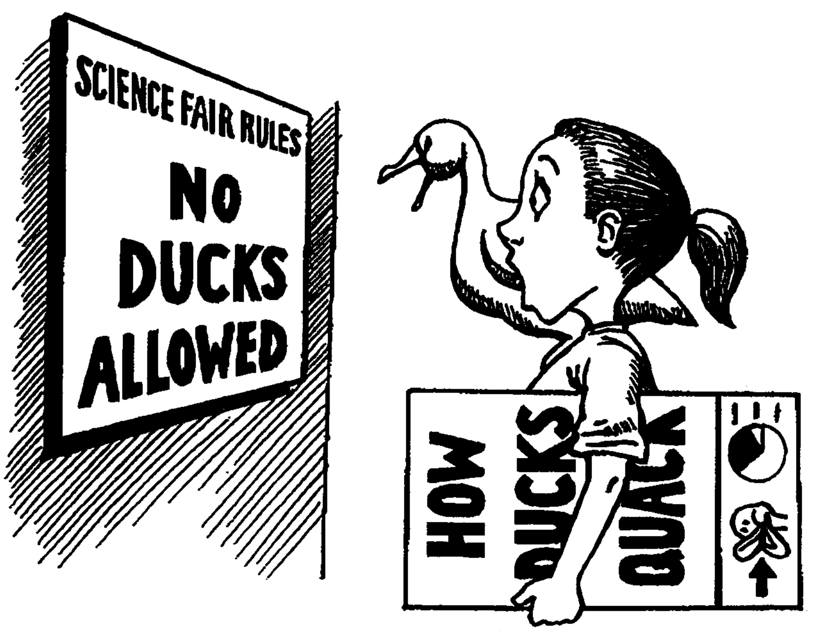
During this phase, you will

1. sketch possible designs for the display
2. create a display board within the appropriate parameters
3. display results in a clear and interesting manner
4. give an oral presentation as practice for the science fair interview

After this phase, you can tell everyone that you know what it is like to be a real scientific researcher—and mean it! Don't forget to update your Student's Progress Report as you go along. You will have until ______________ to complete Phase 5.

Before You Begin

Before you begin your display, review the science fair display and interview guidelines. Some science fairs have a list of items and materials that you are not allowed to use in a display. Double-check to be sure you have followed these guidelines. You wouldn't want to be disqualified after all of the hard work you've already done.

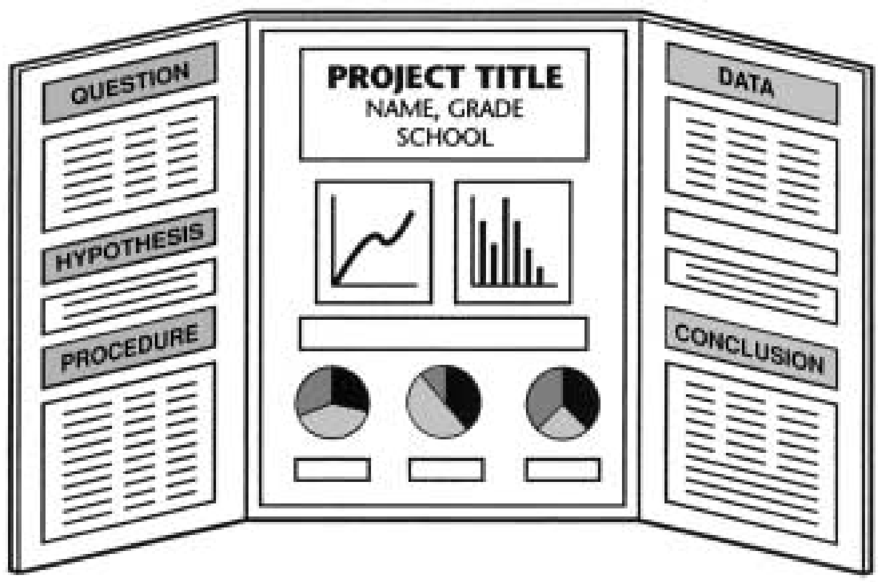


The Layout of Your Display

Displays are usually divided into three sections. You can bend a cardboard box so that it has a large middle section and two smaller "wings" that fold inward across the center. This design allows your display to fold flat, making it easier to transport and store. You can purchase hinges at an art supply or hardware store if you prefer to attach the "wings" that way.

PART 2: RESOURCES FOR STUDENTS

An Example The illustration below is one example of how information can be laid out on the display. You can do it differently, but remember to place the information from left to right in the general order that you performed each item. It is also common to place models, samples, demonstration props, or small pieces of equipment in front of the display board.



Here's how the information is organized on the display shown above:

- **Top Left** This section provides basic background information and introduces the purpose and hypothesis of the project.
- **Bottom Left** This section briefly explains the procedure that was followed (review your Procedural Plan for Action).
- **Right-hand Panel** Brief written summaries of the data and the conclusions are located on this panel. The research is displayed so that it is obvious that the data support the conclusions.
- **Center** The middle panel contains the title of the project and the name, grade, and school of the researcher. Charts, graphs, photographs, and other illustrations are displayed here.
- **Keep It Simple** The display touches on all aspects of the project, but keeps the information general. The details of the project belong in the written report.

Designing Your Display

Back to the Drawing Board Before you construct a display, sketch some ideas of how you want your display to look. Sketching it out on paper lets you easily choose colors, borders, sizes, lettering, and even arrangement of items in your display.

Materials Most students will use corrugated cardboard, cork board, or foam core to construct their display. You can recycle by calling a local appliance store to get a large, corrugated box from a refrigerator, washing machine, or TV. Observe appropriate safety precautions and make sure that an adult helps you cut the cardboard to regulation size.

Remember—Neatness Counts! There may be requirements about the lettering for the display. If you write the information for your display by hand, make sure the writing is neat and easy to read. Your main title and major subtitles should be readable from a distance, and any other information can be smaller. If you use paper or plastic lettering or stencils, use a ruler to apply them in a straight line.

Creative, Yet Clear While you want your display to be as interesting as possible, the design should not distract from the content. Be creative with borders, font, and layout, but make sure that a judge would find it easy to read the information contained in the display. Illustrations should be informative, not just decorative. In your display, you want to impress the judges with the project's seriousness yet be unique and have some fun.

TIP

A simple display is best if it clearly shows what you have learned. An expensive computer display or a flashy presentation is useful only if it relates to your results and helps make your conclusions more clear.

The Interview

If you are going to make a presentation to the judges, it's in your best interest to practice at least once. Practice explaining your project to someone who knows nothing about it. Your family and your classmates are good audiences. It may be difficult at first, but once you run through it a few times, you'll have a great advantage over students who haven't bothered to practice. If you're part of a group project, each person in the group should be responsible for presenting a certain aspect of the project, such as the purpose, hypothesis, or conclusion.

Summarize It! You'll want to prepare a summary of what you did. You can do this by following the steps below.

- Explain why your subject interested you.
- Define the hypothesis you developed.
- Describe how you decided what type of data to collect.
- Outline your Procedural Plan for Action.
- Summarize the data you actually collected.
- Explain the conclusions you drew after you analyzed the data.
- Describe to the judges what you would do differently if you had another chance, and tell them why.

Tricks of the Trade Here are more suggestions that may help you during the interview:

- Carry an index card with an outline of what you want to say, and refer to it if you forget something during your interview.
- Don't read to the judges from your report or from notes—they would rather hear you speak naturally.
- Have copies of the written report near your display so that interested people can learn more about your project.
- Offer a copy of your report to the judges so that they can read about what you have done.
- If a judge asks you a question that you are unable to answer, stay calm. Explain that you aren't sure about the answer to that question, and offer to explain a part of the project that you're more comfortable with.
- If the judge offers you suggestions or says that he or she might have done something differently, try not to react angrily. The judge is only trying to help you be a better scientist.
- It is perfectly natural to be nervous—even seasoned scientists get the jitters. Just remember that this is your project and you are the best person to explain it to others!

✓ Make sure to check off the Phase 5 steps on your Student's Progress Report as you complete each one.