I

A GUIDE TO SCIENCE FAIR PROJECTS

Chapter 1

The Scientific Method

A science project is an investigation using the scientific method to discover the answer to a scientific problem. Before starting your project, you need to understand the scientific method. This chapter uses examples to illustrate and explain the basic steps of the scientific method. Chapters 2 through 4 give more details, and Chapter 5 uses the scientific method in a sample project. The **scientific method** is the "tool" that scientists use to find the answers to questions. It is the process of thinking through the possible solutions to a problem and testing each possibility for the best solution. The scientific method involves the following steps: doing research, identifying the problem, stating a hypothesis, conducting project experimentation, and reaching a conclusion.

RESEARCH

Research is the process of collecting information from your own experiences, knowledgeable sources, and data from exploratory experiments. Your first research is used to select a project topic. This is called topic research. For example, you observe a black growth on bread slices and wonder how it got there. Because of this experience, you decide to learn more about mold growth. Your topic will be about fungal reproduction. **(Fungal** refers to plantlike organisms called fungi, which cannot make their own food, and **reproduction** is the making of a new offspring.)

CAUTION: If you are allergic to mold, this is not a topic you would investigate. Choose a topic that is safe for you to do.

Once the topic is selected, you begin what is called project research. This is research to help you understand the topic, express a problem, propose a hypothesis, and design one or more project experiments—experiments designed to test the hypothesis. An example of project research would be to place a fresh loaf of white bread in a bread box and observe the bread over a period of time as an exploratory experiment. The result of this experiment and other research gives you the needed information for the next step—identifying the problem.

Do use many references from printed sources—books, journals, magazines, and newspapers—as well as electronic sources—computer software and on-line services.

Do gather information from professionals—instructors, librarians, and scientists, such as physicians and veterinarians.

Do perform other exploratory experiments, such as those in the 50 science project ideas in Part II.

PROBLEM

The problem is the scientific question to be solved. It is best expressed as an "open-ended" question, which is a question that is answered with a statement, not just a yes or a no. For example, "How does light affect the reproduction of bread mold on white bread?"

Do limit your problem. Note that the previous question is about one life process of molds—reproduction; one type of mold—bread mold; one type of bread—white bread; and one factor that affects its growth—light. To find the answer to a question such as "How does light affect molds?" would require that you test different life processes and an extensive variety of molds.

Do choose a problem that can be solved experimentally. For example, the question "What is a mold?" can be answered by finding the definition of the word *mold* in the dictionary. But, "At room temperature, what is the growth rate of bread mold on white bread?" is a question that can be answered by experimentation.

HYPOTHESIS

A hypothesis is an idea about the solution to a problem, based on knowledge and research. While the hypothesis is a single statement, it is the key to a successful project. All of your project research is done with the goal of expressing a problem, proposing an answer to it—the hypothesis, and designing project experimentation. Then all of your project experimenting will be performed to test the hypothesis. The hypothesis should make a claim about how two factors relate. For example, in the following sample hypothesis, the two relating factors are light and bread mold growth. Here is one example of a hypothesis for the earlier problem question:

"I believe that bread mold does not need light for reproduction on white bread. I base my hypothesis on these facts:

- Organisms with chlorophyll need light to survive. Molds do not have chlorophyll.
- In my exploratory experiment, bread mold grew on white bread kept in a dark bread box."

Do state facts from past experiences or observations on which you based your hypothesis.

Do write down your hypothesis before beginning the project experimentation.

Don't change your hypothesis even if experimentation does not support it. If time permits, repeat or redesign the experiment to confirm your results.

PROJECT EXPERIMENTATION

Project experimentation is the process of testing a hypothesis. The things that have an effect on the experiment are called **variables.** There are three kinds of variables that you need to identify in your experiments: independent, dependent, and controlled. The **independent variable** is the variable you purposely manipulate (change). The **dependent variable** is the variable being observed that changes in response to the independent variable. The variables that are not changed are called **controlled variables.**

The problem in this chapter concerns the effect of light on the reproduction of bread mold. The independent variable for the experiment is light and the dependent variable is bread mold reproduction. A **control** is a test in which the independent variable is kept constant in order to measure changes in the dependent variable. In a control, all variables are identical to the experimental setup—your original setup—except for the independent variable. Factors that are identical in both the experimental setup and the control setup are the controlled variables. For example, prepare the experiment by placing three or four loaves of white bread in cardboard boxes the size of a bread box, one loaf per box. Close the boxes so that they receive no light. If, at the end of a set time period, the mold grows, you might decide that no light was needed for mold reproduction. But, before making this decision, you must determine experimentally if the mold would grow with light. Thus, control groups must be set up of bread that receives light throughout the testing period. Do this by placing an equal number of loaves in comparable-size boxes, but leave them open.

The other variables for the experimental and control setup, such as the environmental conditions for the room where the boxes are placed—temperature and humidity—and the brand of the breads used must be kept the same. These are controlled variables.

Note that when designing the procedure of your project experiment, include steps for measuring the results. For example, to measure the amount of mold growth, you might draw ½ inch (1 cm) squares on a transparent sheet of plastic. This could be placed over the bread and the number of squares with mold growth could be counted. Also, as it is best to perform the experiment more than once, it is also good to have more than one control. You might have one control for every experimental setup.

Do have only one independent variable during an experiment.

Do repeat the experiment more than once to verify your results.

Do have a control.

Do have more than one control, with each being identical.

Do organize data. (See Chapter 5, "A Sample Project," for information on organizing data from experiments.)

PROJECT CONCLUSION

The **project conclusion** is a summary of the results of the project experimentation and a statement of how the results relate to the hypothesis. Reasons for experimental results that are contrary to the hypothesis are included. If applicable, the conclusion can end by giving ideas for further testing.

If your results do not support your hypothesis:

Don't change your hypothesis.

Don't leave out experimental results that do not support your hypothesis.

Do give possible reasons for the difference between your hypothesis and the experimental results.

Do give ways that you can experiment further to confirm the results of your original experiment.

If your results support your hypothesis:

For example, you might say, "As stated in my hypothesis, I believe that light is not necessary for bread mold to reproduce. My experimentation supports the idea that bread mold will reproduce without light. After 21 days, bread mold had grown both on testing samples kept in the dark and also on the control samples in the light. It is possible that temperature is a factor and that the temperature was higher inside the closed boxes due to lack of air circulation. For further testing, I would select temperature as the independent variable and test the effect of temperature changes on the growth of bread mold."

Chapter 2

Topic Research

Now that you understand the scientific method, you are ready to get started.

KEEP A JOURNAL

Purchase a bound notebook to serve as your **journal**. This notebook should contain topic and project research. It should contain not only your original ideas but also ideas you get from printed sources or from people. It should also include descriptions of your exploratory and project experiments as well as diagrams, graphs, and written observations of all your results.

Every entry should be as neat as possible and dated. A neat, orderly journal provides a complete and accurate record of your project from start to finish, and it can be used to write your project report. It is also proof of the time you spent searching out the answers to the scientific mystery you undertook to solve. You will want to display the journal with your completed project.

SELECTING A TOPIC

Obviously you want to get an A+ on your project, win awards at the science fair, and learn many new things about science. Some or all of these goals are possible, but you will have to spend a lot of time working on your project, so choose a topic that interests you. It is best to pick a topic and stick with it, but if you find after some work that your topic is not as interesting as you originally thought, stop and select another one. Since it takes time to develop a good project, it is unwise to repeatedly jump from one topic to another. You may in fact decide to stick with your original idea even if it is not as exciting as you had expected. You might just uncover some very interesting facts that you didn't know.

Remember that the objective of a science project is to learn more about science. Your project doesn't have to be highly complex to be successful. Excellent projects can be developed that answer very basic and fundamental questions about events or situations encountered on a daily basis. There are many easy ways of selecting a topic. The following are just a few of them.

LOOK CLOSELY AT THE WORLD AROUND YOU

You can turn everyday experiences into a project topic by using the "exploring" question "I wonder . . . ?" For example, you often see cut flowers in a vase of water. These flowers stay pretty for days. If you express this as an exploring question—"I wonder, why do cut flowers last so long in a vase of water?"—you have a good question about plants. But could this be a project topic? Think about it! Is it only the water in the vase that keeps the flowers fresh? Does it matter how the flower stems are cut? By continuing to ask questions, you zero in on the topic of water movement through plants.

Keep your eyes and ears open, and start asking yourself more exploring questions, such as "I wonder, why does my dad paint our house so often?" "I wonder, do different brands of paint last longer?" "I wonder, could I test different kinds of paint on small pieces of wood?" To know more about these things, you can research and design a whole science fair project about the topic of the durability of different kinds of paint. You will be pleasantly surprised at the number of possible project ideas that will come to mind when you begin to look around and use "exploring" questions.

There are an amazing number of comments stated and questions asked by you and those around you each day that could be used to develop science project topics. Be alert and listen for a statement such as "He's a chip off the old block, a southpaw like his dad." If you are in the searching phase of your science fair project, this statement can become an exploring question, such as "I wonder, what percentage of people are left-handed?" or "I wonder, are there more left-handed boys than girls?" These questions could lead you to developing a project about the topic of genetics (inheriting characteristics from one's parents).

CHOOSE A TOPIC FROM YOUR EXPERIENCE

Having a cold is not pleasant, but you could use this "distasteful" experience as a means of selecting a project topic. For example, you may remember that when you had a cold, food did not taste as good. Ask yourself, "I wonder, was this because my nose was stopped up and I couldn't smell the food?" A project about taste and smell could be very successful. After research, you might decide on a problem question such as "How does smell affect taste?" Propose your hypothesis and start designing your project experiment. For more on developing a project, see Chapter 5, "A Sample Project."

FIND A TOPIC IN SCIENCE MAGAZINES

Don't expect topic ideas in science magazines to include detailed instructions on how to perform experiments and design displays. What you can look for are facts that interest you and that lead you to ask exploring questions. An article about Antarctic animals might bring to mind these exploring questions: "I wonder, how do penguins stay warm?" "I wonder, do fat penguins stay warmer than skinny penguins?" Wow! Body insulation, another great project topic.

SELECT A TOPIC FROM A BOOK ON SCIENCE FAIR PROJECTS OR SCIENCE EXPERIMENTS

Science fair project books, such as this one, can provide you with many different topics to choose from. Even though science experiment books do not give you as much direction as science fair project books, many can provide you with exploratory "cookbook" experiments that tell you what to do, what the results should be, and why. But it will be up to you to provide all the exploring questions and ideas for further experimentation. The 50 project ideas described in this book can further sharpen your skills at expressing exploring questions. A list of different project and experiment books can be found in Appendix A.

SOMETHING TO CONSIDER

You are encouraged not to experiment with vertebrate animals or bacteria. If you do wish to include them in your project, ask your teacher about special permission forms required by your local fair organization. Supervision by a professional, such as a veterinarian or physician, is usually required. The project must cause no harm or undue stress to the subject.

Chapter 3

Categories

Every fair has a list of categories, and you need to seek your teacher's advice when deciding which category you should enter your project in. It is important that you enter your project in the correct category. Since science fair judges are required to judge the content of each project based on the category in which it is entered, you would be seriously penalized if you were to enter your project in the wrong category. Listed here are common science fair categories with a brief description of each. Some topics can correctly be placed in more than one category; for example, the structure of plants could be in botany or anatomy. Each of the 50 project ideas in Part II is labeled with the category in which the project could be entered. The categories are

- **astronomy:** The study of the solar system, stars, and the universe.
- **biology:** The study of living things.
  1. **botany:** The study of plants and plant life. Subtopics may include the following:
     - **a. anatomy:** The study of the structure of plants, such as cells and seed structure.
     - **b. behaviorism:** The study of actions that alter the relationship between a plant and its environment.
     - **c. physiology:** The study of life processes of plants, such as propagation, germination, and transportation of nutrients.
  2. **zoology:** The study of animals and animal life. Subtopics may include the following:
     - **a. anatomy:** The study of the structure and use of animal body parts, including vision and hearing.
     - **b. behaviorism:** The study of actions that alter the relationship between an animal and its environment.
     - **c. physiology:** The study of life processes of animals, such as molting, metamorphosis, digestion, reproduction, and circulation.
  3. **ecology:** The study of the relationships of living things to other living things and to their environment.
  4. **microbiology:** The study of microscopic living things or parts of living things.
- **earth science:** The study of the Earth.
  1. **geology:** The study of the Earth, including the composition of its layers, its crust, and its history. Subtopics may include the following:
     - **a. fossils:** Remnants or traces of prehistoric life-forms preserved in the Earth's crust.
     - **b. mineralogy:** The study of the composition and formation of minerals.
     - **c. rocks:** Solids made up of one or more minerals.

   d. **seismology:** The study of earthquakes.
   e. **volcanology:** The study of volcanoes.
2. **meteorology:** The study of weather, climate, and the Earth's atmosphere.
3. **oceanography:** The study of the oceans and marine organisms.
4. **paleontology:** The study of prehistoric life-forms.

- **engineering:** The application of scientific knowledge for practical purposes.
- **physical science:** The study of matter and energy.
  1. **chemistry:** The study of the materials that substances are made of and how they change and combine.
  2. **physics:** The study of forms of energy and the laws of motion. Subtopics include studies in the following areas:
     a. **electricity:** The form of energy associated with the presence and movement of electric charges.
     b. **energy:** The capacity to do work.
     c. **gravity:** The force of attraction between two bodies; the force that pulls objects toward Earth.
     d. **machines:** Devices that make work easier.
     e. **magnetism:** The force of attraction or repulsion between magnetic poles, and the attraction that magnets have for magnetic materials.
- **mathematics:** The use of numbers and symbols to study amounts and forms.

  geometry: The branch of mathematics that deals with points, lines, planes, and their relationships to one another.

Chapter 4

Project Research

Once you have completed the topic research and selected a topic, you are ready to begin your project research. This research is generally more thorough than topic research. Project research is the process of collecting information from knowledgeable sources, such as books, magazines, software, librarians, teachers, parents, scientists, or other professionals. It is also data collected from exploratory experimentation. Read widely on the topic you selected so that you understand it and know about the findings of others. Be sure to give credit where credit is due and record all information and data in your journal.

How successful you are with your project will depend largely on how well you understand your topic. The more you read and question people who know something about your topic, the broader your understanding will be. As a result, it will be easier for you to explain your project to other people, especially a science fair judge. There are two basic kinds of research—primary and secondary.

PRIMARY RESEARCH

Primary research is information you collect on your own. This includes information from exploratory experiments you perform, surveys you take, interviews, and responses to your letters.

Interview people who have special knowledge about your topic. These can include teachers, doctors, scientists, or others whose careers require them to know something related to your topic. Let's say your topic is about the speed of dinosaurs. "Who would know about dinosaurs?" Start with your science teacher. He or she may have a special interest in dinosaurs or know someone who does. Is there a museum with dinosaur exhibits nearby? Owners of rock and mineral shops may have an interest in fossils and could provide information. Contact the geology department of a local university.

Before contacting the person(s) you want to interview, be prepared. You can do this by making a list of questions that you want to ask. You can even discuss what you know about your topic with someone who knows nothing about it. In so doing, you will be forced to organize your thinking and may even discover additional questions to add to your list. Once your list is complete, you are ready to make your call. Simple rules of courtesy, such as the following, will better ensure that the person called is willing to help.

1. Identify yourself.
2. Identify the school you attend and your teacher.
3. Briefly explain why you are calling. Include information about your project and explain how the person can help you.
4. Request an interview time that is convenient for the person. This could be a telephone or face-to-face interview. Be sure to say that the interview will take about 20 to 30 minutes.
5. Ask if you may tape-record the interview. You can get more information if you are not trying to write down all the answers.

It may be that the person is free when you call, so be prepared to start the interview.

6. Be on time, and be ready to start the interview immediately. Also, be courteous and end the interview on time.
7. Thank the person for the time given and the information provided.
8. A written thank-you note should be sent after the interview, so be sure to record the person's name and address.

You may write letters requesting information instead of interviewing, or write letters in addition to interviewing. Check at the end of articles in periodicals for lists of names and addresses where more information can be obtained. Your librarian can assist you in locating current periodicals related to your topic. If your project deals with a household product, check the packaging for the address of the manufacturer. Send your letter to the public relations department. Ask for all available printed material about your topic. Send your letter as soon as possible to allow time for material to be sent. You can use a form letter similar to the one shown here to make it easier to send it to as many different people and organizations as you can find.

Lacey Russell
231 Kids Lane
Woodlands, OK 74443

August 31, 2005

The Dial Corporation
15101 North Scottsdale Road
Station 5028
Scottsdale, AZ 85254

Dear Director:

I am a sixth-grade student currently working on a science project for the Davin Elementary Science Fair. My project is about conditions affecting bacterial growth. I would greatly appreciate any information you could send me on the "anti-bacterial" properties of your product. Please send the information as soon as possible.

Thank you very much.

Sincerely,

Lacey Russell

SECONDARY RESEARCH

Secondary research is information and/or data that someone else has collected. You find this type of information in written sources (books, magazines, and newspapers) and in electronic sources (CD-ROM encyclopedias, software packages, or on-line services, such as the Internet). When you use a secondary source, be sure to note where you got the information for future reference. If you are required to write a report, you will need the following information for a bibliography or to give credit for any quotes or illustrations you use.

Book

Author's name, title of book, place of publication, publisher, copyright date, and pages read or quoted.

Magazine or periodical

Author's name, title of article, title of magazine, volume and issue number and date of publication, and page numbers of article.

Newspaper

Author's name, title of article, name of newspaper, date of publication, and section and page numbers.

Encyclopedia

Name of encyclopedia, volume number, title of article, place of publication, publisher, year of publication, and page numbers of article.

CD-ROM encyclopedia or software package

Name of program, version or release number, name of supplier, and place where supplier is located.

Documents from on-line services

Author of document (if known), title of document, name of organization that posted document, place where organization is located, date given on document, on-line address or mailing address where document is available.

USE YOUR RESEARCH

Now you are ready to use the project research information and data collected to express the problem, propose a hypothesis, and design and perform one or more project experiments. The project research will also be useful in writing the project report. The following chapters, 5 through 8, guide you step-by-step through a sample project from start to finish. You may want to read these chapters more than once and refer back to them as you progress through your project.

Chapter 5

A Sample Project

Pick a topic. Each of the 50 project ideas in Part II begins with a detailed exploratory experiment. Read some or all of these easy experiments to discover the topic you like best and want to know more about. Regardless of the topic you choose for the science fair, what you discover from any of these experiments will make you more knowledgeable about science.

How can you turn a project idea from this book into your own unique project?

This chapter uses a project idea similar in format to those found in Part II. The detailed exploratory experiment will be referred to as the sample experiment and is used for several purposes. Like all exploratory experiments, its main purpose is to provide research data on which to base a hypothesis. But in this chapter, it is also used as a model for a project experiment. During the experimentation phase of your project, you can use the following data-collecting techniques and other ideas to design, develop, and fine-tune your project.

KEEPING YOUR PROJECT JOURNAL

Every step of the way, you will keep a journal in which to record the progress of the project. After experimentation has been completed, the journal will be very useful to you when you begin to write your project report. Chapter 6 explains how to write a project report.

TITLE AND PROBLEM QUESTION

The title and problem question for the sample experiment (see Figure 5.1) may or may not be acceptable for your project. Because you'll know so much more after doing the sample experiment and other research, let's wait before deciding on the title and problem question.

> **How High?**
>
> **PROBLEM**
>
> *When is the Sun at its highest altitude during the day?*

Figure 5.1 Sample Experiment Title and Problem

> **Materials**
>
> pencil
> 5 tablespoons (75 ml) plaster of paris
> 2 tablespoons (30 ml) tap water
> 3-ounce (90-ml) paper cup
> masking tape
> 36-inch (1-meter) piece of string
> yardstick (meterstick)
> protractor
> helper

Figure 5.2 Sample Experiment Materials List

MATERIALS

As Figure 5.2 shows, all the materials for the sample experiment, like those for all the experiments in this book, can be found around the house or purchased without much money at a local grocery or hardware store. Collect the supplies before you start the experiment. You will have less frustration and more fun if all the materials are ready before you start. Substituting materials is not suggested, but if something is not available, ask an adult's advice before using different materials.

Note that each of the project ideas in Part II contains more than one exploratory experiment. The "Materials" section at the beginning of each project contains only the materials for the first experiment. Be sure to read through the entire project prior to starting to determine all the materials you'll need to complete each experiment. *NOTE: Approximate metric equivalents have been given after all English measurements. Both English and metric units are given in this book, but the metric system is often suggested for science fair projects because of its ease in measuring small quantities.*

PROCEDURE

The "Procedure" section for the sample experiment (see Figure 5.3) contains the steps needed to complete the experiment. Figure 5.4 shows the procedure setup. As described in Chapter 1, a variable is anything that has an effect on the experiment. In the sample experiment, the Sun's altitude is measured at specific times during the day. The time of day is the independent, or manipulated, variable. The measured altitude of the Sun at this time is the dependent, or responding, variable. All other variables, such as the latitude and season, are the controlled, or constant, variables.

Procedure

CAUTION: Do not look directly at the Sun. It can damage your eyes.

1. Use the pencil point to mix the plaster of paris and water in the paper cup. Stand the pencil, eraser end up, vertically in the mixture and do not disturb until the mixture hardens. This may take 30 minutes or more. *NOTE: Do not wash plaster down the drain. It can clog the drain.*
2. Tear away the paper cup above the hardened plaster and tape one end of the string to the top of the pencil.
3. Starting at the 0 end of the measuring stick, tape the protractor so that it stands perpendicular to the surface of the measuring stick with the 0 degree mark on the protractor even with the surface of the stick. The end of the stick opposite the protractor will be called the pointer end.
4. Place a piece of tape across the measuring stick even with the center of the protractor. Make a mark across the tape to mark the center of the protractor. This will be called the measuring line.
5. At 8:00 A.M. standard time, set the measuring stick on a flat surface outdoors in a sunny area with its pointer end toward the Sun.
6. Set the cup in the middle of the stick. Adjust the pointer end of the stick so that the shadow cast by the pencil falls on the stick. Move the cup back and forth along the stick until the end of the pencil's shadow touches the measuring line.
7. Hold the cup in place and extend the string between the top of the pencil and the measuring line. Ask a helper to read the angle where the string crosses the protractor.
8. Repeat steps 5 through 7 at these times during the day: 10:00 A.M., 12:00 P.M. (noon), 2:00 P.M., and 4:00 P.M.

NOTE: If the shadow is longer than the measuring stick, place two measuring sticks end to end.

Figure 5.3 Sample Experiment Procedure

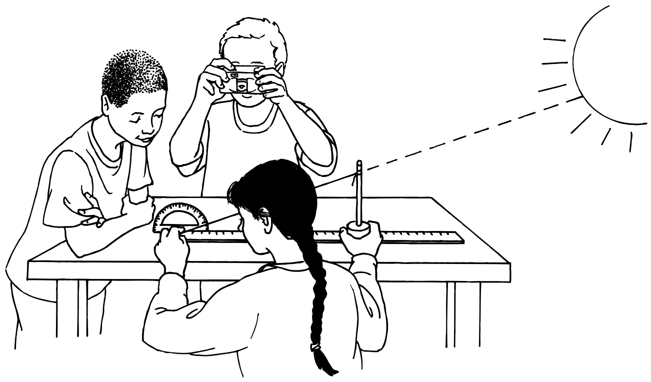

Figure 5.4 Procedure Setup

RESULTS

Before you can state the results of an experiment, you must first organize all the data collected during experimentation. Numbers, called "raw data," have little meaning unless you organize and label them. Data from each experiment needs to be written down in an orderly way in your journal. Use a **table** (a diagram that uses words and numbers in columns and rows to represent data) to record data (see Figure 5.5). Use a graph, such as a **bar graph** (a diagram that uses

SUN ALTITUDE

Time	Altitude (degrees, °)
8:00 A.M.	14
10:00 A.M.	28
12:00 P.M.	42
2:00 P.M.	28
4:00 P.M.	14

Figure 5.5 Example of a Table for Sample Experiment

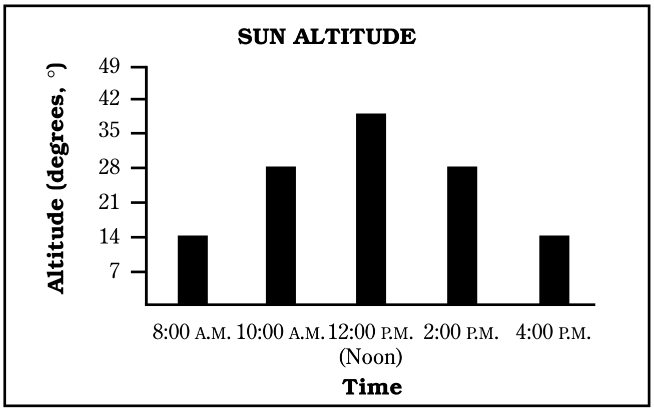

Figure 5.6 Example of a Bar Graph

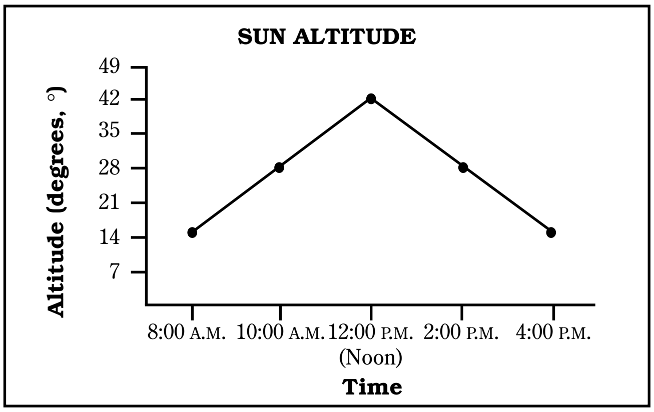

Figure 5.7 Example of a Line Graph

bars to represent data) similar to the one shown in Figure 5.6 to **analyze** (separate and examine) data. Figure 5.7 shows another way to represent the data. This figure is a **line graph** (a diagram that uses lines to express patterns of change).

There are other useful ways to represent data. A circle graph, or **pie chart,** is a **chart** (data or other information in the form of a table, graph, or list) that shows information in percentages. The larger the section of the circle, the greater the percentage represented. The whole circle represents 100 percent, or the total amount. For example, a pie chart can be used to represent the results of an experiment determining the direction of the Sun at different times during one day, from sunrise to sunset. To make a pie chart, first record the directions at different times in a table, as

SUN DIRECTION

Time	**Direction**
6:00 A.M. (sunrise)	east (E)
8:00 A.M.	southeast (SE)
10:00 A.M.	southeast (SE)
12:00 P.M. (noon)	south (S)
2:00 P.M.	southwest (SW)
4:00 P.M.	southwest (SW)
6:00 P.M. (sunset)	west (W)

Figure 5.8 Table of Sun Directions

shown in Figure 5.8. Prepare a second table expressing the number of hours the Sun is in the eastern (E and SE) and western (W and SW) parts of the sky, as shown in Figure 5.9. Then, express the same data as percentages in a pie chart, as shown in Figure 5.10. Note that illustrations of rising and setting suns are placed around the circle to add interest to the data displayed.

A pictograph could be used to represent the results of an experiment measuring the Sun's altitude at noon over a three-month period. A **pictograph** is a chart that contains symbols representing data, such as quantities of an object. In the pictograph shown in Figure 5.11, each sun represents an altitude of 4 degrees. Pictographs are easy to read and can add a little fun to your data display.

The data charted in Figure 5.5 was used to write a statement of the changes in altitude of the Sun as observed in the sample project, as shown in Figure 5.12.

Photographs are another way to display data. Have someone take a photograph of you performing the experiment, as in Figure 5.4,

SUN DIRECTION

Direction	**Hours**	**Percentage of Day**
eastern (E and SE)	6	50
western (W and SW)	6	50

Figure 5.9 Table of Sun Directions

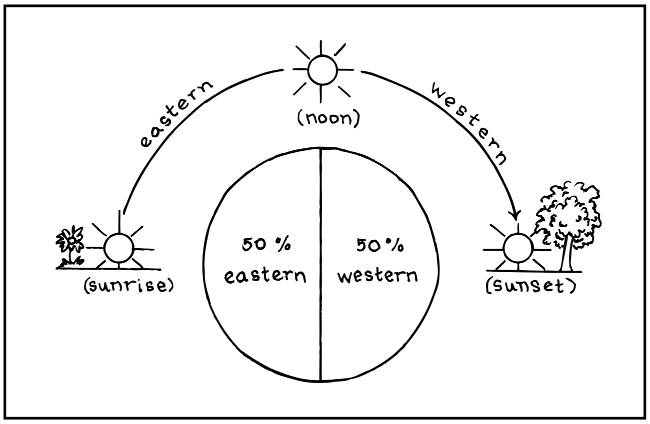

Figure 5.10 Pie Chart of Sun Directions

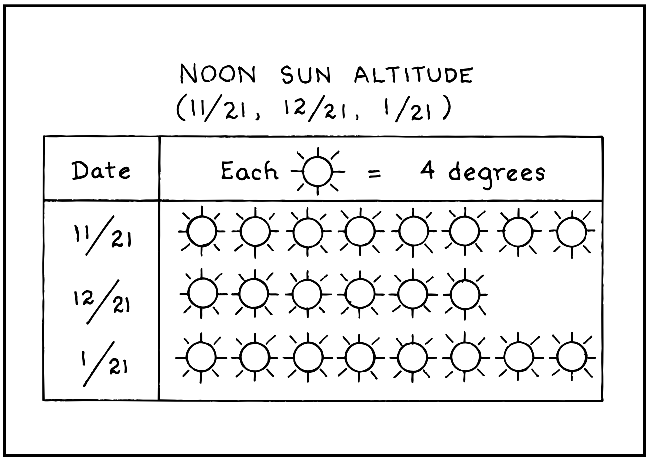

Figure 5.11 Example of a Pictograph

Results

The altitude of the Sun increases before noon, is highest at noon, then decreases after noon.

Figure 5.12 Sample Experiment Results

or take photos of the procedure setup to use as part of the project display. Use the format of the procedure shown in Figure 5.3 as a guideline to design your own project experiment.

WHY?

Figure 5.13 shows an explanation of the results of the sample experiment. This information, along with the other research, will be used to develop a project problem, hypothesis, and experiment(s).

Why?

Extending the line formed by the string points to the position of the Sun. The angle between this line and the measuring stick is equal to the angle of the Sun above the horizon. Thus, the angle measured is equal to the Sun's **altitude** (angular height above the horizon). At noon, standard time, the Sun is at or near its highest altitude during the day.

The Sun appears to move across the sky. Actually, the Sun is not moving. Instead, the Earth is rotating on its axis, giving the illusion that the Sun is moving across the sky. Since the axis of the Earth is tilted in relationship to the Sun, the maximum height of the Sun in the sky during the day changes as the Earth **revolves** (moves in a curved path about an object) around the Sun.

Figure 5.13 Sample Experiment Explanation

LET'S EXPLORE

This is the point at which you begin to ask different exploring questions as the basis for more research ideas, such as "I wonder, where on Earth does the Sun reach its highest altitude?" or "I wonder, how does the latitude of a location affect the Sun's altitude? Wow! That last question is great." You'll find that the more you think about the sample experiment, the more exploring questions you'll be able to think of and the better your questions will be. Figure 5.14 shows exploring questions and how to find their answers by changing the sample experiment. The experiments in this and the following sections could be performed and the data added to the research information. Another use would be as aids in designing your project experiment(s). Before any further experimentation, read through "Let's Explore," "Show Time!", and "Check It Out!".

> **LET'S EXPLORE**
>
> **1.** Does the Sun's maximum altitude change from day to day? Repeat the experiment measuring the Sun's altitude at noon for 7 or more days.
>
> **2.** How does the Sun's maximum altitude compare at different latitudes on the same day? Ask friends at latitudes higher and lower than yours to perform the original experiment at noon on a specific day. Compare and report the results.

Figure 5.14 Sample Experiment "Let's Explore"

SHOW TIME!

The "Show Time!" section in Figure 5.15 shows two ideas related to the sample experiment. It offers different experimental ideas for further investigation of the topic, as well as more ideas for designing your own experiments. (When you design your own experiments, make sure to get an adult's approval if you use supplies or procedures other than those given in this book.) Again, these experiments can provide project research or ideas for designing your project experiment(s).

CHECK IT OUT!

At this point, you are ready for in-depth research on the topic. The questions asked at this point (see Figure 5.16) require some secondary research. A good place to start your research is the library. Earth science books have sections on the Sun, its motion, its location, and the heat from its rays. Science experiment books are also a good source of information and provide experiments to use as well.

You will discover from these sources that as the Earth revolves around the Sun, the Sun's maximum altitude during the day increases and decreases. The higher the Sun's altitude, the more direct the rays and generally the higher the temperature. Wow!

> **SHOW TIME!**
>
> **1a.** As Earth revolves around the Sun, its axis always points in the same direction. But since Earth's axis is tilted 23.5 degrees in relationship to its orbit, the ends of the axis tilt toward the Sun during part of the year and away from the Sun for part of the year. As a result, the altitude of the Sun changes during the year. These changes produce **seasons** (periods of the year characterized by specific weather). The four seasons on Earth are spring, summer, fall and winter. Demonstrate the position of Earth in its orbit when the Sun is at its highest altitude in the Northern Hemisphere. This would be summer, the warmest season. Prepare an Earth model by using a rounded toothpick to draw a circle around the middle of a grape-size ball of modeling clay. Insert the toothpick through the clay ball so that the line you just drew circles the clay as the Earth's equator circles the globe. Use another grape-size piece of clay to support the model. With a drawing compass, draw a 1-inch (2.5-cm) circle in the center of a 12-by-12-inch (30–by-30-cm) piece of white poster board. Label the circle "Sun." On the edges of the poster board, label these seasons in a counterclockwise order: "Spring," "Summer," "Fall," "Winter." Stand the Earth model on the edge of the poster board labeled "Summer" with the top of the toothpick tilted toward the Sun and the wall beyond Sun. Note that the top part of the model (the Northern Hemisphere) tilts toward the Sun and the bottom part (the Southern hemisphere) tilts away from the Sun.
>
> **1b.** With the toothpick still tilted toward the wall, move the model in a counterclockwise direction from one season to the next. Prepare a diagram indicating the areas of Earth where the Sun is at its highest altitude during each season.

Figure 5.15 Sample Experiment "Show Time!"

That's why it's so hot during the summer when the Sun is so high in the sky. This is a real-life experience that you are using to help you with your project. You will want to draw from your personal experiences, not only when looking for a topic as discussed in Chapter 2, but also during your project research.

CHECK IT OUT!

1. In the Northern Hemisphere, the Sun is at its highest altitude on or about June 21. This time is called the *summer solstice.* At this time, the apparent motion of the Sun reaches its northernmost point, which is the *Tropic of Cancer* (latitude 23.5 degrees north of the equator). Find out more about the apparent motion of the Sun. Where is its southernmost point and when does it reach this point? What and when is the winter solstice? What and when are the equinoxes?
2. Earth's equator receives about 2½ times as much heat during the year as does the areas around its Poles. How does the angle of the Sun's rays affect the heating of Earth's surface?

Figure 5.16 Sample Experiment "Check It Out!"

PROBLEM AND HYPOTHESIS

After collecting and analyzing your project research, it's time to zero in on the problem. Let's say you've decided to investigate the relationship between the angle of the Sun's noon rays and air temperature. The question doesn't have to be complex and wordy to be good. Make it as simple and to the point as possible. Look at these two examples:

1. How does the angle of the Sun's rays at noon affect seasonal temperatures?
2. Does the difference in the angle of the Sun's rays at noon affect the amount of energy received by Earth's surface? If so, how does that difference affect temperature during different seasons?

Both of the examples have the same goal of discovering how the angle of the Sun's rays affects air temperature, but the first example is short and quickly read. Keep in mind that your project will be judged at the science fair, and you want each judge to know immediately the single purpose for your project.

With your problem stated, it's time to develop the hypothesis. The hypothesis might be "I believe that the size of Sun ray angles at noon cause seasonal temperatures, small angles causing warm temperatures and large angles causing cold temperatures." This hypothesis is based on these facts:

- In my research, I discovered that shadow angles are the same as the angles of the Sun's rays, and the shadow angles change during the day as well as from season to season.
- In my exploratory experiment, shadow angles were least at or near noon and greatest in early morning and late evening.
- I've observed that early morning and late evening are generally the coolest parts of a day and midday is warmest.

NOW YOU'RE ON YOUR OWN

Test your hypothesis by designing a project experiment(s) to determine if the angle of the Sun's rays during different seasons affects temperature. You might use the instrument in the exploratory experiment to measure the Sun's ray angle. The ray angle would be equal to the angle of the pencil's shadow, which is the angle between the top of the pencil and the stretched string. Since the least shadow angle is at or near noon, a comparison of shadow angles and temperatures at noon during different seasons can be made. Once you have designed one or more experiments, collect data, construct tables and graphs, draw diagrams, and take photos to represent results. The control can be when the Sun is at its lowest or highest angle.

UNEXPECTED RESULTS?

What do you do if your results are not what you expected? First, if there is time, repeat the experiment and make sure everything is done properly. If there isn't time for this, or if you get the same unexpected results again, *don't panic.* A scientist's hypothesis often is not supported by his or her experiments. Report the truth in your conclusion. Assuming your research supported your hypothesis, state your hypothesis as before, but truthfully say that while your research backed up your hypothesis, your experimental results did not. Say what you expected and what actually happened. Report everything—if anything supported the hypothesis, identify it. Continue by giving reasons why you think the results did not support your original ideas. Make your explanation scientific. For example, if you think the experimental materials might have been moved during the experiment:

Do say: "There is a possibility that I did not consider daylight savings time each time I took measurements. This problem could be solved by always using the same watch or clock set to standard time."

Don't say: "My sister gave me the wrong time. I need to find someone who is better at telling time."

It may be that after evaluating your data, you may decide that your original hypothesis was incorrect. If so, say this and give reasons for your change of mind.

Now it's time to sum up the entire project by writing a detailed report. Review the next chapter for advice on how to put together a science-fair project report.

Chapter 6

The Project Report

Your report is the written record of your entire project from start to finish. When read by a person unfamiliar with your project, the report should be clear and detailed enough for the reader to know exactly what you did, why you did it, what the results were, whether or not the experimental evidence supported your hypothesis, and where you got your research information. This written document is your spokesperson when you are not present to explain your project, but more than that, it documents all your work.

Much of the report will be copied from your journal. By recording everything in your journal as the project progresses, all you need to do in preparing the report is to organize and neatly copy the journal's contents. Tables, graphs, and diagrams can be neatly and colorfully prepared. If possible, use a computer to prepare some or all of these data displays.

Check with your teacher for the order and content of the report as regulated by the local fair. Generally, a project report should be typewritten, double-spaced, and bound in a folder or notebook. It should contain a title page, a table of contents, an abstract, an introduction, the experiment(s) and data, a conclusion, a list of sources, and acknowledgments. The rest of this chapter describes these parts of a project report and gives examples based on the sample project in Chapter 5.

TITLE PAGE

The content of the title page varies. Some fairs require that only the title of the project be centered on the page. Normally, your name would not appear on this page during judging. Your teacher can give you the local fair's rules for this. The title should be attention getting. It should capture the theme of the project but should not be the same as the problem question. A good title for the sample project detailed in Chapter 5 is shown in Figure 6.1.

Up and Down:
Seasonal Temperature versus Sun Ray Angle

Figure 6.1 A Project Title

TABLE OF CONTENTS

The second page of your report is the table of contents. It should contain a list of everything in the report that follows the contents page, as shown in Figure 6.2

Contents

1. Abstract
2. Introduction
3. Experiment(s)
4. Data
5. Conclusion
6. Sources
7. Acknowledgments

Figure 6.2 A Table of Contents

ABSTRACT

The abstract is a brief overview of the project. It should not be more than 1 page and should include the project title, a statement of the purpose, a hypothesis, a brief description of the procedure, and the results. There is no one way to write an abstract, but it should be brief, as shown in Figure 6.3. Often, a copy of the abstract must be submitted to the science fair officials on the day of judging, and it is a good idea to have copies available at your display. This gives judges something to refer to when making final decisions. It might also be used to prepare an introduction by a special award sponsor, so do a thorough job on this part of your report.

Abstract
Up and Down:
Seasonal Temperature versus Sun Ray Angle

The purpose of this project was to find out whether the angle of the Sun's rays at noon affects seasonal temperatures. The experiments involved measuring the air temperature and the angle of the Sun's rays at noon during different seasons. This was done by recording air temperature and measuring the angle of shadows at noon on the first day of the month from October through April.

The measurements confirmed my hypothesis that as the angle of the Sun's rays decreases during the year, the outdoor temperature increases. These findings led me to believe that seasonal temperatures are the result of the difference in the angle of the Sun's rays. As the ray angle decreases, sunlight is more concentrated on an area, resulting in a higher temperature.

I discovered that during seasons with high temperatures, the angle of the Sun's rays is lower than during seasons with low temperatures.

Figure 6.3 An Abstract

INTRODUCTION

The introduction is a statement of your purpose, along with background information that led you to make this study. It should contain a brief statement of your hypothesis based on your research. In other words, it should state what information or knowledge you had that led you to hypothesize the answer to the project's problem question. Make references to information or experiences that led you to choose the project's purpose. If your teacher requires footnotes, then include one for each information source you have used. The introduction shown in Figure 6.4 does not use footnotes.

Introduction

The air temperature generally changes quite a bit during the day, but any change from one day to the next at the same time of day is, as a rule, relatively small. But the temperature of some regions changes significantly over the course of a year, resulting in different seasons.

While reading about my project topic, the effect of the angle of the Sun's rays at noon on seasonal temperatures, I thought about my own experience of the Sun's high noon altitude and small shadow angles occurring at the same time as high summer temperatures. Further research provided the facts that as the angle of the Sun's rays decreases, the more concentrated the rays, thus the hotter the area of Earth receiving them. I reasoned that the angle of the Sun's rays at noon must change during the year.

My curiosity about the relation of angle of the Sun's rays to temperature resulted in a project that has as its purpose to discover how the angle of the Sun's rays affects air temperature during the year and thus causes seasons. Based on previous stated research and the fact that it is cooler in the morning when the angle of the Sun's rays is least due to the Sun's low altitude, my hypothesis was that as the angle of the Sun's rays increases during the year, the outdoor temperature increases, causing seasons.

Figure 6.4 Introduction

EXPERIMENTS

Each project experiment should be listed in the experiment section of the report. Experiments should include the problem of the experiment, followed first by a list of the materials used and the amount of each, then by the procedural steps in outline or paragraph form, as shown in Figure 6.5. Note that the experiment described in Figure 6.5 determines the average monthly angle of the Sun's noon rays during 7 consecutive months. A second experiment is needed to measure the average temperature of each month. The experiments should be written so that anyone could follow them and expect to get the same results.

Experiment

Purpose
To determine the angle of the Sun's rays at noon (standard time) during different seasons.

Materials
yardstick (meterstick)
cup with pencil and string prepared in the Sample Experiment
protractor

Procedure
1. At around 11:45 A.M., set the measuring stick on a flat surface in a sunny area outdoors with its pointer end facing the horizon directly below the Sun.
2. Set the cup in the middle of the stick. Move the pointer end of the stick so that the shadow cast by the pencil falls on the stick.
3. At 12:00 P.M. (noon), move the cup back and forth along the stick until the end of the shadow touches the measuring line. *NOTE: If the shadow is longer than the measuring stick, place two measuring sticks end to end.*
4. Hold the cup in place and extend the string from the top of the pencil to the measuring line. Ask a helper to use the protractor to measure the angle between the pencil and string.
5. Repeat steps 1 through 3 one or more times each week during 6 or more consecutive months.
6. Average the angles measured for each month.

Figure 6.5 An Experiment

SUN RAY ANGLES AT NOON

Month	Average Monthly Angle (degrees, °)
October	40
November	31
December	24
January	31
February	40
March	48
April	56

Figure 6.6 A Table

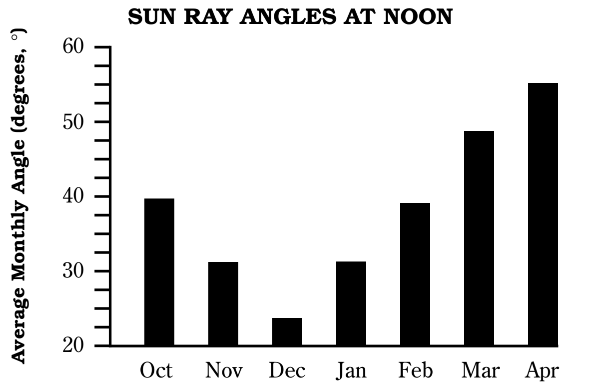

Figure 6.7 Example of a Bar Graph

DATA

Following each experiment, include all measurements and observations that you took during each experiment. Graphs, tables, and charts created from your data should be labeled and, if possible, colorful. Figure 6.6 shows a table and Figure 6.7 a bar graph for the experiment shown in Figure 6.5. If there is a large amount of data, you may choose to put most of it in an appendix, which can be placed in a separate binder or notebook. If you do separate the material, a summary of the data should be placed in the data section of the report.

CONCLUSION

The conclusion summarizes, in about one page or less, what you discovered based on your experimental results, as shown in Figure 6.8. The conclusion states the hypothesis and indicates whether the data supports it. The conclusion can also include a brief description of plans for exploring ideas for future experiments.

SOURCES

Sources are the places where you obtained information, including all of the written materials as well as the people you have interviewed. For the written materials, write a bibliography. See "Secondary Research" in Chapter 4 for information about bibliographies. People that you interviewed should be listed separately, in alphabetical order by last name. Provide title and with permission give their address and business phone number, as shown in Figure 6.9. Do not list home addresses or phone numbers.

Conclusion

As stated in my hypothesis, I believe that the size of Sun ray angles at noon cause seasonal temperatures, small angles causing warm temperatures and large angles causing cold temperatures. The experimental data supported my hypothesis, indicating a direct relation between the angle of the Sun's rays and the air temperature. This direct relation between the ray angles and the temperatures was found to apply over different seasons. The smaller the ray angle, the warmer the season, and the greater the angle, the cooler the season. Experimental data also showed an inverse relation between the Sun's noon altitude and the angle of the Sun's rays; thus, as the altitude of the Sun increases, its ray angle decreases. The experiments confirmed that more direct Sun rays (those with the least angle) heat the earth more.

Through my research as well as experience, I discovered that the length of each day is not exactly the same. Ideas for a future experiment would be to determine the effect of day length on the average daily temperature.

Figure 6.8 A Project Conclusion

Source Interviewed

Lynn, Jennifer
Astronomer
100 Rainy Drive
San Francisco, California 00001
(001) 222-0000

Figure 6.9 An Interview Source

ACKNOWLEDGMENTS

Even though technically your project is to be your work alone, it is permissible to have some help. The acknowledgments is not a list of names, but a short paragraph stating the names of the people and how they helped you, as shown in Figure 6.10. Note that when listing family members or relatives, it is generally not necessary to include their names.

Acknowledgments

I would like to thank the members of my family who assisted me with this project; my mother, who proofread and typed my report, and my father and sister, who assisted in the construction of the display board.

A special note of thanks to Dr. Lauren Russell, professor of astronomy at Lacey University, and to Davin Wade, her assistant, for their expert guidance.

Figure 6.10 Acknowledgments

Chapter 7

The Display

Your science fair display represents all the work that you have done. It should consist of a backboard, the project report, and anything that represents your project, such as models made, items studied, photographs, surveys, and the like. It must tell the story of the project in such a way that it attracts and holds the interest of the viewer. It has to be thorough, but not too crowded, so keep it simple.

The allowable size and shape of the display backboard can vary, so you will have to check the rules for your science fair. Most exhibits are allowed to be 48 inches (122 cm) wide, 30 inches (76 cm) deep, and 108 inches (274 cm) high (including the table it stands on). These are maximum measurements, so your display may be smaller than this. A three-sided backboard is usually the best way to display your work. Sturdy cardboard or other heavy material is easier to work with and is less likely to be damaged during transportation to the fair. Wooden panels can be cut and hinged together. Some office supply stores sell inexpensive premade backboards. If these are not available in your area, see Appendix C for science supply companies from which you can order inexpensive premade backboards.

Purchased backboards generally come in two colors, black and white. You can use a different color by covering the backboard with self-stick colored shelving paper or cloth. For items placed on the backboard, select colors that stand out but don't distract a viewer from the material being presented. For example, if everything is in fluorescent colors, the bright colors will be what catches the eye instead of your work.

The title and other headings should be neat and large enough to be read at a distance of about 3 feet (1 m). A short title is often eye-catching. Self-sticking letters, of various sizes and colors, for the title and headings can be purchased at office supply stores and stuck to the backboard. You can cut your own letters out of construction paper or stencil the letters for all the titles directly onto the backboard. You can also use a word processor to print the title and other headings.

Some teachers have set rules about the position of the information on the backboard. The following headings are examples: Problem, Hypothesis, Experiment (materials and procedure), Data, Results, Conclusion, and Next

Figure 7.1 Example of a Good Display

Time. The project title should go at the top of the center panel, and the remaining material needs to be placed neatly in some order. Figure 7.1 shows one way of placing the material. The heading "Next Time," though not always required, may be included if desired. It would follow the conclusion and contain a brief description of plans for future development of the project. This information could be included in the conclusion rather than under a separate heading.

You want a display that the judges will remember positively. So before you glue everything down, lay the board on a flat surface and arrange the materials a few different ways. This will help you decide on the most suitable and attractive presentation. Figure 7.1 shows what a good display might look like.

HELPFUL HINTS

1. Place all typed material on a colored backing, such as construction paper. Leave a border of about ¼ to ½ inch (0.63 to 1.25 cm) around the edges of each piece of typed material. Use a paper cutter so that the edges will be straight.
2. Make the project title stand out by using larger letters for it and smaller letters for the headings.
3. To arrange the letters on the backboard, first lay the letters out on the board without attaching them. Then, use a yardstick (meterstick) and pencil to draw a straight, light guideline where the bottom of each letter should line up. This will help you keep the lettering straight. Before adhering everything, ask the opinion of other students, teachers, or family members.
4. If you need electricity for your project, be sure the wiring meets all safety standards.
5. Bring an emergency kit with extra letters, glue, tape, construction paper the color of the backboard, stapler, scissors, pencils, pens, touch-up paint, markers, and so forth. This kit should contain anything that you think you might need to make last-minute repairs to the display.
6. Before standing your backboard on the display table, cover the table with a colored cloth. Choose a color that matches the color scheme of the backboard. This will help to separate your project from other projects displayed on either side.

DO'S AND DON'TS

Do use computer-generated graphs.

Do display photos representing the procedure and the results.

Do use contrasting colors.

Do limit the number of colors used.

Do display models when applicable. If possible, make the models match the color scheme of the backboard.

Do attach charts neatly. If there are many, place them on top of each other so that the top chart can be lifted to reveal the ones below.

Do balance the arrangement of materials on the backboard. This means to evenly distribute the materials on the board so that they cover about the same amount of space on each panel.

Do use rubber cement or double-sided tape to attach papers. White school glue causes the paper to wrinkle.

Don't leave large empty spaces on the backboard.

Don't leave the table in front of the backboard empty. Display your models (if any), report, copies of your abstract, and your journal here.

Don't hang electrical equipment on the backboard so that the electric cord runs down the front of the backboard.

Don't make the title or headings hard to read by using uneven lettering, words with letters of different colors, or disorganized placement of materials.

Don't hand-print the letters on the backboard.

Don't attach folders that fall open on the backboard.

Don't make mistakes in spelling words or writing formulas.

Figure 7.2 shows how *not* to set up your display.

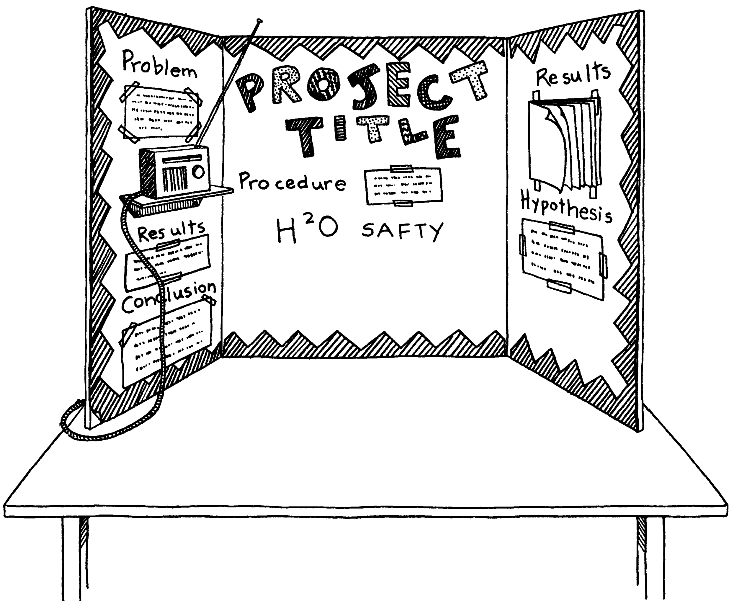

Figure 7.2 Example of a Bad Display

SAFETY

Anything that is or could be hazardous to other students or the public is *prohibited* and cannot be displayed. The following is a list of things that are generally unacceptable for display. Your teacher has access to a complete list of safety rules from your local science fair officials. Your project topic should be approved by your teacher before beginning. This prevents you from working on an unsafe project and from wasting time on a project that would be disqualified. Models or photographs can be used instead of things that are restricted from display.

Unacceptable for Display

1. Live animals
2. Microbial cultures or fungi, living or dead
3. Animal or human parts, except for teeth, hair, nails, and dried animal bones
4. Liquids, including water
5. Chemicals and/or their empty containers, including caustics, acids, and household cleaners
6. Open or concealed flames
7. Batteries with open-top cells
8. Combustible materials
9. Aerosol cans of household solvents
10. Controlled substances, poisons, or drugs
11. Any equipment or device that would be hazardous to the public
12. Sharp items, such as syringes, knives, and needles
13. Gases

Chapter 8

Presentation and Evaluation

Your teacher may require that you give an oral presentation of your project for your class. Make it short but complete. Presenting in front of your classmates may be the hardest part of the project. You want to do your best, so prepare and practice, practice, practice. If possible, tape your practice presentation on a tape recorder or have someone videotape you. Review the tape and/or video and evaluate yourself. Review your notes and practice again.

Practicing an oral presentation will also be helpful for the science fair itself. The judges give points for how clearly you are able to discuss the project and explain its purpose, procedure, results, and conclusion. The display should be organized so that it explains everything, but your ability to discuss your project and answer the questions of the judges convinces them that you did the work and understand what you have done. Practice a speech in front of friends, and invite them to ask questions. If you do not know the answer to a question, never guess or make up an answer or just say “I don’t know.” Instead, say that you did not discover that answer during your research, and then offer other information that you found of interest about the project. Be proud of the project, and approach the judges with enthusiasm about your work.

You can decide on how best to dress for a class presentation, but for the local fair, it is wise to make a special effort to look nice. You are representing your work. In effect, you are acting as a salesperson for your project, and you want to present the very best image possible. Your appearance shows how much personal pride you have in yourself, and that is the first step in introducing your product, your science project.

JUDGING INFORMATION

Most fairs have similar point systems for judging a science fair project, but you may be better prepared by understanding that judges generally start by thinking that each student’s project is average. Then, he or she adds or subtracts points from that. A student should receive more points for accomplishing the following:

1. Project Objectives
   - Presenting original ideas
   - Stating the problem clearly
   - Defining the variables and using controls
   - Relating background reading to the problem
2. Project Skills
   - Being knowledgeable about equipment used
   - Performing the experiments with little or no assistance except as required for safety
   - Demonstrating the skills required to do all the work necessary to obtain the data reported
3. Data Collection
   - Using a journal to collect data and research

- Repeating the experiment to verify the results
- Spending an appropriate amount of time to complete the project
- Having measurable results

4. Data Interpretation

- Using tables, graphs, and illustrations in interpreting data
- Using research to interpret data collected
- Collecting enough data to make a conclusion
- Using only data collected to make a conclusion

5. Project Presentation (Written Materials/ Interview/Display)

- Having a complete and comprehensive report
- Answering questions accurately
- Using the display during oral presentation
- Justifying conclusions on the basis of experimental data
- Summarizing what was learned
- Presenting a display that shows creative ability and originality
- Presenting an attractive and interesting display

DO'S AND DON'TS AT THE FAIR

Do bring activities, such as puzzles to work on or a book to read, to keep yourself occupied at your booth. There may be a lengthy wait before the first judge arrives, and even between judges.

Do become acquainted with your neighboring presenters. Be friendly and courteous.

Do ask neighboring presenters about their projects, and tell them about yours if they express interest. These conversations pass time and help relieve nervous tension that can build when you are waiting to be evaluated. You may also discover techniques for research that you can use for next year's project.

Do have fun.

Don't laugh or talk loud. This may affect the person nearby who is being judged.

Don't forget that you are an ambassador for your school. This means that your attitude and behavior influence how people at the fair think about you and the other students at your school.