SCIENCE FAIR WARM-UP

» LEARNING THE PRACTICE OF SCIENTISTS «

Grades 5–8

JOHN HAYSOM

NSTA press
National Science Teachers Association

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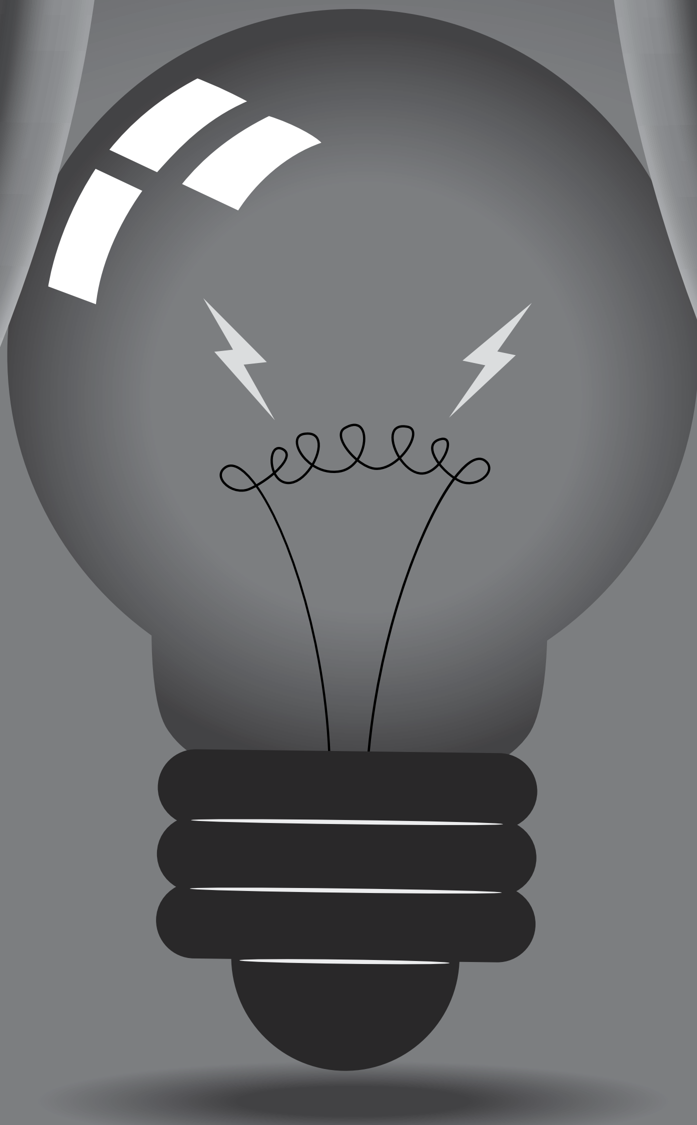

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Contents

LET'S GET STARTED! WHICH PROJECT SHOULD WE CHOOSE?
HOW 'BOUT THE ONE ON NAILS?— YOU LIKE WOODWORKING TOO.

I'LL BET THIS NAIL HOLDS BETTER THAN THE LAST ONE.
I'LL MEASURE IT.

Contents

THIS SIMPLE APPARATUS WORKS GREAT!
YES, BUT DOES IT ALWAYS GIVE THE SAME RESULT?

Be Safe!

As you embark on your science fair adventure, some of the steps and activities will be new to you. Keep yourself and your classmates safe by studying this list of safety precautions.

1. Do not touch animals unless instructed to do so by your teacher. Otherwise, you should stick to observing them.
2. Use caution when working with sharp objects such as scissors, razor blades, electrical wire ends, knives, and glass slides. These items can be sharp and may cut or puncture skin.
3. Wear protective gloves and vinyl aprons when handling animals or working with hazardous chemicals.
4. Wear indirectly vented chemical-splash goggles when working with liquids such as hazardous chemicals. When working with solids such as soil, metersticks, and glassware, safety glasses or goggles can be worn.
5. Always wear closed-toe shoes or sneakers in lieu of sandals or flip-flops.
6. Do not eat or drink anything when working in the classroom or laboratory.
7. Wash hands with soap and water after doing activities dealing with hazardous chemicals, soil, biologicals (animals, plants, and so on), or other materials.
8. Use caution when working with clay. Dry or powdered clay contains a hazardous substance called silica. Only work around and clean up wet clay.
9. When twirling objects around the body on a cord or string, make sure fragile materials and other occupants are out of the object's path.
10. Use only non-mercury-type thermometers or electronic temperature sensors.
11. When heating or burning materials or creating flammable vapors, make sure the ventilation system can accommodate the hazard. Otherwise, use a fume hood.
12. Select only pesticide-free soil, which is available commercially for plant labs and activities.
13. Many seeds have been exposed to pesticides and fungicides. Wear gloves and wash hands with soap and water after any activity involving seeds.
14. Never use spirit or alcohol burners or propane torches as heat sources. They are too dangerous.
15. Use caution when working with insects. Some students are allergic to certain insects. Some insects carry harmful bacteria, viruses, and other potential hazards. Wear personal protective equipment, including gloves.
16. Immediately wipe up any liquid spills on the floor—they are slip-and-fall hazards.

Chapter 1:

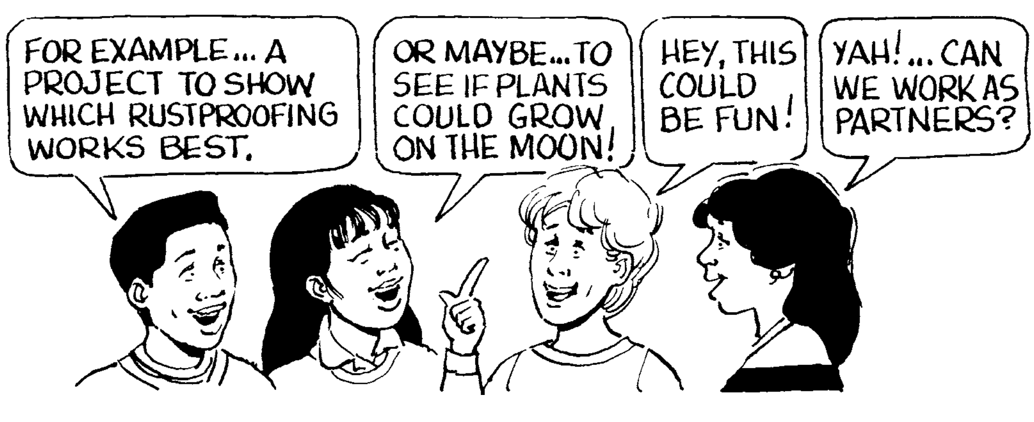
Starting Points

What Are Science Fairs and Projects All About?

It's not easy to tell what science fairs and science projects are all about. Do you know?

Science fair projects are about real problems that you choose to explore. The problems are challenging and fun!

The best way to find out what science fair projects are all about is to do one and then take the project to a science fair.



Chapter 1

Getting Started

In this chapter, you will find Starting Points for projects. These Starting Points have been chosen to give you practice that will help you warm up for a real science fair. You can choose a Starting Point that interests you the most.

As you work on a project, you will meet all sorts of problems: problems with measuring, designing apparatus, devising good investigations, graphing, making sense of what you have discovered. You can get help with these problems from friends who are working on other projects, as well as from your teacher and this book.

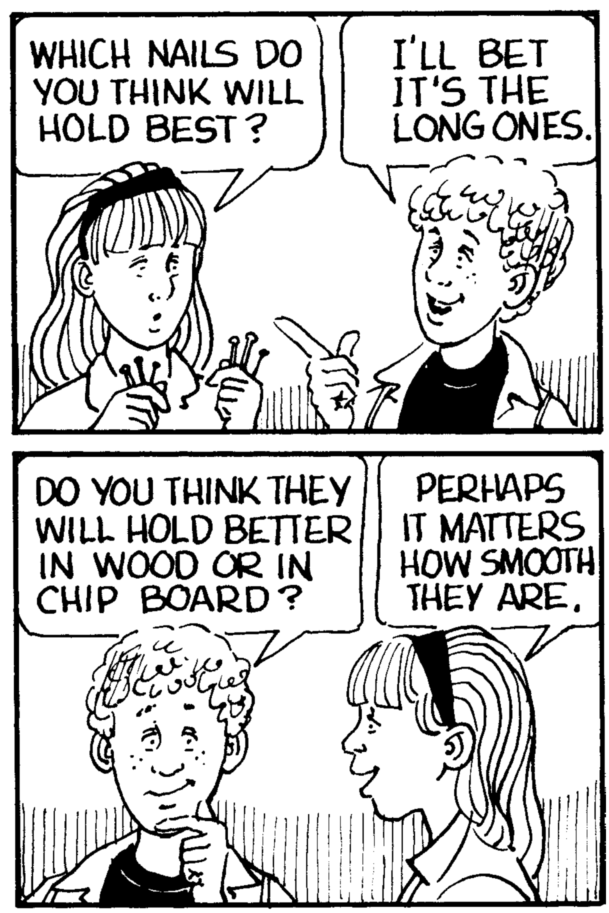
This book looks at scientific ways of dealing with these problems. Take time out from your project to work on the problems, then think about how you might improve your project. Have a look at the contents page to see where you can get help along the way.

If this is the first time you have worked on a science project, begin with the exercises marked with one or two asterisks (*). If you are experienced, you might try the exercises marked with three asterisks.

After the warm-up, you will be ready to go on your own. This book will help you choose a project that can be your own.

Let's Go

1. Review the Starting Points and choose one that interests you. Look for a partner with whom you would like to work on your project.
2. Play around with your project. Explore its scope by writing down all the questions that cross your mind. Discuss your thoughts with your friends and teacher.
3. Plan a simple experiment to find out the answer to one of your questions. Share your ideas with others.



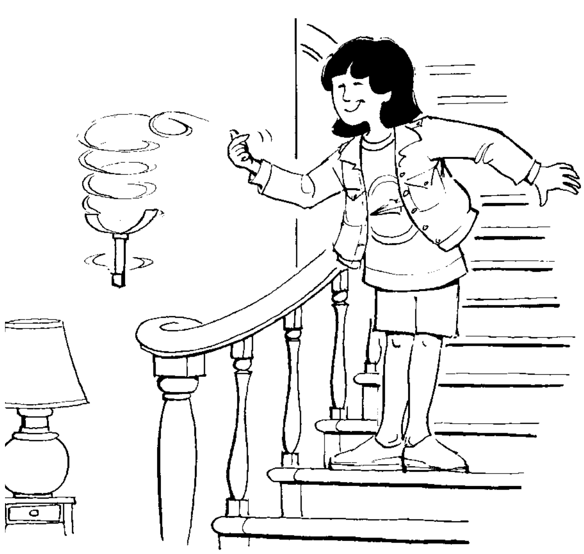
*STARTING POINT 1: PAPER HELICOPTERS

You can make a very good paper helicopter from a sheet of paper. Simply cut along the solid lines and fold along the dotted lines as shown in the diagram (1a). Can you make a truly excellent helicopter? Vary the plan in any way you'd like to improve your helicopter!

The students who first did this project won a silver medal for it at a national science fair. Their target was to see if the helicopter could be scaled up in size to carry a person. Although they failed to achieve this goal, they carried out some fine experiments.

The students' first job was to find out more about how a paper helicopter worked. They changed the wing span. They investigated how much weight the helicopter could carry by adding paper clips to the bottom. Keeping their changes in mind, why not try making your own helicopter?

You will find all sorts of designs for other paper airplanes. Here is a simple one that could take you a long way (1b).



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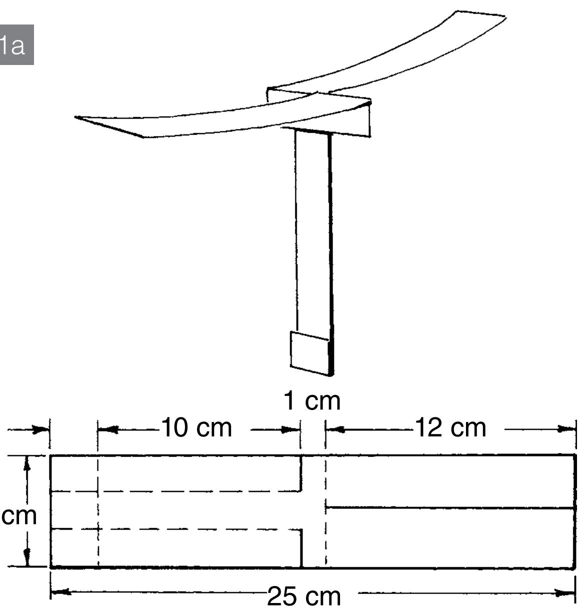

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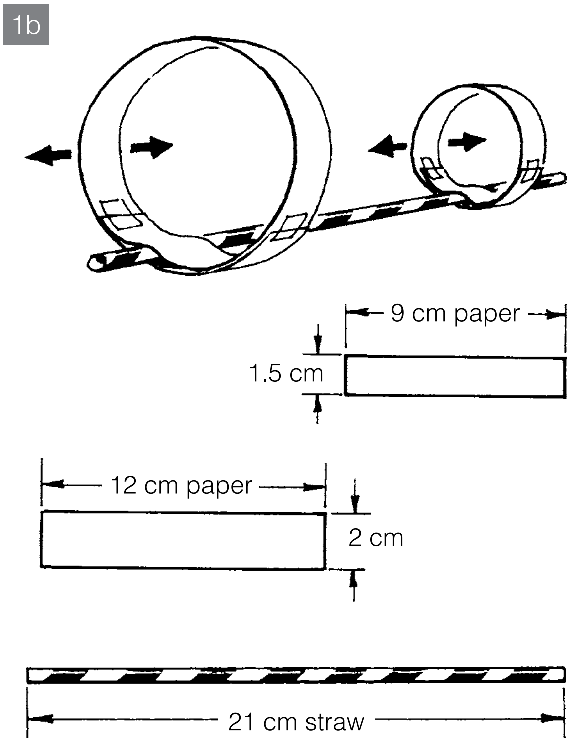
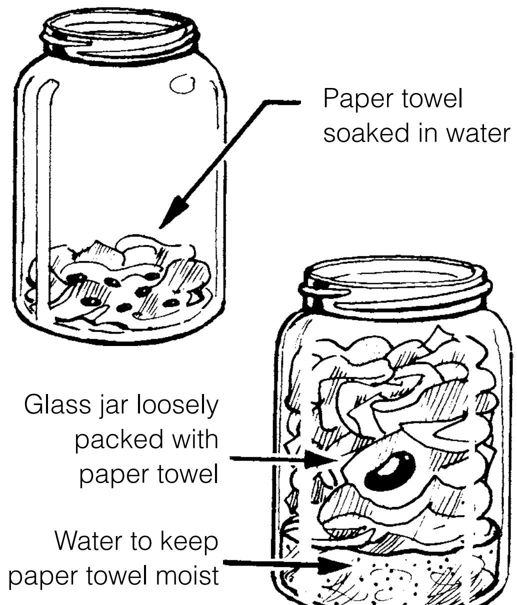


*STARTING POINT 2: WHAT MAKES SEEDS GROW?

You have seen seeds grow, but have you ever taken a really close look? It is a miracle of nature! There are lots of ways to take a really close look. The diagrams show two simple ways.

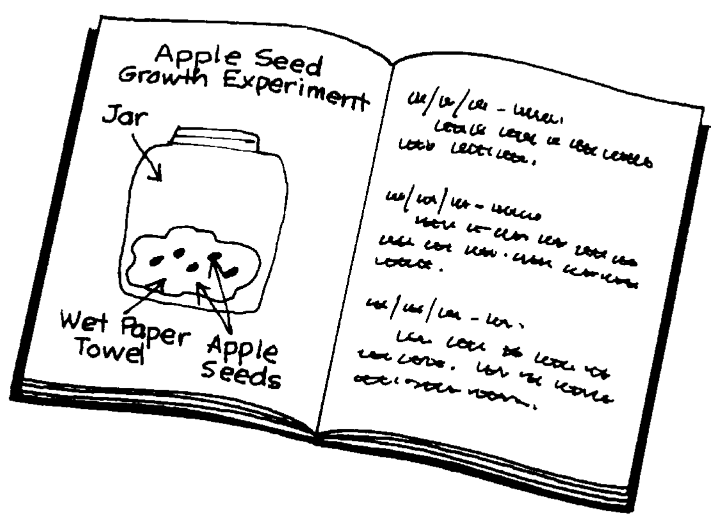


Begin by keeping a diary. Make a careful note of the growing conditions at the beginning (include a diagram). Keep a record in which you note the date, time, and any changes you observe; you should do this two or three times each day. Keeping a diary or log book is recommended for not only this inquiry but for all investigative work.

Check it out! Try radishes, beans, apple or orange seeds, tropical fruits (like the avocado pear), or anything else you'd like to see.

What conditions help seeds germinate? Do seeds need water? Do they need air? Do they need light? Do they need soil? Does fertilizer help?

This investigation can go in many directions. Some students wondered if acid rain would prevent the seeds from germinating. Some students wondered if "zapping" the seeds with a short burst of microwaves would get them going.



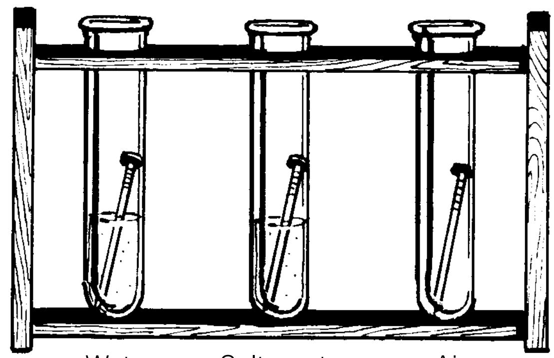
*STARTING POINT 3: CHECK RUST

Rusting bikes! Rusting cars! Rust spoils our possessions and costs us billions of dollars per year. If you could develop a cheap rust-prevention treatment that really worked, you would become a millionaire!

Many attempts have been made to stop rusting by using paint, oil spray, and other methods or substances. Which method works best? Perhaps you can improve on these attempts!

The more you understand about the process of rusting, the better your chances of success. Iron rusts when it combines with oxygen from the air. As you probably know, this happens faster when the weather is wet and there is salt around. To help you start thinking about rusting, set up a simple exploratory experiment like the one shown in the diagram.

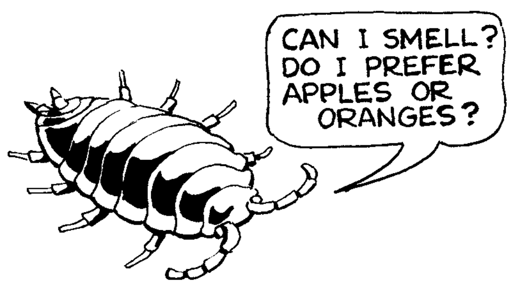
- Leave the samples standing for 24 hours and see what happens.



- Make up a second set of samples with nails that are cleaned with steel wool.
- Try using oily nails.
- Put a set of samples in the refrigerator.

Chapter 1

*STARTING POINT 4: WHAT MAKES SOW BUGS MOVE?

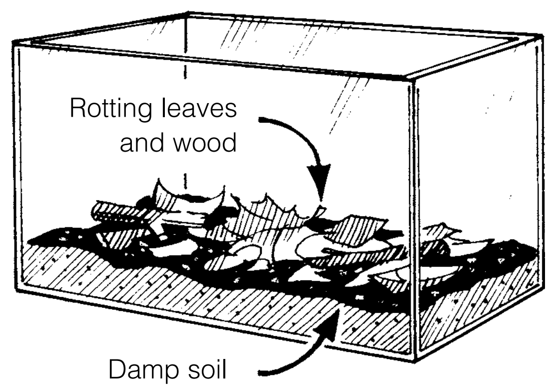


If you accidentally put your hand on a hot range, you move it fast. If someone shines a bright light in your face, you squint your eyes. If you smell your favorite dessert, your mouth waters. All living things respond to stimuli such as these.

How does a tiny animal like a sow bug (wood louse) respond to different stimuli? Can it smell? Does it prefer oranges, apples, or vinegar? Does it move toward or away from stimuli? How does it respond to different stimuli?

You can find wood lice or sow bugs hiding under a pile of rotting wood or leaves. They are easy to keep in a laboratory. A good way to begin your exploration is to put a sow bug on a plastic tray and watch it move. Make notes about anything that catches your eye.

Did you know that scientists who work with animals have to follow ethical guidelines? Just like real scientists, you should handle living things with care; it's important not to harm them in any way.



*STARTING POINT 5: BOUNCING BALLS

Have you ever played with a bouncy ball that you can buy in a toy store—the ball that seems to keep bouncing forever?

You probably remember playing with them, trying to get them to bounce higher and higher. How much did you find out? Do they bounce higher on wood, concrete, or carpeted floors? Do they bounce higher when you drop them from a higher place?

When you were playing with the ball, you were doing what a beginner scientist would do. Now is your chance to be a real scientist and find out all you can about the way balls bounce.

Do you know if a large bouncy ball bounces higher than a small one? Do balls bounce higher on rubber than on wood? Do you know if a steel ball bounces higher than a wooden one? Do you know why any ball would bounce higher than another? Scientists carry out experiments to find out the answers to questions like these. Can you think of any good experiments to do to answer these questions?

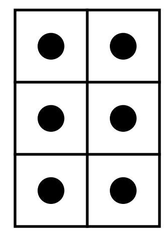
**STARTING POINT 6: LOUIS BRAILLE'S INVENTION

Louis Braille lost his eyesight in an accident when he was a young boy. The accident sparked his inventiveness. When he was a young man, he invented an alphabet that blind people could read. Each letter was in the form of a number of raised dots, and the alphabet became known as Braille.

Blind people write with special typewriters, but you can make your own Braille by pressing a ballpoint pen on an index card laid on top of a piece of soft wood (e.g., spruce or pine). Test yourself and a friend to see how good you are at recognizing the letters.

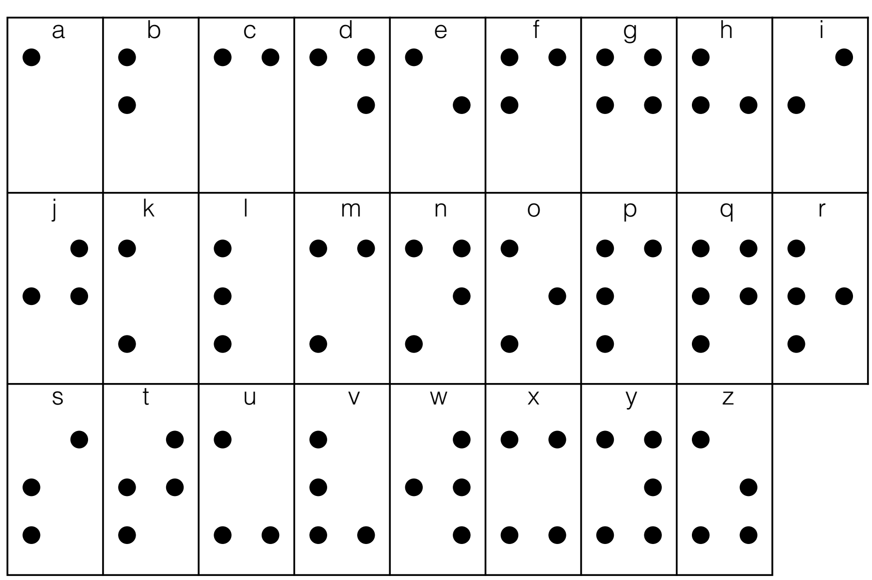
Few major changes have been made in Braille since it was invented nearly 200 years ago. Is it really perfect? Is the space between the dots just right? Why not use lines rather than dots? There are many other questions you could investigate. Can you improve Braille's alphabet?

Braille System



"The basis of the Braille system is known as a braille cell. The cell is comprised of six dots numbered in a specific order. Each dot or combination of dots represents a letter of the alphabet." (CNIB [formerly the Canadian National Institute for the Blind])

Braille Alphabet



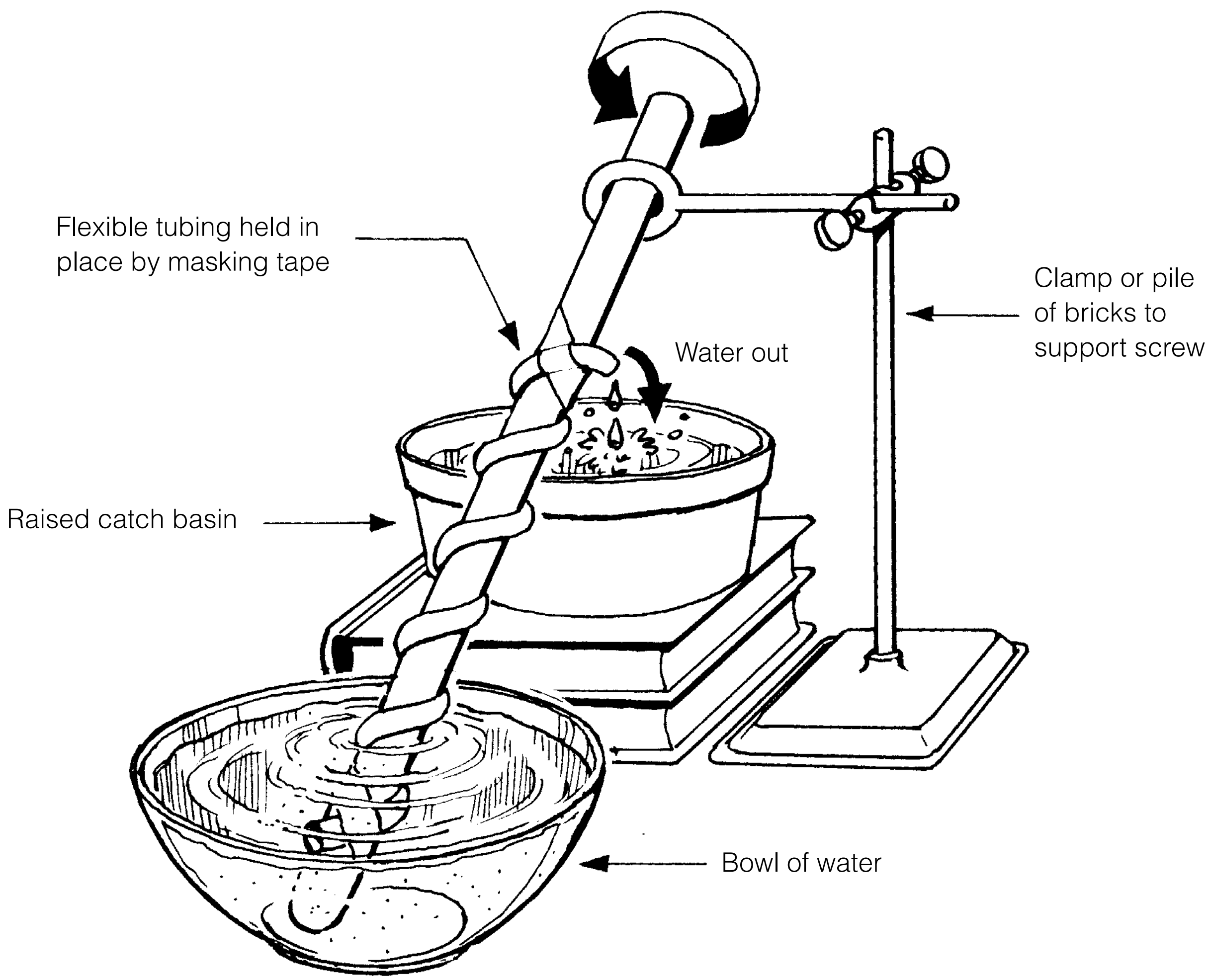
Chapter 1

**STARTING POINT 7: ARCHIMEDES' SCREW

The great Greek scientist Archimedes was an inventor as well as a scientist. He invented a remarkable water pump called the Archimedes' screw.

To draw water, all you have to do is to turn the screw. The water rises almost magically. In ancient times, the Archimedes' screw was used by farmers to irrigate their fields. In today's world, an improved design might find many uses.

Can you improve the design? Make a simple screw and investigate how it works. What's the best size for the tubing? Does the thickness of the central rod matter? Does the angle of the screw make a difference?

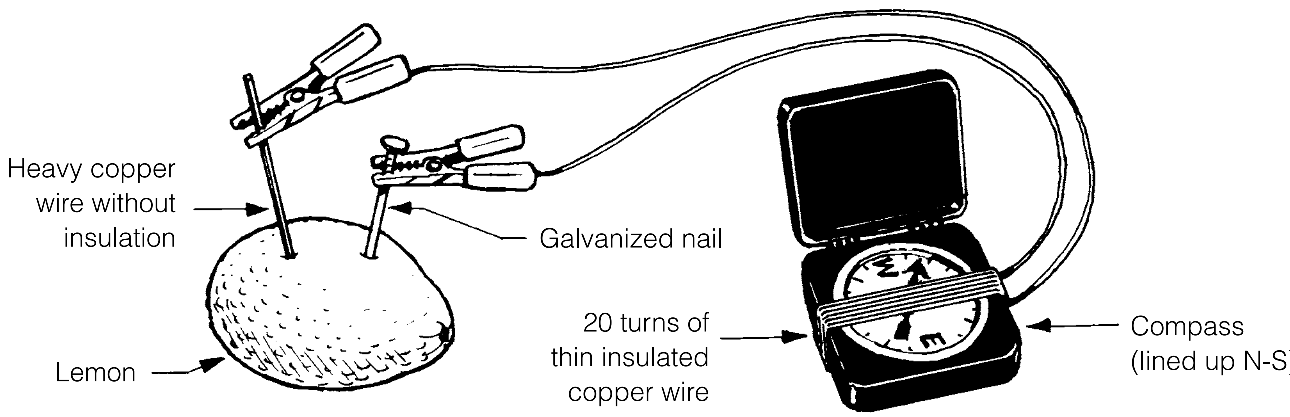


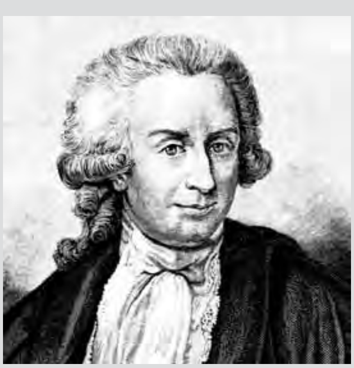
**STARTING POINT 8: ELECTRIC CELLS

If you were stranded on a desert island, you could make your own electric cell if you were able to find a piece of copper, a piece of zinc (a galvanized nail or zinc-plated iron would work), and a lemon.

Unfortunately, just one of these simple cells would not give you enough electricity to light a bulb, but you could prove electricity was produced if you connected it to a homemade current detector or galvanometer. You can make a galvanometer by winding thin, insulated copper wire around a compass; the compass needle deflects or changes direction more when a larger current flows.

Can you improve on this simple cell? Would it help if you used bigger pieces of copper and zinc? Do other metals work? Would orange juice, apple juice, or maybe vinegar work better than lemon juice? Does it matter how concentrated the juice is?





Historical Flashback: How Current Electricity Was Discovered

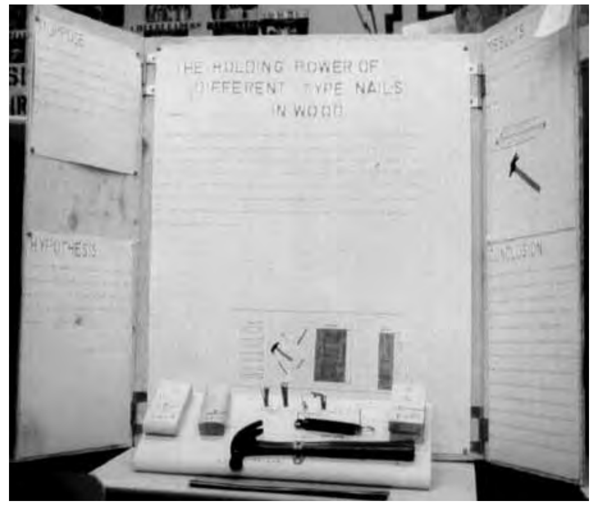
Luigi Galvani was carrying out experiments with frogs' legs. By sheer chance, a frog's leg came in contact with a piece of iron and a piece of copper. A spark flew and the leg was "galvanized" into movement. Alessandro Volta, a physicist, understood the importance of Galvani's discovery and made the first electric cell (or battery) around 1800.

Source: Wikimedia Commons. *http://commons.wikimedia.org/wiki/File:PSM_V41_D302_Luigi_Galvani.jpg*

Chapter 1

**STARTING POINT 9: THE RIGHT NAIL FOR THE RIGHT JOB

Carpenters often wonder which nails they should use. *The Handyman's Digest* has asked you to write an article for them called "The Right Nail for the Right Job." They say their readers want more than mere opinion—they want to understand something of the science of nails. Their readers want to know if thick nails hold better than thin ones, if long nails are better than short ones, and if the type of wood or board stock makes a difference. Are you prepared to accept the assignment?

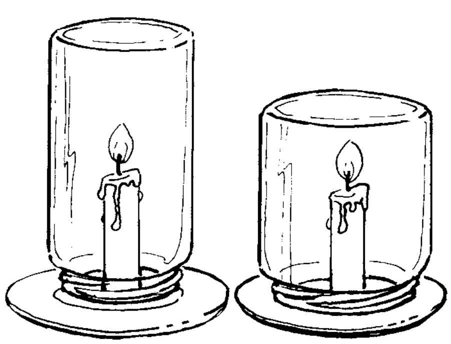


**STARTING POINT 10: SUFFOCATING CANDLES

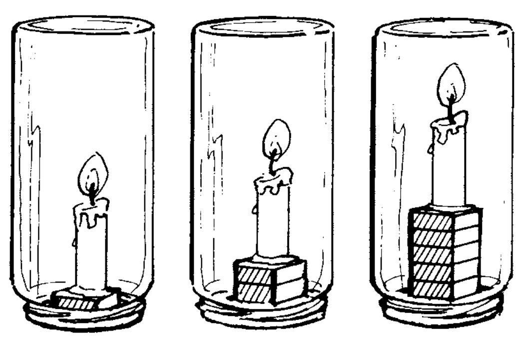
We all know that a candle goes out when we cover it with a bottle, and we know why—because the flame uses up the oxygen in the air and, of course, the flame won't burn without oxygen.

We would expect the flame to stay lit twice as long in a bottle that has twice the volume because there is twice as much air to burn. But some strange things happen when you test this idea:

1. Even though the long, thin bottle and the short, fat bottle have the same volume, the flames don't go out at the same time.



2. The length of time the flame stays lit seems to change as its height in the bottle changes. You can vary the height of the candle by standing it on small wood blocks.

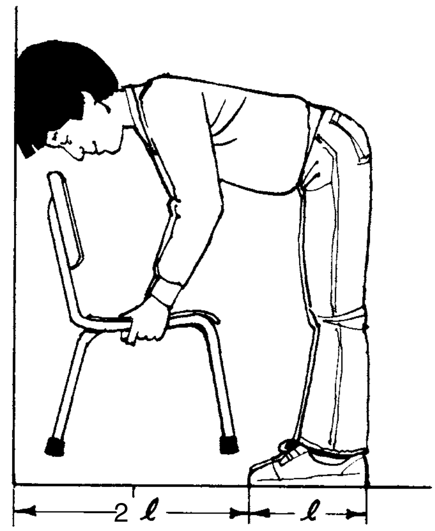


Your assignment is to unravel this mystery to find out all you can about the case of the suffocating candles.

***STARTING POINT 11: WOMEN CAN! MEN CAN'T!

Stand facing a wall with the tips of your toes touching it. Now move backward so that the space between the tips of your toes and the wall is equal to twice the length of your foot. Bend over so that your head touches the wall. Pick up a chair with your arms. Now try to stand up! Can you?

You might be surprised to hear that usually women can stand up easily whereas men cannot. Perhaps you don't believe this. Why not try it out? As you test your subjects, you may begin to wonder why some people can do this but others cannot. What are some possible reasons? Design some experiments to test your explanation. Find out all you can about the reasons for the outcome.

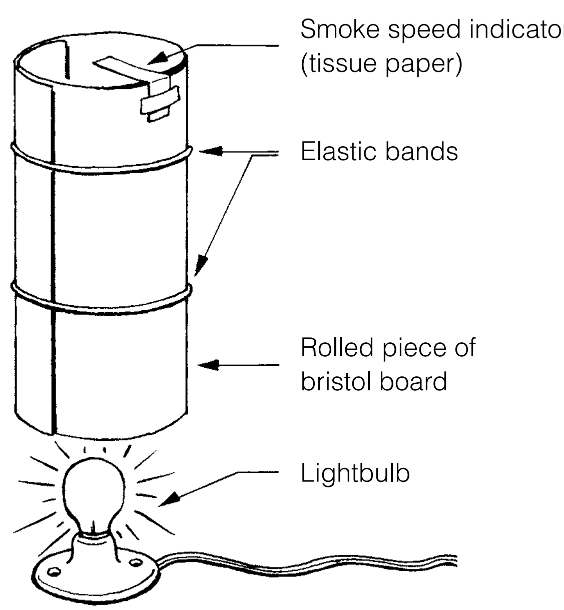


***STARTING POINT 12: SMOKING CHIMNEYS

People love to sit around open fires, but these fires often do not seem to work very well. Smoke sometimes pours into the room instead of going up the chimney as intended. Some people may blame the shape of the fireplace; others, the height of the chimney; others, the wood; and others, the wind. If only we could understand the way chimneys work.

Understanding how chimneys work is a challenging and complex problem, and it would be expensive to build lots of chimneys to test. But there are alternative ways to understand how they work.

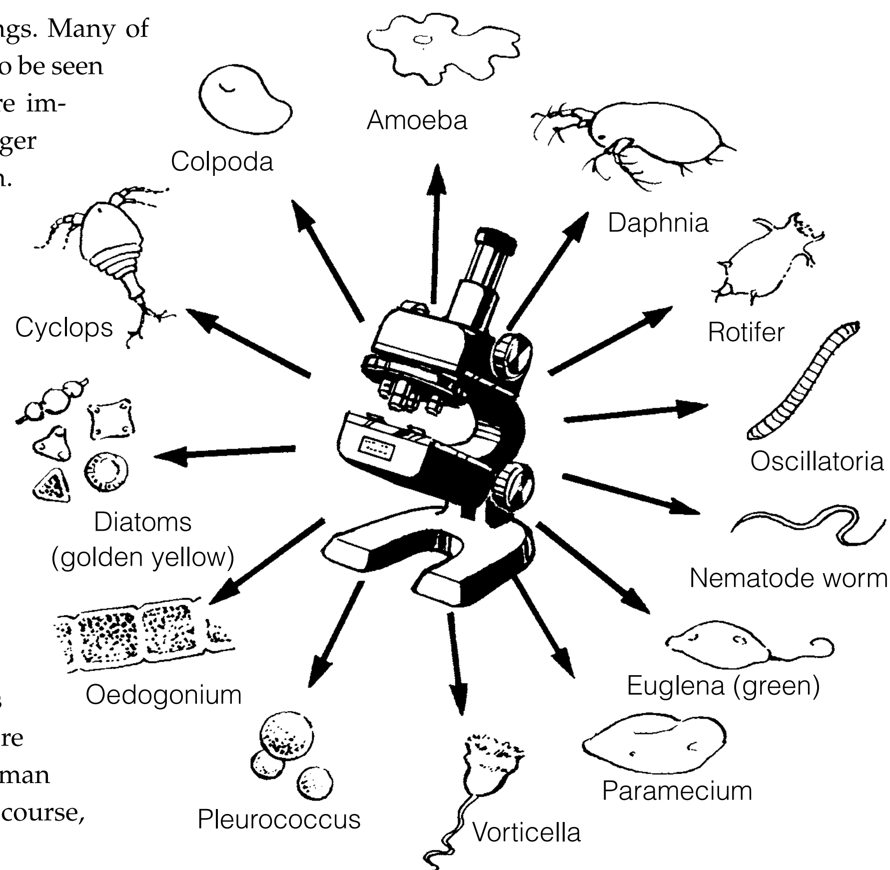
- You could study existing chimneys, collect data about them, and look for patterns among the data.
- You could build a model chimney and study how it works. A simple design made from a lightbulb (the fire) and bristol board (the chimney) is shown in the diagram. You can probably improve on it.



***STARTING POINT 13: ACID RAIN AND POLLUTION

Our ponds, lakes, rivers, and streams contain a remarkable variety of living things. Many of these living things are too small to be seen with the naked eye, but they are important nevertheless because larger creatures and fish feed on them. There is a delicate balance in nature.

Take a look under a microscope at some samples of water from a local source, and survey the population of microscopic organisms that live at various depths. The picture will help you identify some of the more common freshwater organisms.



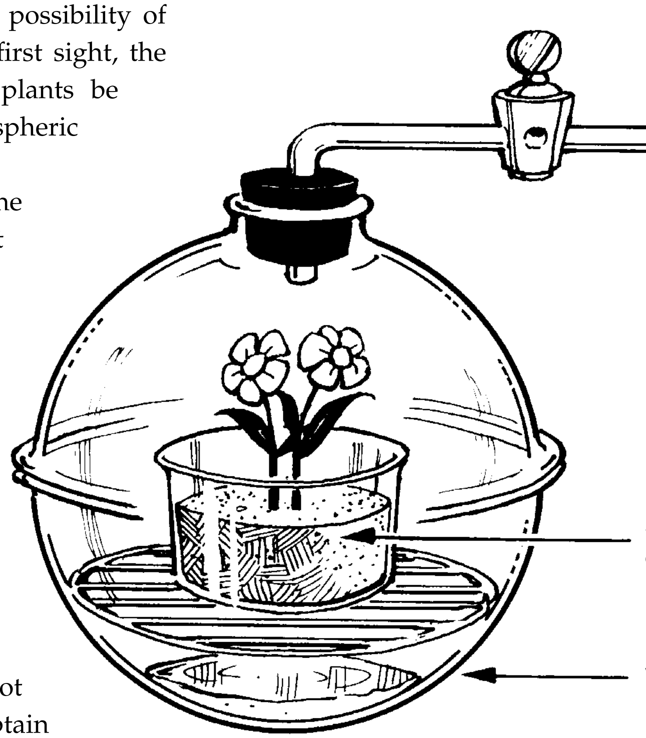
What would happen if the level of pollution in the ponds and lakes increased? There are many sources of pollution: human and industrial waste and, of course, acid rain.

When substances burn, they often give off toxic products. Among these are two particularly harmful gases, sulphur dioxide and nitrogen dioxide. These gases combine with water and other gases in the air to form acids: sulphuric acid, nitric acid, and so on. To find out more about the effects of acid rain, you might add very small amounts of one of these acids to your water sample. Use the dilute acids (one molar) because the concentrated acids can burn your skin. Does acid rain have any effect on any of the organisms you identified?

***STARTING POINT 14: LIFE ON THE MOON

Jenny wondered if there was any possibility of growing plants on the Moon. At first sight, the chances seemed remote. Would plants be able to survive under zero atmospheric pressure?

In a preliminary experiment, she grew some mustard plants, put them in a vacuum dessicator, and sucked the air out with a pump. To prevent the plants from drying out, she put some water in the bottom of the dessicator. To her surprise, as well as the surprise of many scientists, the plants survived well. They even seemed to grow in this atmosphere of water vapor at a very low pressure (1/30 atmosphere).



However, this surely could not last. Where could the plants obtain the carbon dioxide they needed to grow? Was there a possibility of somehow including the carbon dioxide in the nutrient solution? Jenny tried using low concentrations of sodium bicarbonate (baking soda), which contains carbon dioxide. Although she could not be sure, this seemed to help the mustard seeds grow.

Jenny ran some parallel experiments with chlorella, a single-celled algae found in pond water. Chlorella thrived under very low pressures when fed with sodium bicarbonate. Was this a breakthrough?

Although she only scratched the surface of this challenging problem, Jenny won the gold medal in the intermediate life sciences category at a national science fair, as well as three other awards.

There is tremendous opportunity for much more adventurous work in this exciting field. Perhaps you and your classmates would like to combine your efforts to create an ecosystem that could support human life on the Moon. Here are some ideas for how you might proceed:

- An imaginary but realistic letter calling for research proposals (see the example on p. 14).
- A picture showing an alternative to a vacuum dessicator
- A picture of a brainstorming session

Chapter 1

Space North America, Office of the Director, North America Space Research Institute

Contract: SNA/SP14 Artificial Plant Ecosystems

Call for research proposals.

Space North America has committed itself to establishing artificial plant ecosystems on the Moon.

Plant growth is considered an integral part of sustaining human life. Plants are a source of both food and oxygen.

There are many aspects of this problem to consider:

a. Atmosphere: You want to find alternatives to taking solid carbon dioxide and liquid oxygen into space.

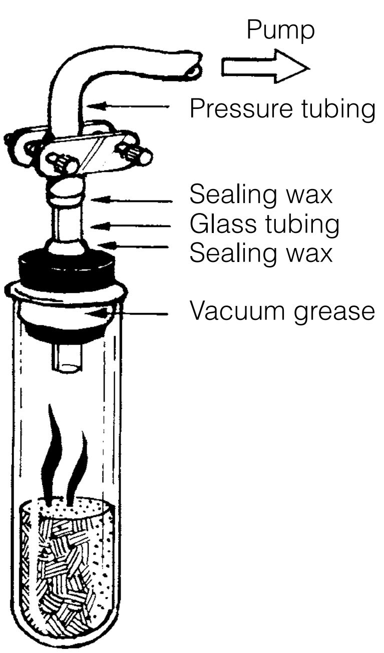
b. Light periodicity: The lunar day and lunar night are each approximately 14 Earth days long.

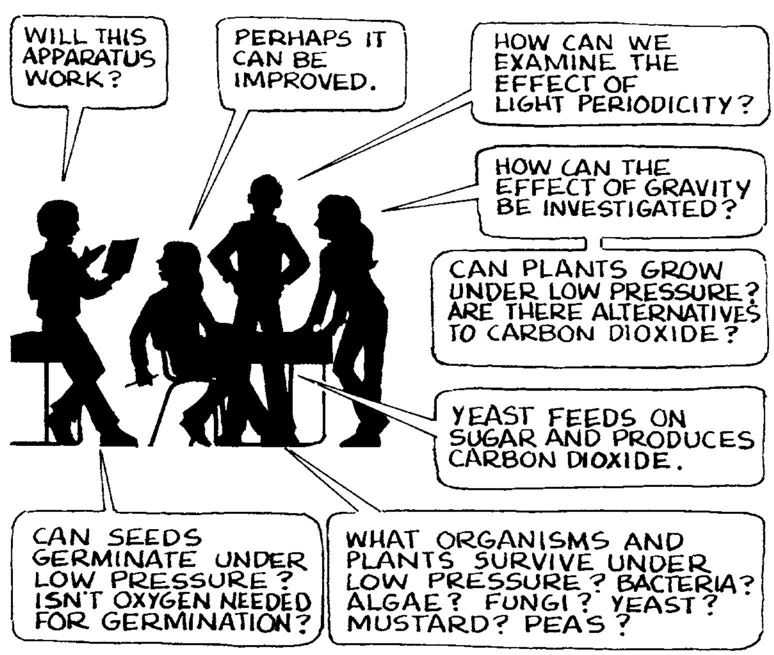
c. Gravity: Lunar gravity is approximately one-sixth of the gravity on Earth.

The proposal should aim to identify sets of conditions under which plants (and other organisms) may be grown on the Moon.

Preferred status will be given to proposals supported by preliminary studies.

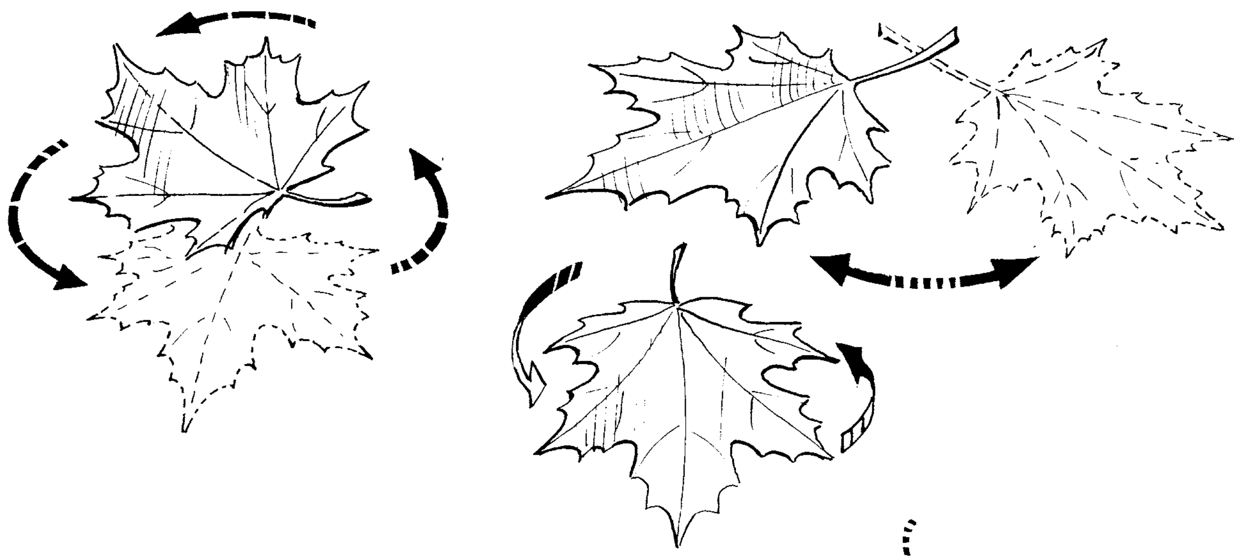
Proposals should be tendered on or before April 1.





***STARTING POINT 15: FALLING LEAVES

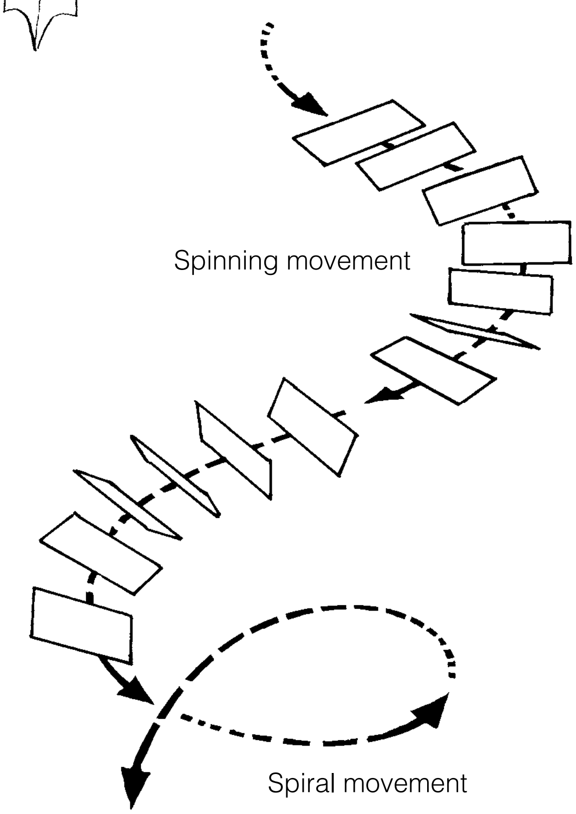
Have you ever watched a leaf fall? It spins. It flips. It sways.



To develop a detailed understanding of why leaves move as they do would be a challenging project. But you can at least start the process.

Make a simple artificial leaf from a small, oblong sheet of paper (approx. 1 cm × 3 cm. If you drop the leaf on its edge, it spirals to the ground in quite a remarkable way. Try changing the size of the paper, the thickness of the paper, and other features as variables.

When scientists encounter a new and interesting situation like this one, they often begin studying it by making careful observations. They use these observations by looking for patterns or regularities in their observations (such as the size of the spiral or the speed of spinning) and wonder if the different patterns they see are related to one another. As their understanding grows, the scientists may try to add precision through measurement.



Chapter 1

Do You Know the Difference Between Science, Technology, and Engineering?

Some of the projects—such as the inquiry into "What makes sowbugs move?"—are scientific projects because they aim to increase our understanding of the natural world. Other projects—such as "Check Rust"—are often described as technology projects because they aim to apply our scientific understanding of rusting to rust prevention. Finally, some projects—such as "Smoking Chimneys"—are engineering problems because they use a scientific approach to solving an important practical problem.

Index

Index

Index

SCIENCE FAIR WARM-UP

» LEARNING THE PRACTICE OF SCIENTISTS «

Grades 5–8

Even science fair enthusiasts may dread grappling with these two questions:

1. How can you organize many students doing many different projects at the same time?
2. How can you help students while giving them the freedom of choice and independence of thought that come with genuine inquiry?

Answer these questions—and face science fairs without fear—with the help of the *Science Fair Warm-Up* series. To save you time, the materials are organized to grow more challenging and encourage independent study as students progress through the grade levels. To help you meet your teaching goals, the series is based on the constructivist view that makes students responsible for their own learning and aligns with national standards and the *Framework for K–12 Science Education*.

This book, for grades 5–8, is particularly suited for those students who have not participated in a science fair before, as it lays a foundation for the ideas developed in the later books about the practices of scientists. Even students who have experienced science fairs will find many ideas about scientific practices that are new to them. In addition to offering original investigations, the book provides problem-solving exercises to help students develop the inquiry skills to carry the projects through.

Science Fair Warm-Up will prepare both you and your students for science fair success. But even if you don't have a science fair in your future, the material can help make your students more proficient with scientific research.

"An exciting publication that engages students and fills a need for innovative and conscientious teachers. Students and teachers are likely to encounter real science with the ideas, approaches, and questions the materials encourage." —Robert Yager, Professor Emeritus at the University of Iowa and past president of NSTA

Grades 5–8

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