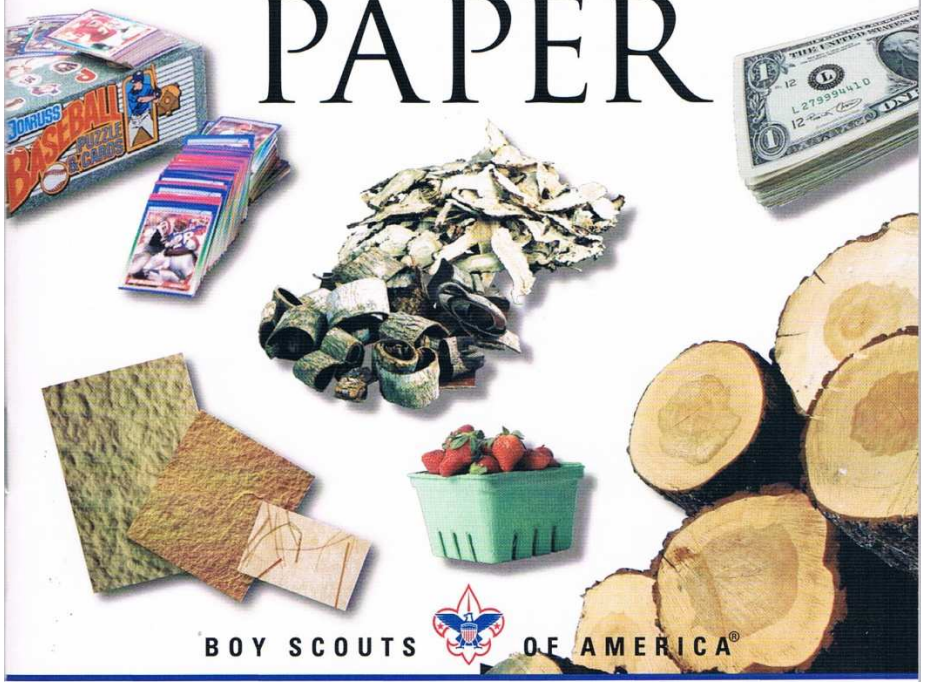
Troop 1292 #91A

MERIT BADGE SERIES

PULP AND PAPER



BOY SCOUTS OF AMERICA®

How to Use This Pamphlet

The secret to successfully earning a merit badge is for you to use both the pamphlet and the suggestions of your counselor.

Your counselor can be as important to you as a coach is to an athlete. Use all of the resources your counselor can make available to you. This may be the best chance you will have to learn about this particular subject. Make it count.

If you or your counselor feels that any information in this pamphlet is incorrect, please let us know. Please state your source of information.

Merit badge pamphlets are reprinted annually and requirements updated regularly. Your suggestions for improvement are welcome.

Send comments along with a brief statement about yourself to Boy Scout Division • Boy Scouts of America • 1325 West Walnut Hill Lane • P.O. Box 152079 • Irving, TX 75015-2079.

Who Pays for This Pamphlet?

This merit badge pamphlet is one in a series of more than 100 covering all kinds of hobby and career subjects. It is made available for you to buy as a service of the national and local councils, Boy Scouts of America. The costs of the development, writing, and editing of the merit badge pamphlets are paid for by the Boy Scouts of America in order to bring you the best book at a reasonable price.

BOY SCOUTS OF AMERICA
MERIT BADGE SERIES

PULP AND PAPER

BOY SCOUTS OF AMERICA®

Requirements

1. Tell the history of papermaking. Describe the part paper products play in our society and economy.

2. List the trees that are major sources of papermaking fibers. Then discuss what other uses are made of the trees and of the forestland owned by the pulp and paper industry. Describe the ways the industry plants, grows, and harvests trees. Explain how the industry manages its forests so that the supply of trees keeps pace with the demand, and tell about one way the industry has incorporated a sustainable forestry concept. Give two ways the papermaking industry has addressed pollution.

3. Describe two ways of getting fibers from wood, and explain the major differences. Tell why some pulps are bleached, and describe this process.

4. Describe how paper is made. Discuss how paper is recycled. Make a sheet of paper by hand.

5. Explain what coated paper is and why it is coated. Describe the major uses for different kinds of coated papers. Describe one other way that paper is changed by chemical or mechanical means to make new uses possible.

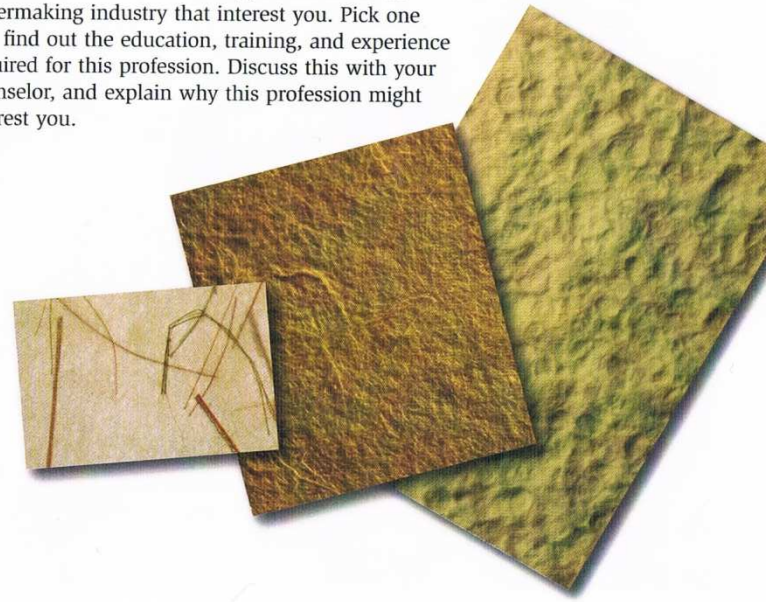
6. Make a list of 15 pulp or paper products found in your home. Share examples of 10 such products with your counselor.

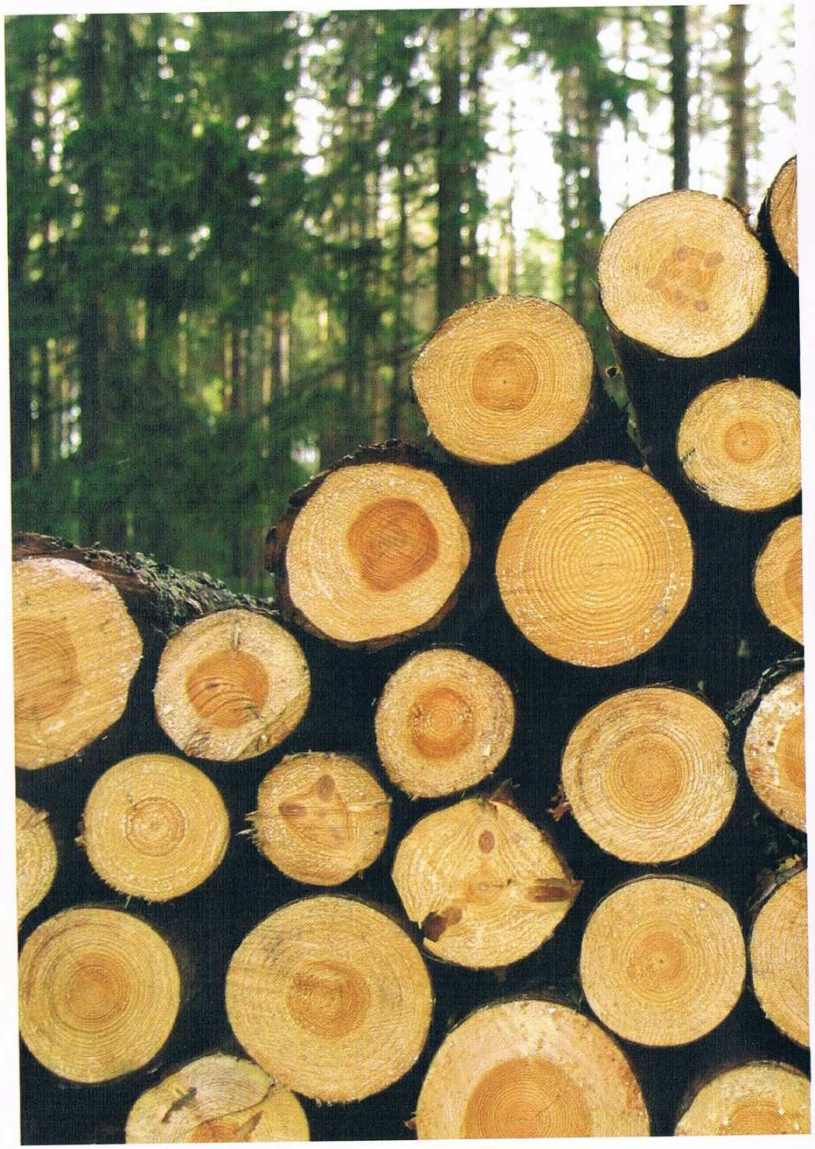
35937
ISBN 978-0-8395-3343-6

2008 Printing

7. With your parent's and counselor's approval, do ONE of the following:
   a. Visit a pulp mill. Describe how the mill converts wood to cellulose fibers.
   b. Visit a paper mill and get a sample of the paper made there. Describe the processes used for making this paper. Tell how it will be used.
   c. Visit a container plant or box plant. Describe how the plant's products are made.
   d. Visit a recycled paper collection or sorting facility. Describe the operations there.
   e. Using books, magazines, your local library, the Internet (with your parent's permission), and any other suitable research tool, find out how paper products are developed. Find out what role research and development play in the papermaking industry. Share what you learn with your counselor.

8. Find out about three career opportunities in the papermaking industry that interest you. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

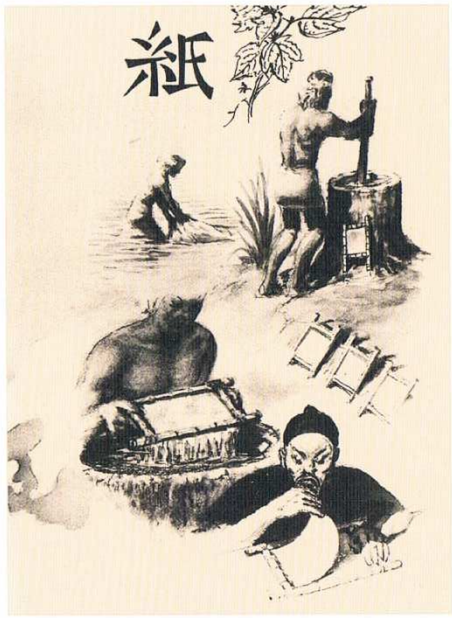




Contents

A Brief History of Paper

Nearly 2,000 years ago, in the year 105, a Chinese man named Ts'ai Lun ground up some plants, including mulberry bark and hemp. He may also have recycled old rags into the mixture. He added water and mixed up the fibers until he had a big, squishy mess. Then he spread the wet pulp on a cloth screen framed in bamboo. He set the thin mat of fibers in the sun to dry.



Papermaking began in China in about A.D. 105. The bark of the mulberry tree *(pictured top right)* was shredded, mixed with scraps of linen and hemp, soaked, and beaten into a pulp. The pulp was dipped up on a mold *(bottom left),* and the water drained away to form a sheet of paper *(bottom right).* The Chinese symbol for paper is shown at *top left.*

Some archaeological evidence suggests there may have been other papermakers even earlier than Ts'ai Lun, but he was the first to have his work recorded for history.

The Chinese kept papermaking their secret for hundreds of years, but gradually their Korean and Japanese neighbors learned the art. Then, in 751, the Chinese lost a battle with the Arabs in Central Asia. The victorious Arabs made prisoners of several Chinese papermakers and took them to Samarkand, an ancient city that today is in Uzbekistan. From the captured Chinese papermakers, the Arabs learned the art of papermaking.

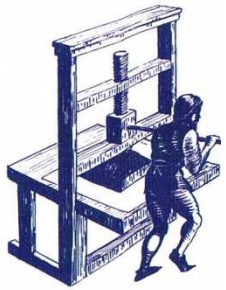
Paper spread across the Arab world, from the Middle East to Egypt (where it displaced papyrus)

Ts'ai Lun was a court official and a scholar. What he invented that day would change the world. He made paper, one of the most important inventions of all time. Imagine getting through just one day without a product made from paper.

and westward to Morocco. The Moors from North Africa brought papermaking to Europe. These Arabic invaders, after conquering Spain, built Europe's first paper mill there in about 1150. Then Italy became a major paper producer in 1250.

Soon the art spread to France, where monks in the 1300s began making paper for holy texts. European monks had long used parchment, made from animal skins that were stretched, scraped, dried, and cut to the right size. Parchment was extremely expensive. It has been estimated that a single Bible handwritten on parchment required the skins of 300 sheep.

When Johannes Gutenberg of Germany perfected the movable-type printing press in the 1450s, a tremendous thing happened. Books suddenly became available to ordinary people. Before Gutenberg, books had been so rare and costly that only monasteries, royalty, and scholars could own them. Now, even poor people could get their hands on books.



People became better educated. More people learned to read, they wanted more books, and the demand for paper skyrocketed. Papermakers couldn't find enough old clothes and rags to turn into enough paper to meet the demand. Surely, they thought, there had to be something they could use that would provide plentiful papermaking material so books and writing paper could be made widely available at low cost.

B.P. (Before Paper)

You have to go back a lot longer than 2,000 years to discover when people started writing. It seems from the time of the cavemen, people wrote and painted on cave walls. Early on, they drew designs on wood, on wet clay, and on metal. The Chinese, before Ts'ai Lun gave them paper, wrote on silk cloth—very expensive stuff—and made heavy, clumsy books from bamboo. The ancient Greeks used parchment made from animal skins. Egyptians more than 5,000 years ago wrote on papyrus made from Nile River reeds, cut into thin strips and crisscrossed in layers, then hammered together into thin, hard sheets. Our word "paper" comes from the word *papyrus,* but papyrus was not true paper as we know it today.

Early paper was made from cotton and linen rags. Papermakers had a tough time getting enough rags. When the Black Death, a horrible plague, killed millions of people in Europe during the 1300s, tons of rags from clothing became available for use, and dealing in old rags became a thriving trade. Some historians say the Black Death entered England from Europe on these infected rags.

In the 1700s, a French scientist named René Antoine Ferchault de Réaumur realized what could be used as a plentiful papermaking material. Réaumur watched a paper wasp build a nest out of chewed-up wood. The wasp would munch on wood, grind it up, and spit it out, making a fine paper to create its nest bit by bit. As far as we know, Réaumur never tried to chew up wood himself to make paper with it. However, he found that paper could be made from wood, and wood was plentiful and practical. A major step toward modern papermaking had been taken.

Papermaking in Colonial America

The first paper mill in America was built in 1690 near Germantown, Pennsylvania, by William Rittenhouse. He had been an apprentice papermaker in Holland. He settled near Philadelphia because the city's population was big enough to provide him with the main raw material that was still being used for paper at that time: old rags. He also chose a spot where there was plenty of water, the other necessary ingredient for making paper. The first American papermakers were trained at the Germantown mill—one sheet at a time.

Making paper by hand, sheet by sheet, was slow and tedious. The rags were washed and then kept damp for weeks so they would partly rot. The wet, decaying rags were then ground into a pulp and pounded with water in large wooden vats to make a creamy batter.

Then it was the role of a skilled "vatman" to dip up a thin layer of the pulp on a wire screen stretched over a wooden frame. This equipment was called a mold. The vatman drained off the excess water, then gave the mold several sharp jerks to shake out most of the remaining water and to help mat and lock the fibers together for strength.

The vatman passed the mold to the "coucher," who carefully turned the mold over on top of a piece of felt and

No Squares Here

Why is paper rectangular in shape, not square? Probably because early papermakers—vatmen—found it easier to control rectangular molds than square ones. The rectangular shape made it easier to dip the mold into the vat, then jerk the layer of pulp evenly. Tradition kept the shape rectangular, even after papermaking machines took over from skilled vatmen.

gently pressed on the wire screen until the wet paper fell out of the mold. The coucher stacked a layer of felt between each sheet of wet paper until the stack grew to 144 papers. Then the stack, or post, was squeezed in a press to force out water and compact the paper fibers together.

The post was turned over to a "layman" who carefully peeled the paper from the felt, then laid each sheet of damp paper on a fresh, dry piece of felt. The layman restacked all the sheets of paper, layering them as before with dry felt. Then the stack (the post) was again squeezed in the press to remove more water. This was repeated three times. After the last pressing, the paper was hung up to dry.

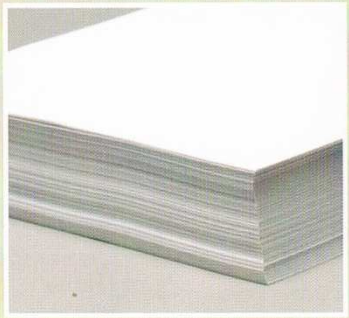
At this stage, the paper was too absorbent to print on. Ink would make blotches, like trying to write on a paper towel with a felt-tipped pen. To prepare the surface to take ink crisply, each dried sheet of paper was dipped in a vat of sizing, a gummy liquid. Then the sheets were once more layered with felt and squeezed in the press to remove the excess sizing and bond the sizing with the paper.

Because the process was slow and rags were hard to get, paper was always in short supply. In the early 1700s a good papermaking team could make only about 1,500 sheets of paper, about 22 by 30 inches, in one day's work.

Still, with some paper available, the American colonists could publish newspapers. The first newspapers in the colonies were the *Boston News Letter* (founded in 1705), the *Boston Gazette* (1719), and *Bradford's Mercury* (1719).

After a while, Great Britain required the colonists to pay a tax on newspapers and pamphlets. This new tax, imposed by the Stamp Act of 1765, did not sit well with the Americans.

One of the oldest words in papermaking is "ream." The word can be traced to the Arabic "rismah" or "rizmah," meaning a bale or bundle (of clothes, paper, etc.). In French the word is "rame," and the Dutch variation is "riem." Over time, the number of sheets of paper in a "bundle" or ream became fixed at about 480 or 500. In the United States, a 500-sheet ream of paper is the most common.



Colonial printers published works that spoke out against British rule, and the British government responded by trying to restrict papermaking in America.

So important was papermaking in the colonies that a skilled maker of paper molds, Nathan Sellers of Pennsylvania, was discharged from the American army in 1776 by a special resolution of the Continental Congress. They sent him home to make the molds that were desperately needed to produce paper for writing military orders and dispatches during the Revolutionary War.

The modern paper machines on which most of our paper is made today are basically just improved Fourdrinier machines.

From Handmade to Machine-Made Paper

In Europe, inventors continued to work on ways to speed up papermaking. In 1798, Nicholas-Louis Robert of France invented a machine that would form a continuous sheet of paper on a moving wire screen, making paper production much faster and less expensive than molding single sheets by hand. The invention, a huge step forward, was patented in 1799.

Two English brothers, Henry and Sealy Fourdrinier, developed a practical version of the continuous paper machine in the early 1800s. Mills in Britain, Europe, India, and America acquired these Fourdrinier machines, as they were commonly called. The first paper machine in the United States was set up in a mill near Philadelphia in 1817.

By 1810, the new United States boasted 185 paper mills. Rags for making paper became critically scarce, and the search was on for plentiful raw materials that could serve as a better alternative. Mills tested tree bark, sugarcane waste, straw, and cornstalks for sources of fiber.

Of the available raw materials, wood stood out as the best and most plentiful. Inventors developed workable ways to grind wood for making wood pulp. In the 1850s and '60s, English and American chemists found they could use chemicals to separate the wood fibers. About 1880, German chemist Carl F. Dahl perfected the use of wood for papermaking by adding yet another chemical. His sulfate, or kraft, method spread quickly and reached the United States in the early 1900s. (*Kraft* means "strength" in German.) Low-cost, mass-produced paper soon became available. Books, newspapers, and magazines were printed in large numbers. Schoolchildren gave up their writing slates in favor of paper.

In 1863, the *Boston Weekly Journal* became the first American newspaper to be printed on paper made from ground wood pulp.

Paper Firsts

Today, paper products such as cups, towels, and tissues are so common that we use them daily and hardly think about them. Not so long ago, however, people did not have these handy items. Consider these:

- Toilet paper, invented by American Joseph Gayetty in 1857, was considered a luxury item at first, but it came into widespread use after the Civil War.
- George Eastman manufactured coated photographic paper in 1885.
- In the 1800s it was common for people to drink after one another from a single cup attached to a public water fountain. Disposable paper cups came along in the early 1900s as protection against the germs and diseases that were spread by people drinking out of the same cup.
- During a cold epidemic in 1907, a Philadelphia teacher suspected that her students were spreading germs by all using the same cloth towel. She cut heavy paper into squares—the first paper towels—and gave them to her students to use.
- When cars came on the American scene, women began using more cosmetics to protect their skin from the effects of wind hitting their faces as they rode in cars that were open to the elements. Women used cold cream to remove the cosmetics, and they needed cloths for wiping away the cold cream. In the 1920s, facial tissues were developed for women to use for removing cold cream and makeup.

A Walk Through the Papermaker's Woods

Paper consists mainly of *cellulose*, a substance that strengthens the stems, roots, and leaves of trees, grasses, and other plants. Early papermakers discovered that the inner bark of certain shrubs and trees contains a fairly pure form of cellulose fibers. Wood is about half cellulose. The purest form of cellulose fibers that occurs naturally is cotton, which is more than 95 percent cellulose. The highest quality papers are almost pure cellulose.

Anselm Payen, a French chemist, identified cellulose in wood in the 1830s. Wood has been the major raw material in papermaking for more than 100 years because it is widely available and it is a *renewable* (replaceable) resource.

All fruits and vegetables contain cellulose. The stiff stalks of celery, for example, are rich in cellulose.

Many of the natural resources we use, such as ores, oil, and coal, are not renewable. Once they're taken from the ground, they can't be replaced. They are gone forever. Trees, however, are a renewable resource. We can plant and grow more of them to replace the ones we use.

Trees Used in the Paper Industry

Trees are often grouped as softwoods (needleleaf or evergreen trees) and hardwoods (broad-leaved trees that lose their leaves in the fall and winter). The wood fibers from different trees vary in length, from about 1/32 to 1/4 inch (1 to 5 millimeters) long. The longer fibers come from softwood trees such as pines, firs, hemlocks, and spruces. Broad-leaved trees such as aspens, beeches, birches, gums, maples, and oaks have short fibers.

The shorter hardwood fibers provide bulk and smoothness and are used to produce papers for printing and writing. The longer fibers from softwoods are used to make papers that need to be strong, such as packaging papers. Papermakers often mix these fibers in various combinations, depending on what they want the finished paper to look like and what it will be used for.

Pine—a softwood

Spruce—
a softwood

Maple—
a hardwood

Oak—
a hardwood

Some trees are grown and harvested, like a crop, especially for papermaking. Mostly, however, paper manufacturing uses leftover scraps of lumber and the trimmings, shavings, and wood chips from trees that are used for other purposes such as furniture making and building construction. In the United States, recycled paper and leftover wood make up about two-thirds of all the fiber used in pulp and paper mills. The other one-third comes from whole tree trunks. These whole trees are generally small, between 4 and 8 inches across. High-quality trees larger than 8 inches in diameter can be too valuable to chip up for paper. They're normally sawed into lumber—boards and planks.

Trees that are dying from old age, insects, disease, or forest fires are also used in papermaking. Foresters must remove these trees to keep the forest healthy, and it's sensible to use them for wood pulp.

Tree leaves, needles, small branches, and roots are generally left behind in the forest to enrich the soil and hold it in place. But nearly every other part of a tree gets used for something—if not for lumber and paper, then for by-products ranging from photographic film to chewing gum, shoe polish, dyes, soaps, glues, and medicines.

Sustainable Forestry

Many pulp and paper companies plant, harvest, and replant their own forestlands. In the United States, most of the trees that are harvested for papermaking are planted and grown in forests called *tree farms*. When these trees mature and are cut down, new ones are planted to replace them, a practice known as reforesting. This type of forest management is called *sustainable forestry*.

Professional forest managers know they must use forests wisely so that the trees and other resources are not permanently damaged or used up. Healthy, productive forests provide wood fiber for the products that the pulp and paper industries make. It's in these industries' best interests, therefore, to protect the health

of forests at the same time they harvest trees to make their products. Paper companies work to manage their lands so that the forests will keep on producing fiber for paper products, habitat for fish and wildlife, clean water, clean air, and woods where Scouts can go hiking and camping.

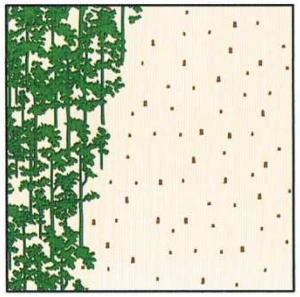
To sustain a thing means to keep it up or keep it going.

In the 1920s, people were predicting that demand for lumber, paper, and other wood products would use up the country's supply of trees by 1945. Not only have those predictions proved untrue, but today the United States has more trees than it did 70 years ago.

Forest Management Systems

Several methods, or systems, are used to harvest, then replant trees. Here's a quick look at the systems commonly used in American forests. (You can find more about these in the *Forestry* merit badge pamphlet.)

- **Clear-cutting** is harvesting all (or almost all) of the trees in an area of the forest. The cleared area is then sown with seeds or planted with seedlings. Or a new stand of trees, all the same age, may grow naturally from seeds dropped by trees around the cleared space, from seeds already on the forest floor, or from sprouts that grow from the stumps and roots of the cut trees. Clear-cutting is a common harvest method for trees grown for pulpwood.



Clear-cutting

Seed trees

Shelterwood

Single-tree selection

- **Seed trees** provide a natural source of seeds from which a new stand of trees grows after a mature stand is harvested. During harvesting, a few healthy seed-producing trees are left standing to reseed the area. Then, when the fresh crop of young trees has become established, the seed trees themselves are harvested. The seed-tree system can be used with various pines.
- In the **shelterwood system**, trees are harvested in stages over a period of 10 to 20 years. A new stand grows where an old one stood. The mature trees that are left uncut—the shelterwood—shade the seedlings and young trees. Such trees as oak, ponderosa pine, and white pine need shade when they're young. As the new trees grow up, the shelterwood trees can be harvested.
- In the **single-tree selection system**, trees are harvested individually as they mature. Seedlings or sprouts grow in the open spaces created. Similarly, small patches of mature trees can be selectively harvested, making room for younger trees but leaving many larger trees standing to produce seeds. Selection cutting creates only small openings in a forest, and so it works best with trees that grow well in shade, such as American beech and hemlock.
- **Improvement cuttings** may be made to thin the forest and remove undesirable trees—undersized trees or ones that are crowding larger trees, for example. **Salvage cuttings** are made to harvest trees damaged by wind, ice, or fire and to clear the way for new growth. **Sanitation cuttings** remove trees infested by insects or infected by disease, to protect the health of neighboring trees.

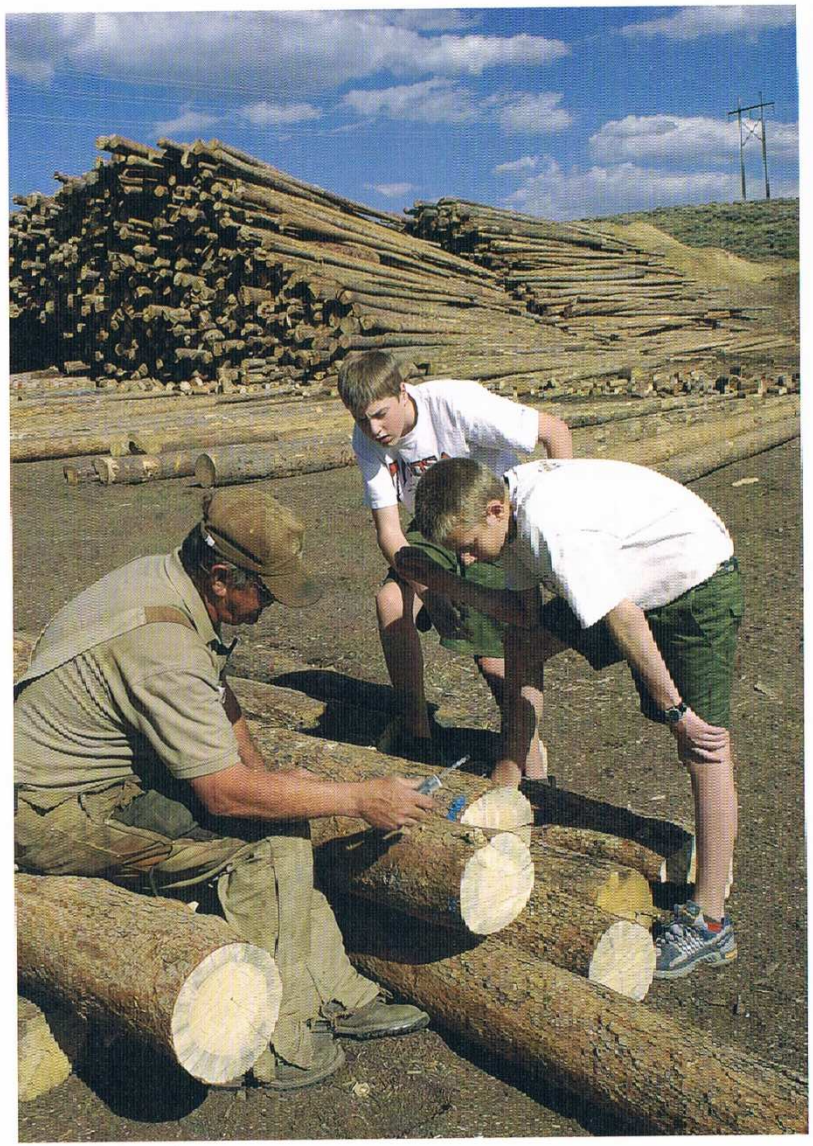
Forests and the Greenhouse Effect

You've probably heard of the *greenhouse effect*—the warming that happens when carbon dioxide and other gases trap heat in Earth's atmosphere much as a glass greenhouse captures sunlight. Many scientists believe the trapped heat can raise Earth's average temperature, cause sea levels to rise, and change the world's climate in ways that may lead to extreme, damaging weather.

Forests combat the greenhouse effect because, in wood, they naturally capture and store carbon (carbon dioxide) from the atmosphere. Products from the forest also store carbon. Paper and wooden houses and structures may store carbon for decades or throughout their lifetimes.

In this way, the cycling of carbon back into the atmosphere is delayed. The forests, especially young, vigorously growing forests like those used in the paper industry, are carbon *sinks*, good at "fixing" atmospheric carbon as trees take in far more carbon than they give out.

Recycling a ton of paper spares 17 trees, which can absorb up to 250 pounds of carbon dioxide from the air each year. If that same ton of paper were burned instead of recycled, it would create 1,500 pounds of carbon dioxide, which in turn would contribute to pollution and greenhouse gases.



How Paper Is Made

To see how wood is made into paper, let's start with a tree that is harvested from a tree farm. The tree's limbs are taken off, and the trunk is hauled to a pulp mill. At the mill, the bark is removed, to be burned for fuel or made into garden mulch. Then the wood in the trunk has to be separated into individual fibers, a process called *pulping*. And from the pulp, paper is made. These are the steps.

PULPING

Step 1—Separate the wood fibers, either by breaking them apart mechanically or by cooking the wood in chemicals until it falls apart, or by combining these methods to turn wood into pulp.
Step 2—Clean the pulp.
Step 3—Bleach the pulp, if desired.

PAPERMAKING

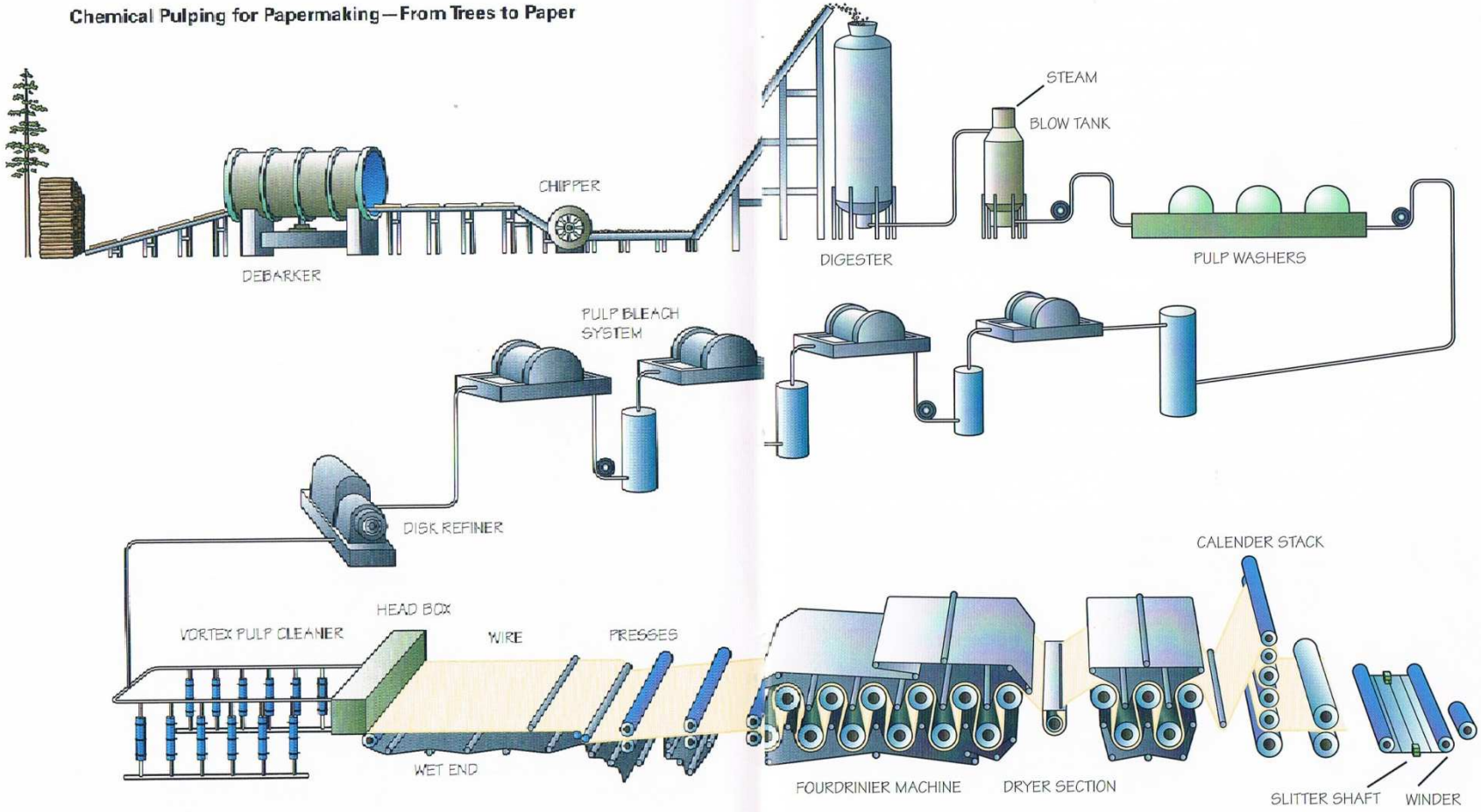
Step 4—Rough up the fibers to create more surfaces for better fiber-to-fiber bonding. This process, called refining, makes for a stronger finished paper.
Step 5—Add dyes and fillers to the pulp to color the paper and give it other desirable properties.
Step 6—Make the paper by spreading the watery pulp on a fast-moving screen and draining off the water. Then press the wet paper to remove more water, and dry it on hot rollers.
Step 7—Coat the paper, if desired.
Step 8—Cut the paper to the final shape. The paper is now ready for use or for converting.

CONVERTING

Step 9—Converting means cutting and shaping the paper to make boxes, cups, plates, bags, and many other products.

From log of wood to finished paper product, that's just nine steps. It can't be that easy, you say? Well, it is—and it isn't. Take a closer look at each step, and you'll see how much goes into making the paper you use every day.

Chemical Pulping for Papermaking—From Trees to Paper



Pulping

The three main pulping methods are mechanical, chemical, and semichemical (which combines chemical and mechanical methods).

Mechanical Pulping

Groundwood pulp. The original way that papermakers made wood pulp was by mechanical means, simply grinding up the wood to separate the fibers. In the oldest mechanical method, called the *stone groundwood* process, short logs are pressed sideways against a grindstone that tears fibers out of the logs. Friction heats the wood and softens the *lignin* (a natural glue in trees that sticks the fibers together). The lignin is not removed. Paper made from groundwood pulp is good for printing on, but it's weak and—because of the lignin—it will discolor, especially in sunlight. Mechanical pulps are suited for low-quality printing papers that are used briefly, such as newsprint for newspapers.

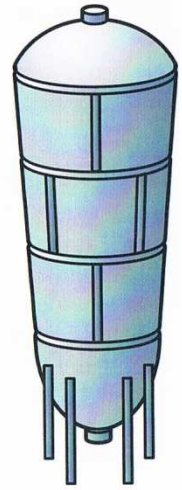
Thermomechanical pulp (TMP). Though the old stone groundwood method hasn't altogether disappeared, modern methods of mechanical pulping have nearly replaced it. In the method known as *thermomechanical* pulping, the wood is first cut into chips about the size of a quarter. The chips are steamed to heat and moisten them, then fed through the spinning disks of a machine called a refiner. The disks tear the chips into fibers. This pulp makes a stronger paper than groundwood pulp, but its uses are similar.

When you were younger and just learning to write, you may have used a grayish paper with wide rules. Get a piece of that kindergarten writing paper and hold it up to the light. Can you see bits of wood in it? This is an example of paper made from mechanical pulp. Such paper doesn't need to be strong, bright, or pure, because it isn't meant to last as long as a book printed on fine paper will last.

Logs to Chips. Logs are tumbled through a big, rotating debarking drum that removes the bark. Then the logs are cut into even-sized chips (about the size of quarters).

Chemical Pulping

In chemical pulping, chemicals dissolve and remove much of the lignin. Wood chips are cooked in a solution of water and chemicals, in a big pressure cooker called a digester, until the fibers fall apart. Chemical pulp produces strong paper that is used for printing and writing, shipping boxes, paper bags, and other products needing strength.



Chips to Fiber: The Digester. The wood chips go into the digester for cooking. The cooking chemicals dissolve the wood's lignin, the natural glue that holds wood fibers together. The used solution of chemicals and dissolved lignin is drawn off and recycled.

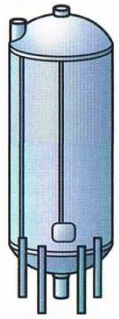
Finished pulp looks like watery mush. But examine a sample of pulp under a microscope, and you'll see the separate, individual wood fibers.

Semichemical Pulping

Semichemical processes also use chemicals to soften and break down lignin. But then special rotating disks are used to mechanically separate the wood fibers.

Cleaning and Bleaching

Pulps are screened to remove knots and clumps, and are washed to get rid of impurities. Some pulps are bleached to produce white paper. Good-quality writing papers, for instance, are made from blends of bleached chemical pulps. Bleaching is often done in a series of steps, using different chemicals at each stage. The bleaching chemicals either remove the color-causing compounds from the pulp or make them colorless.



Brown to White: Bleaching. A series of chemical bleaching and washing processes turns brown wood fiber into white pulp. Unbleached pulp makes brown paper, as for grocery bags and kraft wrapping paper.

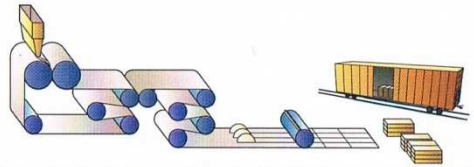
Rag Pulping

The oldest pulping process—rag pulping—is still done. New rags—scraps from the textile industry—are preferred, though old rags can be used. The rags are cut up, cooked in chemicals, then washed, bleached, and rewashed. The resulting pulp is used for making fine writing papers, business letterhead and art papers, and durable, high-quality papers for such things as blueprints, legal documents, and paper money.

The paper used for American paper money is a blend of cotton and flax. The long cellulose fibers in cotton and flax make a strong paper—which is why a dollar bill can go through the laundry, hidden in a pocket, without falling apart.

Papermaking

Pulp is either made into paper in the same location as the pulp mill (an integrated pulp and paper mill) or dried and shipped to a stand-alone paper mill. Here's a look at how paper is made by machine.



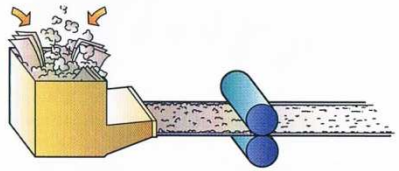
Repulping Pulp. Pulp can be rolled, dried, and cut into sheets that are baled for shipment to papermaking customers around the world. To be used in papermaking, the baled pulp is repulped in water to make a slurry.

Refining

Most pulp can't be used for papermaking as it comes from the pulp mill. For most grades of paper, fibers direct from a pulping operation won't bond well enough to make a strong sheet. The fibers must be unraveled or frayed to increase their ability to bond. So before the fibers are put into a paper machine, various types of beaters and refiners loosen them and make them more flexible so the fibers can bond better. The quality of the paper depends on how much the pulp is refined.

Mixing and Blending

To get a paper that has the desired color, strength, texture, writing surface, and other qualities, the right ingredients must be mixed together in the proper amounts. Softwood and hardwood pulps may be blended, and they may be mixed with recycled pulp. Papermaking chemicals and minerals are added: sizing, to make paper resist water and take ink; fillers, to fill the spaces between the fibers to improve the properties of the final paper; and dyes, to add color.



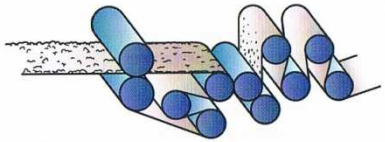
Mixing Things Up. In the paper mill, different pulps are combined, and papermaking chemicals and minerals are added.

Forming Sheets

Modern papermaking machines, running at speeds above 60 miles per hour, can make continuous sheets of paper up to 33 feet wide.

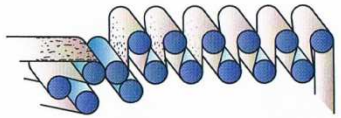
At the *wet end* of the papermaking machine, the well-blended pulp (99 percent water at this stage) is spread onto a long, wide, endlessly moving screen called a wire. Right away, water begins to drain out the bottom of the wire. The water is collected and recycled, to be used again and again. On the top side of the wire, fibers from the pulp catch and begin to bond together in a thin mat. A vacuum sucks more water from the mat. But when the wet paper leaves the wire, it is still mostly water.

To press out more water, the wet paper is squeezed between heavy rollers or presses. The paper, supported on endless fabric loops called felts, leaves the wet end of the papermaking machine. As it moves rapidly to the *dry end*, the paper passes between huge metal cylinders that are steam-heated. These hot rollers heat and dry the wet sheet.



Drainage: A Pressing Problem. On the paper machine, some water drains by gravity, while a vacuum pulls more water through the bottom wire. On a twin-wire machine, water is squeezed out where the top and bottom wires come together. The paper machine also has presses—rollers—that squeeze water out of the paper.

More heavy cylinders press, or iron, the drying paper smooth. This part of the machine, called a *calender stack*, evens the surface and makes the paper all the same thickness.

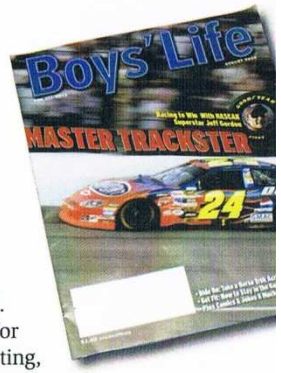


Temperature Rising: The Dryers. The steam-heated cylinders of the main dryer heat and dry the paper. Then the sheet may go through a size press, where a starch solution is applied to seal both sides of the paper before it passes through an afterdryer.

Coating the Paper

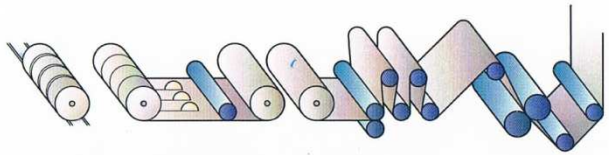
Either on the paper machine or afterward, paper can be coated. Papers are coated to give them certain kinds of surfaces, to whiten or color them, or to make them waterproof. Milk cartons and paper cups are made from heavy paper (paperboard) coated with wax or plastic. Household waxed paper, for wrapping sandwiches and covering foods in the microwave, is a type of coated paper. So is the glossy paper, coated with a solution of starch and clay, that slick magazines are printed on.

Because most coatings (except wax and plastic) can't stick to paper by themselves, they are "glued" on. Common adhesives or binders are starch, casein (a milk by-product), and synthetic adhesives such as resins and latexes. These fix the pigment (the whiting or coloring) to the paper. The pigment and adhesive are mixed in water to make a creamy liquid, and this liquid is rolled, sprayed, or otherwise put on the paper.



Rolling and Cutting the Paper

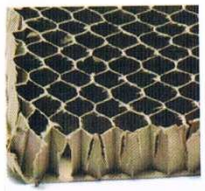
When the paper is dry, it's rolled onto a big spool or reel. These jumbo rolls of paper can be cut into smaller rolls for sale or for further processing. From these rolls come printing, publishing, and writing papers, newsprint, tissue, wrappers and bags, cartons and boxes, plates and cups, envelopes, and many other products.



All Rolled Up. The paper passes through a calender stack that gives it a smooth and even surface. Then it's collected on a large reel in jumbo rolls that weigh 20 tons or more. On the winder, the rolls are slit to desired widths and wound on cores, ready to be shipped to customers or cut into smaller sheets.

Converting

The process of making paper products from the large rolls coming off the paper machine is known as *converting*. Paper is slit and cut to the right size and shape, and may be bent, folded, and glued to form the final product. Some paper is overlaid with a thin sheet of plastic, called laminating. Much paper is formed into folded cartons, such as cereal boxes, and into *corrugated* board, used for making shipping boxes.



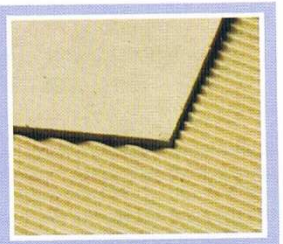
Corrugated board is made on machines called corrugators. Various types of converting machines are then used to make boxes out of the board.

Corrugated Board

Companies ship products such as light bulbs, glassware, and your new DVD in corrugated boxes to secure and protect them from damage. A whopping 95 percent of all manufactured goods are shipped in corrugated board—stiff paper that is lightweight and recyclable.

Corrugated packaging is made from two flat sheets of paper called *liners* glued to a middle layer that has ridges and grooves—the *fluting*. This construction is like a sandwich with a filling of connected arches, which can support a lot of weight. The three-layer structure makes corrugated board rigid, strong, and hard to crush. The air circulating in the flutes (the grooves) also acts as an insulator, protecting against changes in temperature.

All of these things make corrugated board a good material for packaging and shipping. Manufacturers use it to pack, stack, cushion, and transport their products to stores and individual customers. Afterward, used boxes and cartons made of corrugated board can be pulped down and their fiber recycled into new paper and board.



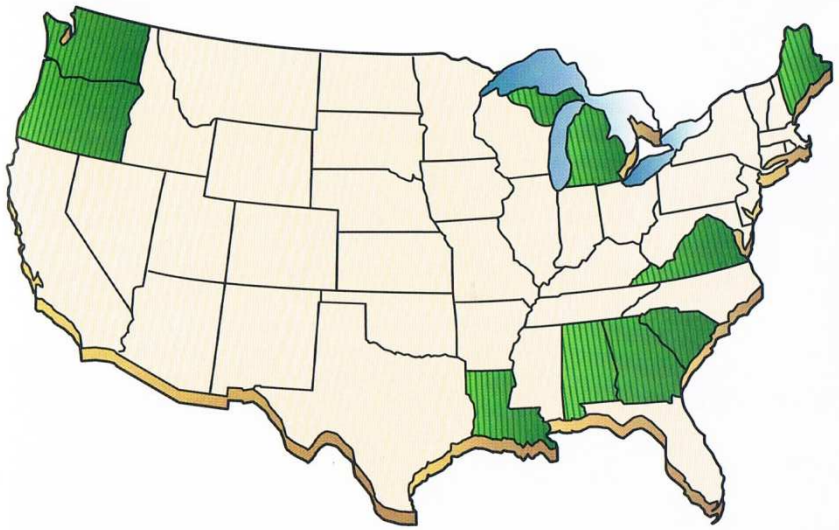
What many people call cardboard is known to papermakers as *paperboard*. This stiff type of paper is used in food packaging (such as cereal boxes) and for other kinds of containers such as shoe boxes and video game boxes. *Corrugated* paper is folded into ridges and grooves, giving it a strong structure.

Get samples of paperboard and corrugated and compare them. You can find many examples of paperboard in the kitchen, in food packages. For corrugated, cut a piece from a shipping carton and peel apart the layers to see the fluting inside.

Visiting a Mill or Plant

For your work on this merit badge, you may choose to visit a pulp or paper mill, or a container plant or box plant. In the United States are more than 500 paper and pulp mills, found—as you might expect—mostly in forested areas. Some are in the Pacific Northwest. Many operate in the South, in the lake states, and eastward through the Middle Atlantic States and New England.

Work with your merit badge counselor to arrange a visit, if there is a pulp or paper mill in your area. Or, to find a box plant to visit, check the yellow pages of your local telephone directory under "Boxes—Corrugated" and "Boxes—Paper." Companies that manufacture corrugated boxes and paper cartons are located nationwide, in cities large and small.



As of 2000, the 10 states ranking highest in paper production were Georgia, Alabama, Louisiana, Washington, Wisconsin, Michigan, South Carolina, Maine, Oregon, and Virginia.

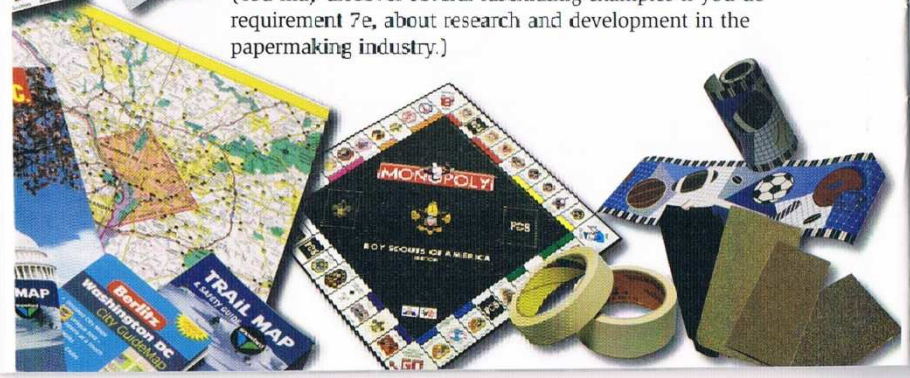
How We Use Paper Today

Here's an astonishing number to digest. Each person in the United States uses about 700 pounds of paper each year. Paper is everywhere in our lives. Every year in the United States, more than 2 billion individual books, 24 billion newspapers, and 350 million magazines are published on paper. Movie tickets, popcorn tubs, cereal boxes, cash register receipts, crayon wrappers, paper board games, your television set, and even the batteries in your digital camera contain paper.

How could you possibly get through your school day without using paper? How about money, checks, birth certificates, marriage licenses, driver's licenses, and all of the documents we need to go about our daily lives?

The home you live in was built with wood and paper products. Those laminated kitchen countertops, the insulation that keeps your house cool in summer and warm in winter, gypsum wallboard, wallpaper, flooring, and shingles—all are at least partly paper. Sandpaper, electrical cable wrapping, and masking tape all have paper backing.

In our world today are more than 6,000 products made from paper. Listed are some everyday examples you can find all around you. What other paper products can you think of or find in your home? What new products are being developed? (You may discover several fascinating examples if you do requirement 7e, about research and development in the papermaking industry.)



At School and Work
Books
Business cards
Calendars
Copier and printer paper
Envelopes
Maps
Masking tape
Notebook paper
Paper money and checks
Postage stamps
Poster board
Report cards

At Home
Cereal boxes
Egg cartons
Facial and toilet tissue
Grocery bags
Lamp shades
Magazines and newspapers
Microwave-food containers
Milk cartons
Paper plates and cups
Paper towels
Pizza boxes
Tea bags
Waxed paper
Wallpaper
Window shades
Wrapping paper

In Medicine and Technology
Bandages
Filters and gaskets
Hospital and surgical gowns
Medical charts
Surgical dressings
Sutures
Pollen and dust masks

Just for Fun
Board games
Bumper stickers
Coloring books
Confetti
Gum and candy wrappers
Jigsaw puzzles
Kites
Paper airplanes
Party hats
Photographs
Stickers
Streamers
Tickets
Trading cards

Products From By-products*
Caulk and putty
Cellophane
Cellulose sponges
Chewing gum
Combs and brush handles
Eyeglass frames
Furniture polish
Ink
Paint and varnish
Photographic film
Pine oil
Rayon clothing
Sausage casings
Shoe polish
Suntan lotion
Turpentine

*These items are made from by-products of the papermaking process.

People pretty much take paper for granted, but we would be hard-pressed to live without it.

New Paper From Old: Recycling

A third of all the papermaking fiber used at American mills comes from recycled paper. Papermaking fibers typically can be reused five to seven times before they become too short to bond together. Newspapers are often recycled into tissue and paperboard. Magazines, in their second life, may become newsprint. Many magazines are printed on glossy paper, and the clay that was added to the paper to make it glossy actually helps separate the ink from the paper during recycling.

What happens when you recycle a piece of paper? The process begins when you gather up wastepaper—old newspapers, magazines, office and computer paper, and corrugated boxes—and put it in a recycling bin. You'll do papermakers a favor if you separate newspapers from glossy magazines. And please keep all paper products out of sunlight and wet weather, because exposure to the elements makes it harder to remove the ink from the paper.

The paper is collected, sorted, wrapped in tight bales, and transported. Once it reaches a recycling facility, repulping is next. In a pulper—a big vat containing water and chemicals—the wastepaper is chopped into small pieces. Heat helps to further break down the old paper into fibers, thus turning the mixture into pulp.

Recyclers Wanted

In the United States, more paper is recycled than is buried in landfills. That is good for our environment, but we need to do better. According to the Weyerhaeuser Company 2003 Citizenship and Environment Report:

> Current trends in recycling are not encouraging. . . . fewer consumers are making the effort to recycle. Some research indicates that consumers in their 20s and 30s are less committed to recycling than consumers in their 40s and 50s, who came of age at a time of vigorous public education efforts on the merits of recycling.

You and your fellow Scouts are coming of age now. Will you be part of the problem, or part of the solution? Remember the three R's: **Reduce, Reuse, Recycle.**

The pulp is screened to remove small contaminants. It's further cleaned by spinning it around in cone-shaped cylinders. Heavy bits like staples and paper clips are thrown to the side of the cone and fall out the bottom. Lighter contaminants collect in the center of the cone and are removed.

To get the ink out, a process known as deinking (de-inking), the pulp is washed to rinse away loose ink particles. Soaplike chemicals are added to make the remaining ink float to the surface, where it is skimmed away, leaving clean pulp behind. The ink, along with clay, glue, and other materials and impurities removed during deinking, can be burned for energy to run the recycling facility.

The pulp, minus all the ink, goes for refining and, if necessary, for color stripping and bleaching. (Pulp for making brown recycled paper, such as that used for industrial paper towels, doesn't need to be bleached.) From this point, the pulp is used just as it would be if it had been made from fresh wood chips rather than recycled paper. Papermakers may used the recycled fiber alone, or combine it with varying amounts of new wood fibers to produce different kinds of paper. Recycled fibers can be made into many new products including boxes, newsprint, napkins, towels, tissue, writing paper, envelopes, egg cartons, and paper bags.

What's great about recycling is that, in the end, a new paper product is created from material that might have ended up instead in a landfill. Recycling is an excellent way people and papermakers can work together to have a cleaner and more sustainable environment.

The industry is trying to cut down on its need for new fiber taken from trees. New technologies are being developed to make paper with less fiber, and to make even more products with wastepaper and recycled fibers. Though most recovered paper is recycled back into paper and paperboard products, it can be used for such purposes as insulation and roofing—even animal bedding and cat litter.

Every day, U.S. papermakers recycle enough paper to fill a train of boxcars 15 miles long.

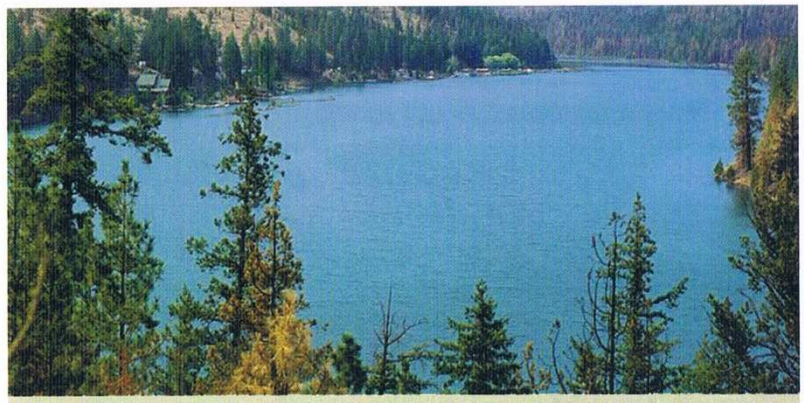
The United States is the world's largest paper recycler, with more than 400 mills now using recycled paper. Even so, the wastepaper that we Americans throw away makes up almost a third of all the trash that goes into landfills. We could save a lot of landfill space if we would start thinking of wastepaper as a valuable resource rather than as trash. We could also save energy. Recycling uses half the energy needed to manufacture paper from new wood. Think about that the next time you throw away a piece of paper.

Reusing Water and Leftovers

Recycling is important in many ways in the pulp and paper industries. Fiber from recycled paper isn't the only thing that gets recovered and reused.

- Millions of gallons of water are used in papermaking. The water is recycled, up to 25 times, to cut down on the need for freshwater.
- The chemicals necessary in pulping and papermaking are recovered and reused to keep them out of rivers and streams. Useful products such as turpentine or lignin are drawn off and saved. Recovery and recycling keeps many potentially hazardous chemicals from ever reaching the environment outside the mill.

- Making paper takes an enormous amount of energy, but with all the wood they use, pulp and paper mills can generate much of their own energy by burning waste wood, bark stripped from logs, and used chemicals for fuel. Steam from the paper-drying process is captured, and the heat is used in other parts of the mill. From its own leftovers, the paper industry generates more than half of the energy it uses. Some mills are almost completely self-sufficient in energy.

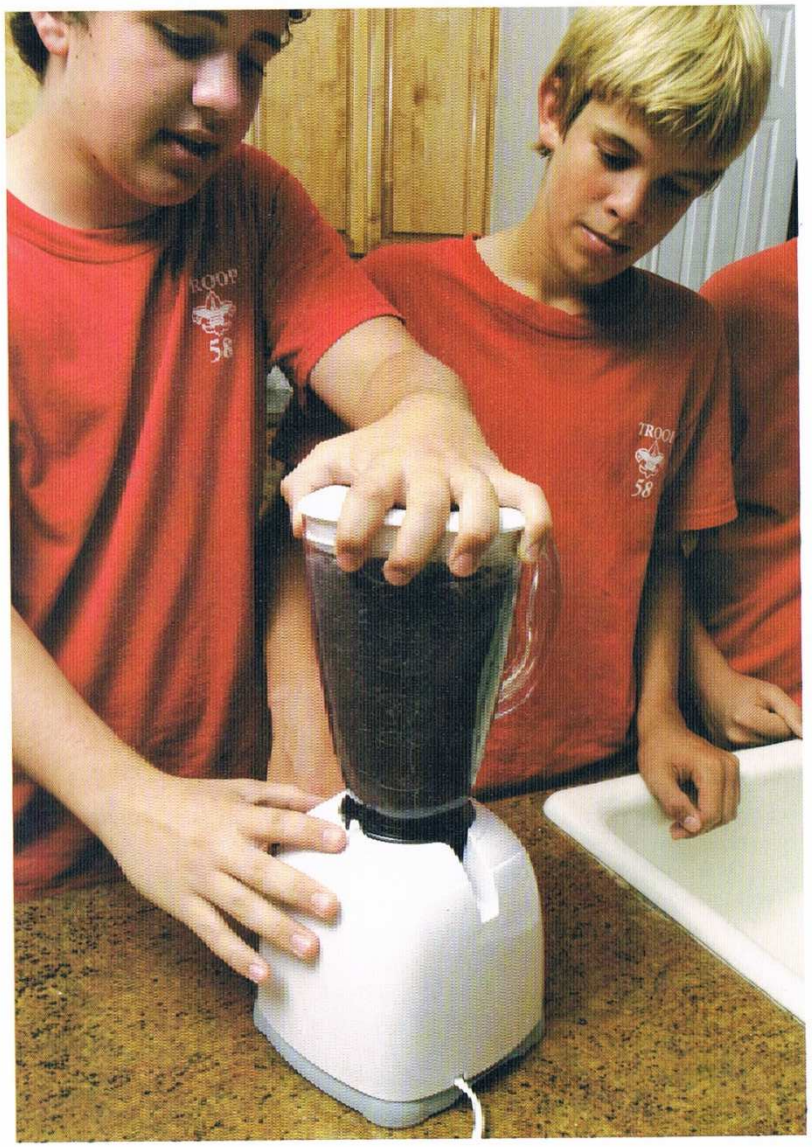


Looking to Nature

Some of the harshest chemicals used in papermaking are the bleaching chemicals that whiten pulp. Researchers are looking for more environmentally friendly bleaching agents. One promising approach uses enzymes—natural chemicals made by living things—to get the brown out in a clean, biological way. Enzymes are also being used as an energy-efficient method of removing ink from recycled newspapers and magazines.

Other researchers are interested in a fungus that chews through the lignin in wood. The fungus can predigest wood chips, making them softer and easier to tear apart into fibers. Mechanical pulping using the softened, "biopulped" wood chips takes less energy. And because the pulp has less lignin (the fungus ate it), the paper made from this kind of mechanical pulp is stronger and less prone to discolor.

These are just two examples of research in the paper industry aimed at reducing pollution, protecting the environment, and improving the products. What other new ideas can you find out about?



Making Paper by Hand

Now you are ready to make paper at home. Just follow these simple instructions.*

Materials Needed

- ❑ 20 to 30 sheets of scrap paper:
  - — Unprinted computer paper or copy paper
  - — Tissue paper (mixed with heavier paper for strength)
  - — Napkins
  - — Paper bags
  - — Construction paper
  - — Index cards, old greeting cards, or cardstock scraps (makes a heavier handmade paper)
  - — Combinations of the above (no newspapers or glossy magazines)
- ❑ Bucket (for presoaking the paper)
- ❑ Wooden frame (such as an inexpensive 5-by-7 or 8-by-10 wooden picture frame)
- ❑ Fine mesh screen (fiberglass window screening)
- ❑ Staples or tacks
- ❑ Kitchen blender or food processor
- ❑ Plastic basin or tub (big enough to completely immerse the wooden frame)
- ❑ Liquid starch or a packet of gelatin (for sizing)
- ❑ Squares of white felt; flannel fabric; or absorbent, disposable cleaning cloths
- ❑ Sponge
- ❑ Palette knife or putty knife
- ❑ Two cookie pans
- ❑ Newspapers (for drying the finished paper, *not* for use in the papermaking)

*This papermaking process has been adapted and reproduced here with permission from J. D. Irving, Limited, Saint John, New Brunswick, Canada. The original process can be found on the company's education Web site at *http://www.ifdn.com/teacher/tre2prod.htm*, under "Papermaking in the Classroom."

Instructions

Step 1—Tear (do not cut) the scrap paper into pieces about the size of a postage stamp, or roughly an inch square. Mix different types of paper to get unique effects.

Step 2—Soak the paper in a bucket of hot water for a few hours or overnight.

Step 3—Make a mold by stretching a piece of screening over a wooden frame. Pull the screening tight and staple or tack it in place.

Step 4—Put about 1 cup of presoaked paper into a blender or food processor. Fill the blender jar almost to the top with very warm water (about 4 cups of water in a 5-cup blender). Blend on low or medium speed at first, then increase the speed until the paper pulp is smooth and well-beaten (30 to 40 seconds for

most papers; 60 to 70 seconds for heavier paper such as cardstock). The pulp should look like thin, watery oatmeal. If you see flakes of paper in the pulp, blend longer.

Step 5—Pour this first batch of pulp into a basin or tub. Make more batches until you have used up all the presoaked paper. Stir the batches together in the tub. The mixture should be watery. The more pulp in the tub, the thicker the finished paper will be. Thin a too-thick pulp with warm water.

Step 6—For sizing, stir 2 teaspoons of liquid starch into the pulp. (If you use gelatin, first dissolve the packet in hot water, then stir the dissolved gelatin into the pulp.) The sizing will help keep inks from soaking into the paper fibers, making your handmade paper better for writing on.

Step 7—Immediately after stirring the pulp, dip the mold (the framed screen) into the tub. Completely submerge the mold and level it out, screen side up. Catch a layer of pulp on the top of the screen. Jiggle the mold side to side to even out the pulp on top of the screen.

Step 8—Carefully lift the mold out of the water, trying to get an even layer of pulp on the screen. The layer should be neither too thin nor too thick. With practice you'll learn what works best for the kind of paper (lightweight or bulky) that you want to make. Keep the mold level so the pulp has the same thickness all across the screen. Hold the mold over the basin until most of the water has drained from the new paper sheet.

For the new papermaker, couching (removing the damp paper from the mold) can be the trickiest part. You will get better with practice.

Step 9—Now it's time for *couching*, which is the traditional word for transferring the paper from the mold onto the surface where it will dry. When the mold stops dripping, gently place one of its edges on the side of a square of felt or flannel fabric or a disposable cloth. Carefully lay the mold over on its face so that the paper lies flat, directly on the fabric.

Step 10—Pat and press a sponge against the back side of the screen, squeezing out water and pressing the paper down flat on the fabric. Keep soaking up the water (frequently wringing out the sponge over the tub of pulp) until you see the paper trying to separate from the screen.

Step 11—To remove the mold, slowly lift it at one corner while holding the fabric down. The damp sheet of paper should stay on the fabric. If it sticks to the screen, you may have lifted the mold too quickly, or maybe you didn't press out enough water. After sponging away as much as you can, try sopping up more water by pressing a wadded paper towel against the back of the screen. Gently shaking the mold may release the paper. If necessary, use a palette knife or a putty knife (the kind with a wide, flexible blade and no cutting edge) to gently loosen the edges. Once you have the edges free, carefully lift up the mold by one corner to release the entire sheet.

Step 12—Repeat steps 7 through 11 to make as many sheets of paper as you wish. Be sure to keep the pulp stirred; otherwise, the fibers will settle to the bottom. Stack the sheets on a cookie pan, with a square of fabric between each sheet. Top the stack with a fabric square to cover the last sheet of paper. Put another cookie pan on top of the stack and press down, squeezing water out of the stacked sheets. (Do this final pressing outdoors or in a bathtub. It can be messy.)

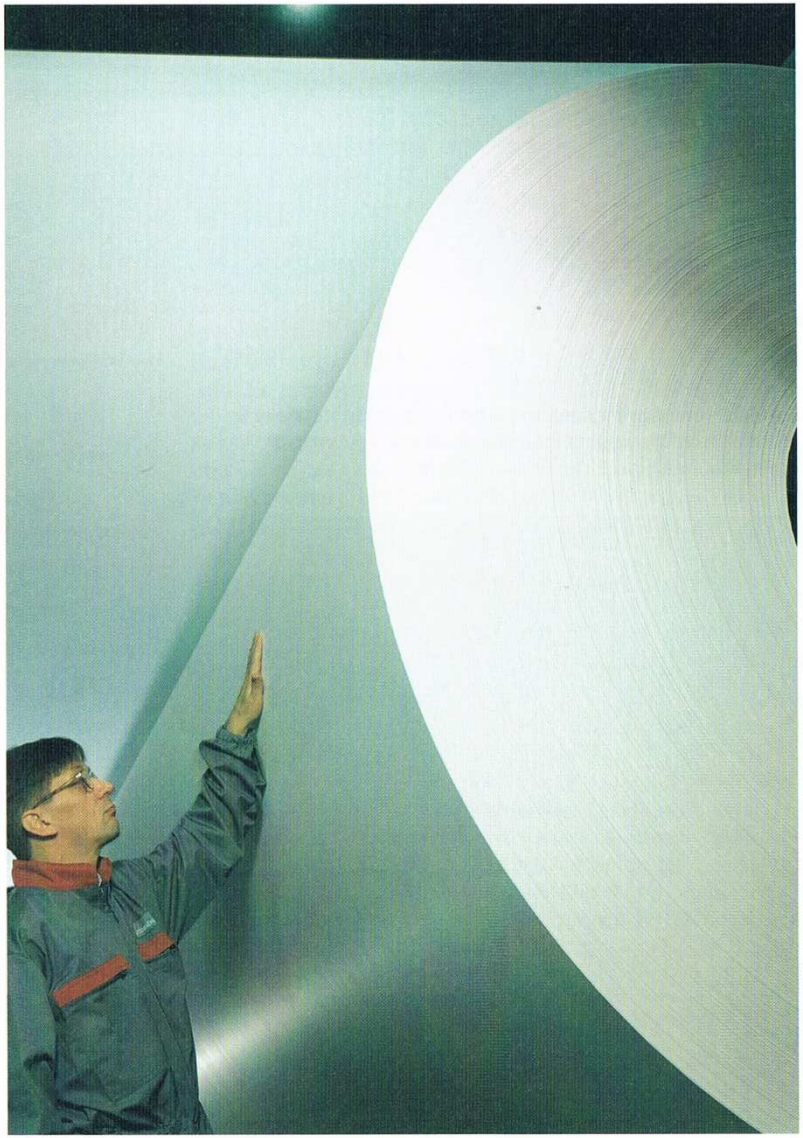
Step 13—After pressing the stack, gently separate the sheets of new paper, keeping each sheet on its fabric backer. Lay them out on newspaper to dry overnight. Wait until they are dry to peel the sheets off the fabric.

Step 14—Paper may curl as it dries. To flatten it, put finished paper under a heavy book or two.

Note: If you have pulp left over, it can be stored in jars or other covered containers for later use. *Do not* pour pulp down the drain.

Want to add unusual colors and textures to your handmade paper? Try dripping a little food coloring or water-based ink into the pulp. Mix in small bits of colored paper, tissue, confetti, tin foil, or glitter. Crumble dried flower petals, leaves, grass, small seeds, dried herbs, bits of fern, burlap fibers, or snippets of yarn or embroidery thread into the pulp. Or sprinkle them across the newly formed sheets before couching the paper.

Try your hand at making 3-D paper. Create a paper bowl, for example, by couching a sheet of damp paper over an overturned bowl. Fold and smooth the sides, then let the paper dry in place. Use a similar technique to make a paper tray. Let your imagination be your guide to creating all sorts of artful objects with your own handmade paper.



Careers in Pulp and Paper

The pulp and paper industry offers hundreds of different career possibilities. The work may include making paper, helping to protect the environment, running laboratory tests, working in a forest, or working in a corporate office. If you have enjoyed earning the Pulp and Paper merit badge, you may find the perfect career in this field. The industry needs trained people in many areas, including forestry, engineering, manufacturing, research and development, sales and marketing, and administration.

If you like to work outdoors and enjoy being in the woods, forestry might be the career for you.

Forestry and Timber Operations

Professional foresters manage the timberlands that provide wood fiber to the pulp and papermaking industry. Foresters plan and direct tree planting and timber harvesting. They help prevent damage from insects, disease, and fire. They know how to help trees grow, how to get more wood from an acre of land, and how to keep a never-ending supply of trees growing to meet the demand for wood fiber. It's also the responsibility of foresters to protect and manage wildlife, water, soil, and other forest resources. Foresters also plan for recreational uses of timberlands, including hiking, fishing, and camping.

Most foresters have at least a bachelor's degree in forestry. Many have advanced degrees. In college, forestry students take classes in biology, physical and social sciences, ecology, silviculture (the science of growing and harvesting trees and caring for forests), forest economics, forest protection, and resources management.

To prepare for an engineering or technical career, in high school you should study biology, chemistry, physics, mathematics, social studies, computers, and English.

Engineering

Engineers work to make pulp and paper mills more productive, safe, clean, and efficient. They supervise the mills' operations, design and oversee the construction of new mills, and make improvements to older manufacturing plants to reduce waste, prevent delays, and keep costs down. Civil, mechanical, chemical, industrial, and electrical engineering skills are all useful in this career.

Environmental engineering is another needed specialty. These professionals design and supervise systems to control pollution, protect the environment, protect the health and safety of people, and make sure that pulp and paper mills are good neighbors in their local communities. Education in chemical and civil engineering, biology, and chemistry can prepare you for a career as an environmental engineer.

Another position that is important to the industry is the systems engineer. This person is an expert in the control systems and computers that run high-speed paper machines.

Manufacturing

Modern pulp and paper mills need skilled people to plan mill operations, keep those operations running smoothly, and maintain the machinery so that pulp and paper production continues—oftentimes around the clock—with no breakdowns or interruptions. In addition to engineers, chemists, and other scientists, the workers needed in mill operations include electricians, pipe and steam fitters, and machine operators. Technical training is generally required for these positions.

Some examples of machine operators are

- *Chippers,* who run the machine that cuts logs into small chips to be made into pulp
- *Digester operators,* who are in charge of the big, kettlelike digesters that break down the wood chips through chemical action, heat, and pressure
- *Paper machine operators,* who adjust the flow of pulp onto the paper machine and, with the help of computer-controlled monitors, run and track the machine's functions
- *Backtenders,* who work at the dry end of a paper machine, operating the equipment that dries and smoothes the paper and winds it on rolls

Research and Product Development

Research and development professionals come up with the paper industry's new and improved ideas. They develop new paper products, find solutions to air and stream pollution, and devise more efficient production methods. In this field, formal training and advanced degrees are often required in physics, chemistry, chemical engineering, biochemistry, biology, mathematics, paper science, engineering, or ecology.

Quality control experts check to make sure a mill's finished paper products are of high quality. They test sample sheets for strength, brightness, and weight, and direct laboratory tests to look for flaws in the paper. People working in quality control often have backgrounds in industrial engineering or chemistry.

Sales and Marketing

After the products are created, they must be marketed to a large variety of users. Salespeople identify potential clients and explain or demonstrate their company's products. If they make a sale, they follow up to be sure the customer is satisfied. People who have a flair for sales and marketing combined with an engineering or technical background do well in these positions. There are also sales and marketing positions available at companies that supply equipment, chemicals, and services to pulp and paper manufacturers.

Administration

In every company, there are management and administrative positions, and positions for accountants, computer programmers, and legal professionals. Many college graduates who go into the paper business become managers early in their careers.

Are you interested in traveling overseas? The U.S. paper industry has a global market, and its professionals often go to other countries to oversee or expand a company's operations. It's not unusual for people in the paper business, or for those in engineering consulting, to spend a year or more on assignments abroad.

Career opportunities also exist in related industries, including agriculture, product packaging and containers, chemical products, industrial products, scientific instruments, machinery, printing, and consulting.

Papermaking Resources

Scouting Literature

Chemistry, Energy, Engineering, Environmental Science, Fish and Wildlife Management, Forestry, Graphic Arts, Soil and Water Conservation, and *Textile* merit badge pamphlets

Visit the Boy Scouts of America's official retail Web site at *http://www.scoutstuff.org* for a complete listing of all merit badge pamphlets and other helpful Scouting materials and supplies.

Books

Asuncion, Josep. *The Complete Book of Papermaking.* Sterling, 2003.

Couzins-Scott, Elizabeth. *Papermaking.* Anness Publishing Ltd., 2002.

Dawson, Sophie. *The Art and Craft of Papermaking: Step-by-Step Instructions for Creating Distinctive Handmade Paper.* Sterling, 1997.

Draper, Allison Stark. *Choosing a Career in the Pulp and Paper Industry.* Rosen Publishing Group Inc., 2001.

Grummer, Arnold E. *Arnold Grummer's Complete Guide to Easy Papermaking.* Krause Publications, 1999.

Hiebert, Helen. *The Papermaker's Companion: The Ultimate Guide to Making and Using Handmade Paper.* Storey Books, 2000.

Rainey, Rhonda. *Papermaking for the First Time.* Sterling, 2005.

Reimer, Mary. *300 Papermaking Recipes.* Martingale and Company, 2004.

Saddington, Marianne. *Making Your Own Paper: An Introduction to Creative Paper-Making.* Storey Books, 1992.

Saltman, David. *Paper Basics: Forestry, Manufacture, Selection, Purchasing, Mathematics and Metrics, Recycling.* Krieger Publishing, 1991.

Toale, Bernard. *The Art of Papermaking.* Davis Publications, 1983.

Woods, Samuel G. *Recycled Paper: From Start to Finish.* Blackbirch Press, 2000.

Organizations and Web Sites

American Forest and Paper Association
1111 19th St. NW, Suite 800
Washington, DC 20036
Toll-free telephone: 800-878-8878
Web site: *http://www.afandpa.org*

Robert C. Williams Paper Museum
Institute of Paper Science and Technology
Georgia Institute of Technology
500 10th St. NW
Atlanta, GA 30332-0620
Telephone: 404-894-7840
Web site:
http://www.ipst.gatech.edu/amp

Society of American Foresters
5400 Grosvenor Lane
Bethesda, MD 20814-2198
Telephone: 301-897-8720
Web site: *http://www.safnet.org*

Society of Wood Science and Technology
One Gifford Pinchot Drive
Madison, WI 53726-2398
Telephone: 608-231-9347
Web site:
http://www1.fpl.fs.fed.us/swst/index.html

Technical Association of the Pulp and Paper Industry
Paper University
Web site: *http://www.tappi.org/paperu*

Wisconsin Paper Council
250 N. Green Bay Road
P.O. Box 718
Neenah, WI 54957-0718
Telephone: 920-722-1500
Web site: *http://www.wipapercouncil.org*

Acknowledgments

For assistance in updating the *Pulp and Paper* merit badge pamphlet, the Boy Scouts of America thanks Dick Madsen of Weyerhaeuser Company, one of the world's largest forest products companies and a winner of many awards for social responsibility and environmental protection.

We appreciate the Quicklist Consulting Committee of the Association for Library Service to Children, a division of the American Library Association, for its assistance with updating the resources section of this merit badge pamphlet.

Thanks also to those who contributed to previous editions of this pamphlet, lending a level of expertise that continues to guide the BSA's approach to this fascinating subject:

- T. J. Stenuf, Ph.D., Professor of Paper Science and Engineering, State University of New York, College of Environmental Science and Forestry, who provided the original text
- Richard A. Horn of Pulp, Paper, and Composites Research, USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin, who updated and revised the 1993 edition
- TAPPI, the Technical Association of the Pulp and Paper Industry, for its cooperation in the production of the pamphlet

The Boy Scouts of America thanks J. D. Irving, Limited, Saint John, New Brunswick, Canada, for allowing us to adapt and reproduce with permission its "Papermaking in the Classroom" process, which can be found on the company's education Web site at *http://www.ifdn.com /teacher/tre2prod.htm*. J. D. Irving has more than 120 years of involvement in the forest products business and has won national awards in Canada for its education initiatives, which include the Web site of the Irving Forest Discovery Network.

Photo and Illustration Credits

American Paper Institute, courtesy—page 6

©Photos.com—cover *(all except merit badge, tissue box, toilet paper, magazines, and trading cards)*; pages 3–4 *(all)*, 8–9 *(all)*, 12, 15, 17, 23 *(photo at center right)*, 31 *(all)*, 33 *(top)*, and 34 *(bottom)*

©Realworld Imagery Inc.—pages 13 and 14 *(left three)*

Stora Enso, courtesy—pages 14 *(right)*, 42, and 44–45 *(both)*

U.S. Department of Agriculture, Natural Resources Conservation Service/Tim McCabe, courtesy—page 35

U.S. Department of Agriculture/ Bill Tarpenning, courtesy—page 17 *(bottom)*

All other photos and illustrations not mentioned above are the property of or are protected by the Boy Scouts of America.

John McDearmon—all illustrations on pages 15–16, 20–21, and 23–27

Brian Payne—cover *(trading cards)*; pages 18 and 34 *(top)*

Randy Piland—page 22 *(top)*

MERIT BADGE LIBRARY

Though intended as an aid to Boy Scouts, Varsity Scouts, and qualified Venturers in meeting merit badge requirements, these pamphlets are of general interest and are made available by many schools and public libraries. The latest revision date of each pamphlet might not correspond with the copyright date shown below, because this list is corrected only once a year, in January. Any number of merit badge pamphlets may be revised throughout the year; others are simply reprinted until a revision becomes necessary.

If a Scout has already started working on a merit badge when a new edition for that pamphlet is introduced, he should continue to use the same merit badge pamphlet to earn the badge. He should fulfill the requirements listed in the pamphlet he was using when he began. In other words, the Scout need not start all over again with the new pamphlet and possibly revised requirements.

Merit Badge Pamphlet	Year
American Business	2002
American Cultures	2005
American Heritage	2005
American Labor	2006
Animal Science	2006
Archaeology	2006
Archery	2004
Architecture	2004
Art	2006
Astronomy	2004
Athletics	2006
Auto Mechanics	2000
Aviation	2006
Backpacking	2007
Basketry	2003
Bird Study	2005
Bugling (*see* Music)	
Camping	2005
Canoeing	2004
Chemistry	2004
Cinematography	2001
Citizenship in the Community	2005
Citizenship in the Nation	2005
Citizenship in the World	2005
Climbing	2006
Coin Collecting	2002
Collections	2003
Communications	2003
Composite Materials	2006
Computers	2005
Cooking	2007
Crime Prevention	2005
Cycling	2003
Dentistry	2006
Disabilities Awareness	2005
Dog Care	2003
Drafting	1993
Electricity	2004
Electronics	2004
Emergency Preparedness	2003
Energy	2005
Engineering	2000
Entrepreneurship	2006
Environmental Science	2006
Family Life	2005
Farm Mechanics	1997
Fingerprinting	2003
Fire Safety	2004
First Aid	2007
Fish and Wildlife Management	2004
Fishing	2002
Fly-Fishing	2002
Forestry	2005
Gardening	2002
Genealogy	2005
Geology	2005
Golf	2002
Graphic Arts	2006
Hiking	2007
Home Repairs	2002
Horsemanship	2004
Indian Lore	2003
Insect Study	2002
Journalism	2006
Landscape Architecture	2002
Law	2003
Leatherwork	2002
Lifesaving	2001
Mammal Study	2003
Medicine	2002
Metalwork	2007
Model Design and Building	2003
Motorboating	1992
Music and Bugling	2003
Nature	2003
Nuclear Science	2004
Oceanography	2003
Orienteering	2003
Painting	2002
Personal Fitness	2006
Personal Management	2003
Pets	2005
Photography	2005
Pioneering	2006
Plant Science	2005
Plumbing	2004
Pottery	2002
Public Health	2005
Public Speaking	2002
Pulp and Paper	2006
Radio	2001
Railroading	2003
Reading	2003
Reptile and Amphibian Study	2005
Rifle Shooting	2001
Rowing	2006
Safety	2006
Salesmanship	2003
Scholarship	2004
Sculpture	2007
Shotgun Shooting	2005
Skating	2005
Small-Boat Sailing	2004
Snow Sports	2007
Soil and Water Conservation	2004
Space Exploration	2004
Sports	2006
Stamp Collecting	2007
Surveying	2004
Swimming	2002
Textile	2003
Theater	2005
Traffic Safety	2006
Truck Transportation	2005
Veterinary Medicine	2005
Water Sports	2007
Weather	2006
Whitewater	2005
Wilderness Survival	2007
Wood Carving	2006
Woodwork	2003

BOY SCOUTS OF AMERICA • SUPPLY DIVISION

NATIONAL DISTRIBUTION CENTER
2109 Westinghouse Boulevard
P.O. Box 7143
Charlotte, NC 28241-7143

www.scoutstuff.org

DIRECT MAIL CENTER
P.O. Box 909
Pineville, NC 28134-0909
For fast credit card orders—
VISA, MasterCard, American Express—
call BSA operators toll-free
1-800-323-0732