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ABSTRACT

This unit is designed to help the intermediate elementary school student become aware of the history of paper, the papermaking process, the variety of uses and kinds of paper, the economic aspects of the paper industry, and the importance of recycling. It includes 13 major concepts relating to paper, the behavioral objectives and expected student criteria for evaluation of each concept, pretests and posttests, background information (including a list of vocabulary definitions), suggested sequence of activities and appropriate methodologies, a bibliography of student and teacher reference materials, a list of appropriate films, and forms to record individual student data. (MLB)

ENVIRONMENTAL ECOLOGICAL EDUCATION PROJECT

Parkway School District
Chesterfield, Missouri

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Unit: Paper

Revised: June 1972

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SETTING

The setting for the unit model can be the intermediate grade of any elementary school in the United States*. The unit concerns itself with paper - a product of which even the culturally deprived student has come into contact. The unit is specifically planned to make the student aware, through active involvement, of the history of paper; the papermaking process; the variety of uses and kinds of paper; the economic aspects of the paper industry; and the importance of recycling.

*While it is not essential to the unit, a visit to a wood source, paper mill, or paper processing plant would be most helpful. The teacher should check with the company to be visited to be sure there are no dangers involved and to see if children of her age group are allowed to tour the company.

CONCEPTS

I. Paper has been and remains a useful tool to mankind.

II. Paper is by no means a new invention; it has been used in various parts of the world since ancient time.

III. The first writing materials did not consist of paper, but were clay, papyrus, metals, stone, tree leaves, bark, wood coated with wax, etc. However, it seems that the first use of paper was specifically for writing.

IV. The first recorded process of papermaking originated in the Far East, in China, and filtered westward through the centuries.

V. In the Far East paper was made from vegetable fibers and bamboo; in the West, during the middle ages, paper was largely made from rags of cotton and linen; today wood pulp is the resource most widely used in papermaking. All three materials have a common denominator-they contain cellulose, the basis of paper.

VI. During the past century in particular, paper has been used not only in the field of communications, but for many diverse purposes: packaging, consumer products, household items, building materials, and others. As technology expands, certainly new uses will be created in the future.

VII. The modern-day process of making paper includes the following steps:

1. selection of trees and cutting
2. removal of bark
3. grinding, chipping, and cooking of chips
4. bleaching, beating, and refining
5. papermaking - Fourdrinier machine
6. color, sizing, and "finishing"
7. distribution

VIII. The process of papermaking involves extensive use and depletion of one of the world's resources: wood from forests. Steps must be taken to replenish this resource (and some measures are already in effect), or we must find paper substitutes.

IX. Paper mills are usually located near a source of wood and water.

X. Paper's characteristics correspond to the purpose for which it will be used.
Varieties of Paper:

1. soft and weak (newsprint, newspapers, leaflets, etc.)

2. hard and strong (building materials, magazines, paper furniture, etc.)

3. absorbent (towels, blotters, etc.)

4. non-absorbent (art papers, magazines, etc.)

5. slick and smooth (gift wrapping, glossy magazines)

6. rough (laminated, corrugated for packaging, etc.)

XI. Some papers are bio-degradable; they return naturally to the soil. Others are so treated that they cannot return to the soil without man's intermediary effort. (e.g. Japanese plastic-paper, paper colored with non-degradable chemicals, paper treated with non-degradable chemicals).

XII. Paper, its processing, consumption and waste, can be a destructive agent in the environment. Man must find a way to use paper constructively, while simultaneously eliminating its harmful effects and its waste.

XIII. Paper, its processing, consumption and recycling, provides opportunities for many and varied vocational careers.

BEHAVIORAL OBJECTIVES

Concept Number		
VIII.	1.	Seventy percent of the students should be able to list at least four possible consequences of the depletion of trees used in papermaking.
IX.	2.	One hundred percent of the students should be able to explain in no more than twenty-five words why paper mills are located near a source of water and near forests.
II. & IV.	3.	Ninety percent of the students should demonstrate a knowledge of the origin and historical spread of papermaking by numbering in sequential order the ancient and modern civilizations that used the process.
V.	4.	Ninety percent of the students should be able to match up materials used for papermaking with the historical era in which they were used, with one hundred percent accuracy.
I. & VI.	5.	Ninety percent of the students should list at least two types of paper products used in each of the following areas: packaging, household products, building materials, and communications.
VII.	6.	Eighty percent of the students should recognize and place in sequential order at least five of the seven steps in the papermaking process while looking at the flow chart. (See Background Information for the flow chart, which may be reproduced).
XI.	7.	Ninety-five percent of the class should recognize at least two types of paper which are not bio-degradable and be able to tell why they are not.
I.	8.	One hundred percent of the students should name and explain at least five ways that paper has been important in man's history.

Concept Number

XII. 9. Ninety percent of the class should name three paper products and describe one way to reuse one of them.

XII. 10. One hundred percent of the class will cut down on paper consumption by performing at least one of the following activities:

1. saving art and construction paper scraps in a scrap box, eighty percent of the time.

2. using both sides of all paper in school for an entire week.

3. saving newspapers for recycling and bringing them to school for transfer to a recycling center, eighty percent of the time.

4. devising one recycling project and using it eighty percent of the time at school or at home.

5. listing alternatives to paper products, choosing one, and using the substitute eighty percent of the time.

"Inventory sheets" may be devised for the students to use in keeping a record of their activities.

VII. 11. Ninety percent of the pupils should be able to list at least two reasons why there must be a sound re-forestation (replenishing and/or replanting) plan.

III. 12. Ninety percent of the students should be able to name at least five writing materials used before paper was invented.

X. 13. Ninety percent of the students should be able to list at least three varieties of paper and a particular use for each quality.

Concept Number

XIII. 14. One hundred percent of the students should be able to name and describe, in twenty-five words or less, some of the duties of one vocation or career related to papermaking (processing, consumption, or recycling).

PRE-POST TEST

Related Behavioral Objective	
1.	1. If trees were cut down and used up until none remained, what four possible consequences can you name? a. b. c. d.
2.	2. Explain in no more than twenty-five words why paper mills are located near a source of water (on river) and near forests.
3.	3. Number the following countries in order to show where papermaking began and how the process of making paper spread. (The first country to make and use paper will be #1, etc.) ____ Egypt ____France ____China ____ Mexico ____United States
4.	4. In ancient times paper was made from _____. During the middle ages, paper was made from _____. Today most paper is made from _____.

Related Behavioral Objective		
4. cont.	4.	Choose from possible answers: wood pulp, bamboo, papyrus, cotton, vegetable fibers, linen.
5.	5.	Name at least two types of paper or paper products used in each area: Household items:_____and _____ Building materials:_____and _____ Packaging materials:_____and _____ Communications:_____and _____
6.	6.	Place a number (1 to 7) in front of each step of the papermaking process to show that you know the correct order of paper processing. You may look at the flow chart as you work. __1__ put into machine to make paper __2__ removal of bark __3__ color, sizing, and finishing __4__ distribution of paper __5__ selection and cutting of trees __6__ grinding, chipping, and cooking of chips __7__ bleaching, beating, and refining
7.	7.	Underline the types of paper which are least likely to be bio-degradable: a. paper coated with plastic b. paper treated with chemicals c. colored tissue paper d. paper made from vegetable fibers
8.	8.	Name five ways that paper has been important in man's history. a. b. c. d. e.

Related Behavioral Objective	
9.	9. Name three paper products and explain in no more than twenty-five words a good way to reuse one of them.
10.	10. It is possible for all of us to cut down on paper consumption. Explain how you can help.
11.	11. List two reasons why forests should be replanted after being chopped down.
12.	12. Name five materials which were used to write on before paper was invented.
13.	13. List three varieties of paper and explain one use that each quality has.
14.	14. Choose a vocation or career related to papermaking (processing, consumption, or recycling). Describe in no more than twenty-five words some duties a person in this position might perform.

ANSWER KEY FOR PRE-POST TEST

1. a. Man would have to create new ways to produce oxygen chemically.
   b. Man would have to stop soil erosion without the aid of trees.
   c. There would be no wood available.
   d. Mills would be out of business and unemployment would result.
   e. Paper and other products now made from wood would have to be synthesized in other ways.
   (Or any other acceptable answers)

2. Answers will vary. Forests are the source of raw materials for paper mills. Water is used in the papermaking process for electricity and for transportation.

3. 2 Egypt 3 France 1 China
   4 Mexico 5 United States

4. In ancient times paper was made from vegetable fibers, bamboo. In the Middle Ages from cotton, and linen. Today most paper is made from wood pulp.

5. Answers will vary. Some possible responses are:
   Household items: toilet paper and paper towels
   Building materials: wallpaper and roofing
   Packaging materials: paper bags and paperboard containers
   Communications: writing paper and paper for books

6. 5 put into machine to make paper
   2 removal of bark
   6 color, sizing, finishing
   7 distribution of paper
   1 selection and cutting of trees
   3 grinding, chipping, and cooking of chips
   4 bleaching, heating, and refining

7. Underline the types of paper which are least likely to be bio-degradable:

   a. Paper coated with plastic
   b. Paper treated with chemicals
   c. Colored tissue paper
   d. Paper made from vegetable fibers

8. Answers will vary. Possible responses:
   a. communication
   b. packaging
   c. use in photography
   d. use in art
   e. recording anything

9. Possible examples:
   a. Milk cartons may be reused in art projects or as planters.
   b. Orange juice container to store pencils.
   c. Old magazines for art work
   Accept any reasonable answers

10. Answers will vary and must be evaluated individually by the teacher.

11. Forests should be replanted after being chopped down so that the supply of trees does not become depleted, to prevent soil erosion in areas where trees now grow, and to supply oxygen. (Or any other acceptable answers)

12. Any five of the following are acceptable: Stone, clay bricks, table books, leaves, bark, parchment, and papyrus.

13. Any of the following are acceptable:
   1. soft and weak (Newspapers, leaflets, newsprint)
   2. hard and strong (building materials, magazines, paper furniture)
   3. absorbent (towels, blotters, etc.)
   4. Non-absorbent (art papers, magazines, etc.)
   5. Slick and smooth (gift wrapping, glossy magazines)
   6. Rough (laminated, corrugated for packaging, etc.)

14. Answers will vary. Examples: lumberjack, forester, truck driver, fork lift operator, commercial artist, salesman, plant operator, etc. (See Background Information on careers related to the paper industry).

BACKGROUND INFORMATION

The lessons contained in this unit need not be taught in sequential order, nor need all the activities in each lesson be included. The choice of activities and the order in which they are used will be left to the discretion of the teacher.

VOCABULARY

Bio-degradable - describes any product which is capable of returning naturally to the soil.

Calligraphy - fair or elegant writing; handwriting in general.

Fourdrinier - (Fur-drin-eer) the name of brothers who improved upon a previously-invented papermaking machine. Their machine, in some form, is still used today and bears their name.

Kraft paper - a very high-strength paper, usually unbleached and used for wrapping purposes.

Paper - a harmonious combination of cellulose fibers formed in water suspension on machine wire, and bound together by weaving the fibers and by bonding agents.

Paper industry - includes manufacturers of pulp, paper, and paperboard and those who convert these materials into useful products.

Pulp - a papermaking material existing in a disintegrated wet or dry fibrous state; the stage of paper before it enters the papermaking machine.

Reclaimed fibers - another term for fibers (or papers) to be recycled.

Recycling - the process of chemically reproducing a product over again for the same or for different purposes. (Example: Waste paper can be taken back to a paper company. It is put into a huge vat filled with water and chemicals and remade into pulp.) Recycling is important in ecology because it not only eliminates additions to the dump but conserves on natural resources.

Reforestation - the replanting of trees after the forest has been partially or totally depleted of vegetation.

Reuse - the process of using a product over again for the same or different purpose without changing its form. (Example: milk cartons first used for milk can then be used for planters, mixing paints, etc.)

Sizing - a water resisting material which is added to paper.

Stock - another term for pulp.

Today, with our abundance of paper, it is difficult to comprehend that there was ever a time when this commodity was not readily available. It is interesting to trace the various materials in use prior to the advent of paper and to try to realize how impossible it would be for modern civilization to endure, even for an hour, the total lack of this indispensable material.

Stone was probably the first material upon which effigies, and later characters and letters were graven. Through this medium of expression countless historical records have been preserved.

The ancient Chaldeans stamped characters or letters into clay bricks or tablets of various sizes. A wedge-shaped bone served as a stylus to press the characters into the soft clay, which was then baked hard.

The use of such metals as brass, copper, bronze, and lead for writing materials was not unknown to ancient civilizations. Sheets of lead and other metals were used for preserving treaties, laws and alliances. In the Bible (Job: xix, 24) reference is made to the use of "an iron pen and lead." The Romans used bronze to record their memorials, and on the field of battle Roman soldiers wrote their wills on their metal buckles or on the scabbards of their swords.

Table books, composed of pieces of wood from box and citron trees were used long before the time of Homer (9th century B.C.). The sections of wood were usually covered with a thin coating of wax, chalk, or plaster, and letters or marks were scratched into the coating with a metal or bone stylus. With this method, the letters could be erased by recoating the wooden boards. The separate boards were fastened together with leather thongs and thereby composed a book, called a codex. These table books seem to have remained in use long after the invention of paper, for their existence is recorded in Europe as late as the beginning of the 14th century and are spoken of in the works of Chaucer (c. 1344-1440).

Writing on palm and other species of leaves was practiced from earliest times. In ancient Syracuse a judge wrote on olive tree leaves the names of persons condemned to banishment. The sentence was termed "petalism", from the Greek word for "leaf". Writing on leaves was practiced until recent times in some parts of India and Ceylon. The Ceylonese used the leaves of the talipot tree because these were broad and long and well-suited for writing. In Assam the leaves of the aloe were used, while in other parts of India the leaves of the palmyra were employed. From the large palmy leaves strips of any desired length and about two inches in width were cut. A metal stylus left indentations in the leaf, and these scratches were then filled with a black pigment which made the letters discernable and distinct. Each leaf was pierced with two holes, and the leaves were strung together with cords, making a book in ancient times. The word "leaf" is now used to name a part of a modern book.

The bark of certain trees has been used as a writing material in almost every historical period and locality. The American Indians wrote their sign language with wooden sticks and liquid pigment upon the immaculate bark of the white birch tree. The aborigines of Mexico and Central and South America have, at one time or another, made a sort of paper by beating the inner bark of the moraceous tree. However, the aboriginal people formerly occupying the territory now comprising the United States and Canada never made any material that even resembled paper.

The use of parchment as a writing material also antedates paper, the name "parchment" being derived from Pergamum, ancient city of Asia Minor. Parchment is made from the split skin of the sheep. The grain or wool side of the skin is made into skiver; the flesh or lining side of the skin is converted into the best parchment. Vellum is made from calfskin, goatskin, or lambskin.

Papyrus is not paper in the true sense; it was, however, the first writing material to assume many of the properties of the substance we now know as paper. Papyrus is a laminated material; true paper must be made from disintegrated fiber. It would be possible to manufacture true paper from the papyrus plant since it contains cellulose. The term "rice paper" is a misnomer. Rice paper is a thin substance cut spirally from the inner pith of the Fatsia papyrifera tree and has no relation whatever to rice or to true paper. It is used in China for painting.

HISTORY OF PAPERMAKING

The techniques of early papermaking were developed over long periods of time. Papermaking began about A.D. 105 when a Chinese court official developed the idea of forming a sheet of paper from the macerated bark of tree, hemp waste, old rags, and fish nets. It is believed that the spread of writing (calligraphy) in China influenced the development of paper more than any other event. It is highly probable that the Chinese conceived the idea of matting and intertwining vegetable fibers into sheets of paper through their knowledge of felt-making and cloth weaving. The first paper was probably fabricated from disintegrated cloth, but before long the bark of trees and other vegetable materials were employed.

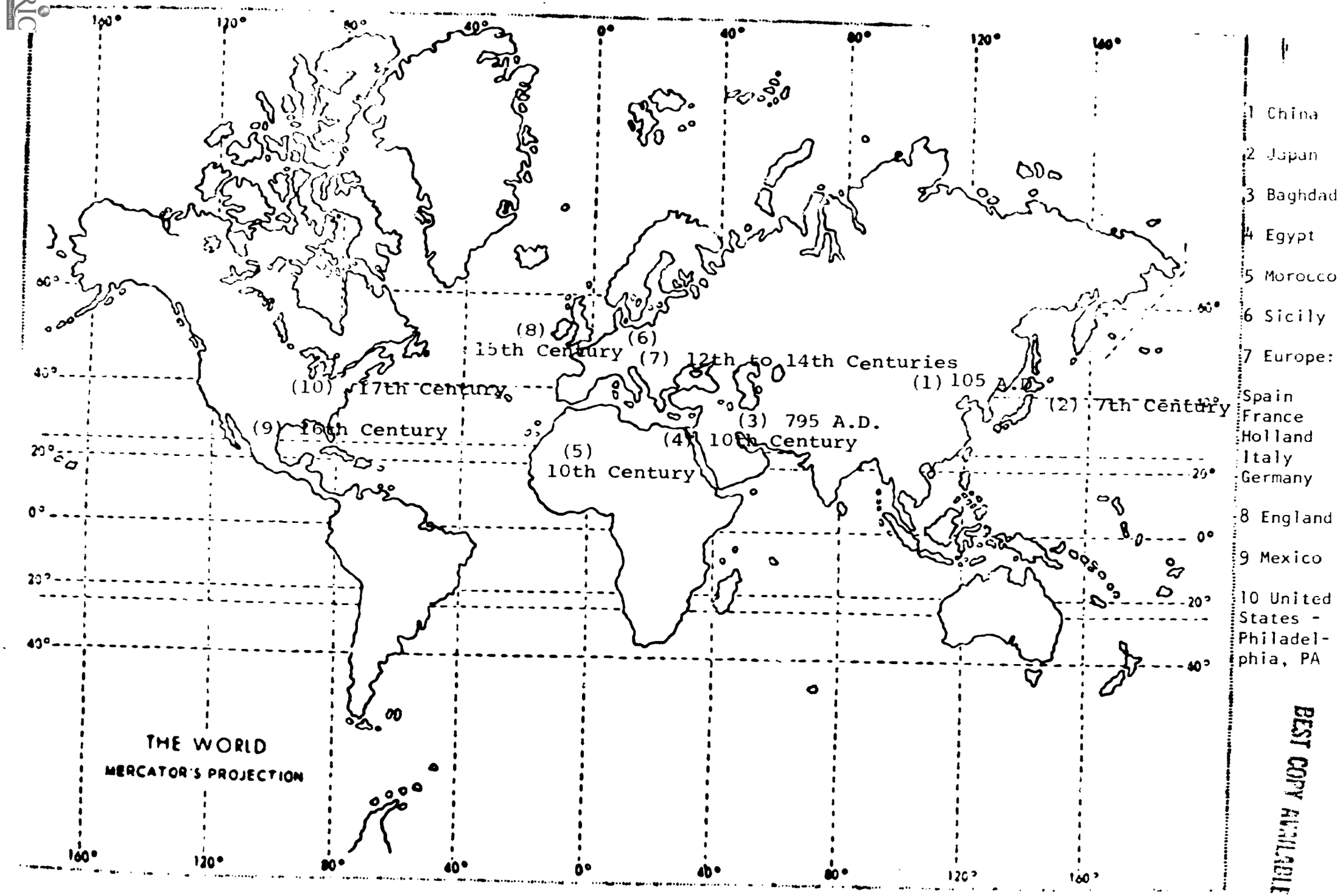
For over 500 years the art of papermaking remained in China. At the beginning of the 7th century knowledge of papermaking spread to Japan when manuscript books were introduced by Buddhist monks.

Over six centuries elapsed before the art of papermaking found its way westward, following the caravan routes from the Pacific Ocean to the Mediterranean. In the eighth century the Arabs captured Samarkand from the Chinese, learned their craft, and then set up a papermill in Baghdad. Following caravan routes through Baghdad and Damascus, the art of papermaking reached Egypt in the 10th century. From the continent of Africa it spread across the Mediterranean Sea to Europe. There was a lapse of about 1,000 years between the invention of paper in China in 105 and its use on the European continent in Sicily in about 1102. During the 12th and 14th centuries paper mills were run by the Spanish, Dutch, French, Italians, and Germans. It was at the beginning of the 14th century that paper was first used in England; however, it was not until the 15th century that paper was manufactured there.

In 1575, the Spanish built the first paper mill in the Western Hemisphere in Mexico. However, it was more than one hundred years later, in 1690 in Germantown, Pa., that the first paper mill was built in the colonies of North America. Until then, paper used by the colonies was imported from Europe.

Summary of Development Within Countries
(Numbers correspond to those on map, page 16a)

1.	105 A.D.	China
2.	7th Century	Japan
3.	8th Century	Arabia (Baghdad)
4.	10th Century	Egypt
5.	10th Century	Morocco
6.	1102	Sicily
7.	12th - 14th Centuries	Europe (Spain, France, Italy, Netherlands, Germany)
8.	15th Century	England
9.	1575	Mexico (first paper mill in Western Hemisphere)
10.	1690	America (first paper mill in Germantown, Pennsylvania)



16 a

MOVEMENT OF PAPERMAKING FROM EAST TO WEST

IMPORTANT NAMES IN THE HISTORY OF PAPERMAKING

Ts'ai-Lun - A Chinese scholar who was dissatisfied with silk and bamboo writing materials. He made the first "real" writing paper from the mulberry plant.

de Reaumur - A French scientist who observed the wasp making its nest. The insect would rub tiny wood fibers loose from a dry post and mix them with the secretions from its own body by chewing. When the mixture dried it formed a paper-like material from which the wasp built its nest.

Kellar - A German who in 1844 patented a wood-grinding machine where sticks of wood were forced against a grindstone while water was added.

Hugh Burgess, Charles Watt - Two Englishmen who, in 1851, developed a process using chemicals to break down wood into fibers which was called the soda process.

Benjamin Tighman - In 1857 this American chemist further developed a chemical process for breaking down wood fibers, called the sulphite process.

C. F. Dahl - In 1889 the last of the three wood-breaking processes, sulphate, was developed by Dahl. Today, it is the most popular method.

Nicholas Robert - A Frenchman who in 1799 patented a machine for making paper in a continuous roll.

Fourdrinier brothers - These men made an improved version of Robert's papermaking machine in London. Today the machine, though modified considerably over the years, still bears their name.

THE PAPERMAKING PROCESS
FROM FOREST TO DISTRIBUTION

This informational section is to be used in conjunction with the illustrated sheets immediately following on pages 23 to 25.

Facts indicate that the paper industry is very important to the U.S. economy in addition to paper's many valuable consumer uses. There are over 800 mills in the United States. A typical mill employs 3,000 people; uses 116,000 tons of coal for fuel; utilizes enough electricity to run 4,000 households; uses over $12,500 worth of rags to clean its machinery; uses millions of tons of chemicals; and consumes over 40 million gallons of water (175 gallons per finished pound of paper) daily.

When trees are removed from the forest, they must be replaced to insure that the supply does not become depleted. Small mill owners cannot do the job necessary because of their limited area and the prohibitive price of replacing trees. Therefore, large factories must take the initiative in proper forest management if a sound reforestation program is to be carried on.

SELECTING, CUTTING, SHIPPING, AND STORING

A forester, trained either by the government or by a privately-owned mill, selects the trees that are to be cut. Quality of paper is dependent upon the quality of wood. The forester bases his selection upon the height, condition, and type of trees, and the density of the forest. The density of the trees is also important because the denser the wood, the heavier it is and the greater the yield of fiber per cubic foot. The trees that are selected for cutting are marked with spray paint. (Another method is to spray the trees that are <u>not</u> to be cut.) The choppers must also be skilled workers, as they must first cut branches from larger trees and must decide in which direction the trees will fall. After felling, trees can either be cut into shorter lengths on location or shipped to the mill for further cutting.

Shipment is either by floating, truck, rail, or barge. The method depends upon available facilities, location of the mill, and cost. Generally mills are located near the sources of the wood and water supplies. When the wood reaches the mill

it is dumped or stacked. Stacking is expensive and time-consuming, but it helps eliminate fungus growth on the wood caused by moisture. Fungus is very detrimental to the pulp-maker if the decayed wood should go into the digester.

DEBARKING

Debarking can be accomplished by a) logs rubbing against one another, b) high-pressured water, c) killing the trees by injections so that the bark falls off, or d) knives. To obtain quality paper knots and defects must also be removed. Bark and charred or decayed woods, as stated above, are a menace to the pulpmaker because what is not removed from the wood before it is fed into the digester (grinder) consumes valuable space and uses expensive chemicals unnecessarily in the blow pit step of production. Bark also carries dirt into the pulp mixture which effects the quality of paper. Bark that has been removed is collected, dried, and pressed for use as fuel to power some of the processing machinery. A spokesman for Alton Box Board Company, however, said bark has not been used for fuel for many years.

CHIPPING THE WOOD

Logs are usually brought to the mill in four-foot sections. After debarking, the chipper cuts the cords of wood at 45° angles to insure that the fibers are not too short. The length of the fibers is important in the meshing of paper. Sawdust and slivers are troublesome as they are either too coarse or too long. Good paper needs chips, but sawdust can be used for the making of coarse paper.

GRINDING

The chips can be ground further by use of a large, expensive stone, sometimes costing as much as $4,000, which is pressed against the wood inside a huge metal or wooden container. Water washes through the pulp and sifts it through a screen.

COOKING

In this process the cellulose fibers are freed from the lignin, resin, and sap. One-half of the weight of the wood is lost in this step. The digester, in which the chips are

cooked without chemicals, is enormous, holding twenty-five tons of pulp. The pulp is fed through the top of the digester and cooked under steam for several hours. No chips will remain, only liquid and stick woods fibers, dark-colored like asphalt. Three cooking processes are used: sulphate, sulphite, and soda - but they are not detailed in this unit.

BLOW PIT AND WASHING

The pulp is blown by steam pressure from the digester, through the blow pipes, into a pit which is two times larger than the digester. There the pulp is washed thoroughly, as all impurities must be eliminated until only pure pulp remains. A small hole at the bottom of the pit allows water to drain out but is too small for the pulp to seep through.

Washers are equipped with two perforated sheets which hold the pulp. Suction draws out the liquid (organic matter and carbonate of soda), which was previously added to the pulp, through the perforated sheets. During this step a great deal of chemical skill is required to insure successful addition and removal of all necessary ingredients.

BLEACHING

Paper color ranges from dark brown to pale yellow. Kraft paper is dark, but chlorine addition produces a lighter, brighter paper. Bleaching is accomplished in several stages. A dilute chlorine is added then washed away, and the pulp is pumped into a bleaching tower. There it is again treated with a chlorine dioxide or a gas less strong than the chlorine solution. A double treatment is used for extra bright paper. Again, the pulp is washed so that all chlorine is removed.

WASHING AND STORING

After repeated washings the pulp becomes "snowy white and granular fluffy, like soap suds"....ninety-five percent water and five percent pulp. It can now be stored for later use.

BLEACHING, COLORING, AND SURFACING

In this step the variety of paper wanted . . the finished product is usually produced. However, the types of woods used,

the bleaching stage, and the coating process also help produce various end results. Some factories use only one beater, others use two. Beating makes the paper strong, more uniform, more opaque, and less porous. During the beating step various chemicals are added to the stock to produce different kinds of paper. Dyes are added for coloring; fillers, such as talc, clay, zinc, sulphide, or calcium carbonate, are added for a smooth-surfaced paper; rosin and starches are added to produce water-repellent paper.

JORDAN REFINERY

This process, named after its inventor, Jordan, is another step in further refining the pulp. The fibers are fubbed and cut to required degrees. As stated earlier the quality of paper is dependent upon the length of the fibers.

FOURDRINIER MACHINE

During this step pulp actually becomes what we know as paper. There are several types of papermaking machines: a) cylinder, b) special paper machines, and c) Fourdrinier.

The Fourdrinier machine, named after its inventors, can make paper ranging in thickness from light weight to 16 point test (one point equals 1/1,000 inch). It moves at speeds up to 2,6000 feet per minute. The Fourdrinier machine is divided into four sections: 1) wet end, 2) press section, 3) drying section, and 4) calendar section.

WET END: The stock flows from a headbox, through an artificial passage way, called a sluice, to the top of a moving, endless belt of wire cloth. There a web of paper is formed as the water is removed from the fiber by drainage and suction boxes.

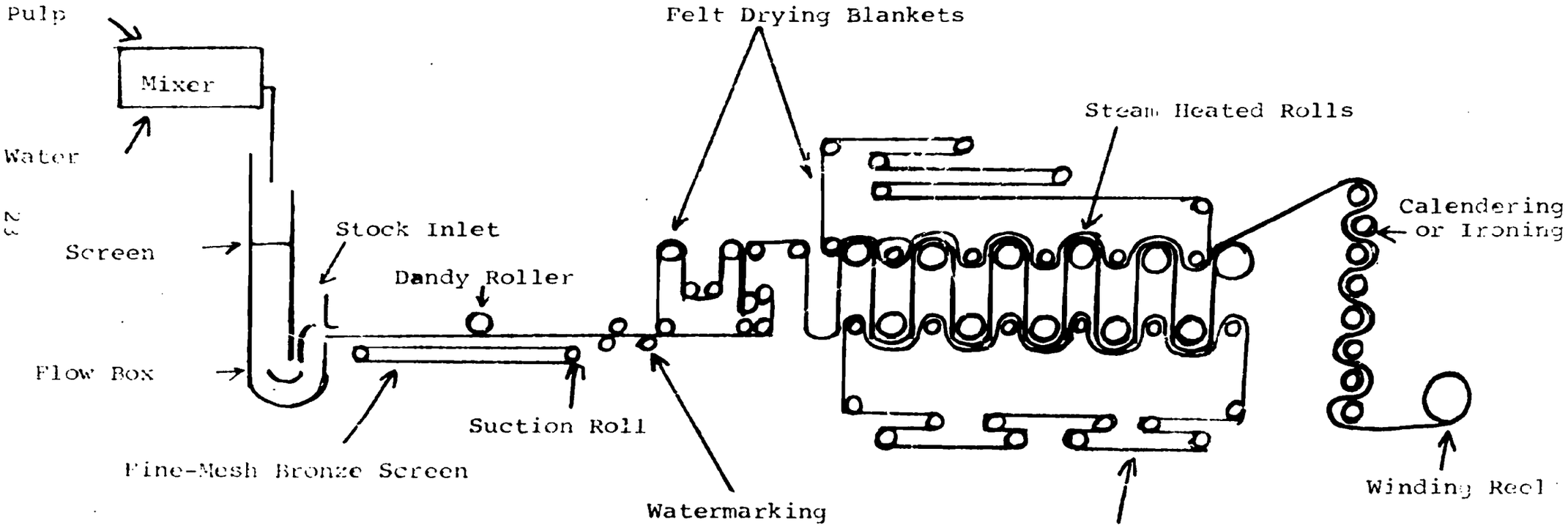
PRESS SECTION: This is made up of two or more press rolls to remove additional water from the web and to form surface characteristics on either side of the paper. The wet web is moved on through the press by felts.

DRIER SECTION: This section is comprised of two or more tiers of steam-heated cylinders and "the paper is held close to the heated surfaces by means of canvas drier felts."

CALENDAR STACKS: The paper winds into a roll as it leaves the machine by means of one to three calendar stacks equipped with a reel device. The calendars smooth the paper and imprint the finish or gloss required to the surfaces. More finish can be obtained by using a super calendar.

Source: Sutermeister, Edwin, The Story of Papermaking.

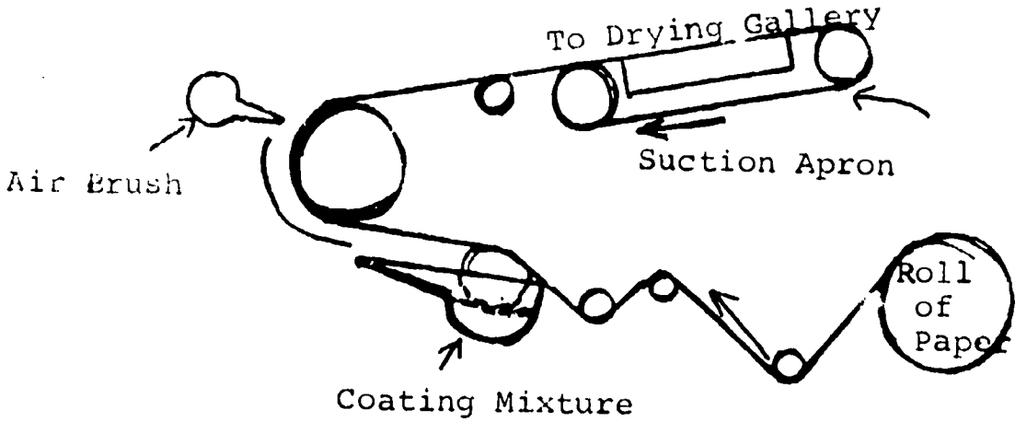
PAPERMAKING PROCESS
(Fourdrinier Papermaking Machine)



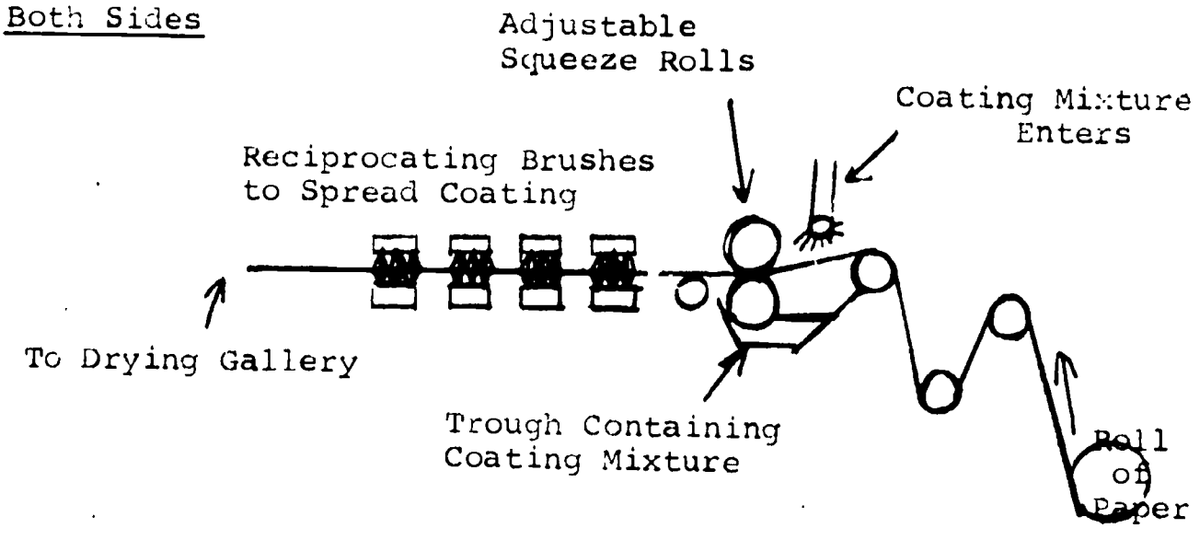
Taken from: Edwin Sutermeister
The Story of Papermaking

PAPERMAKING PROCESS
(Coating Paper)

One Side

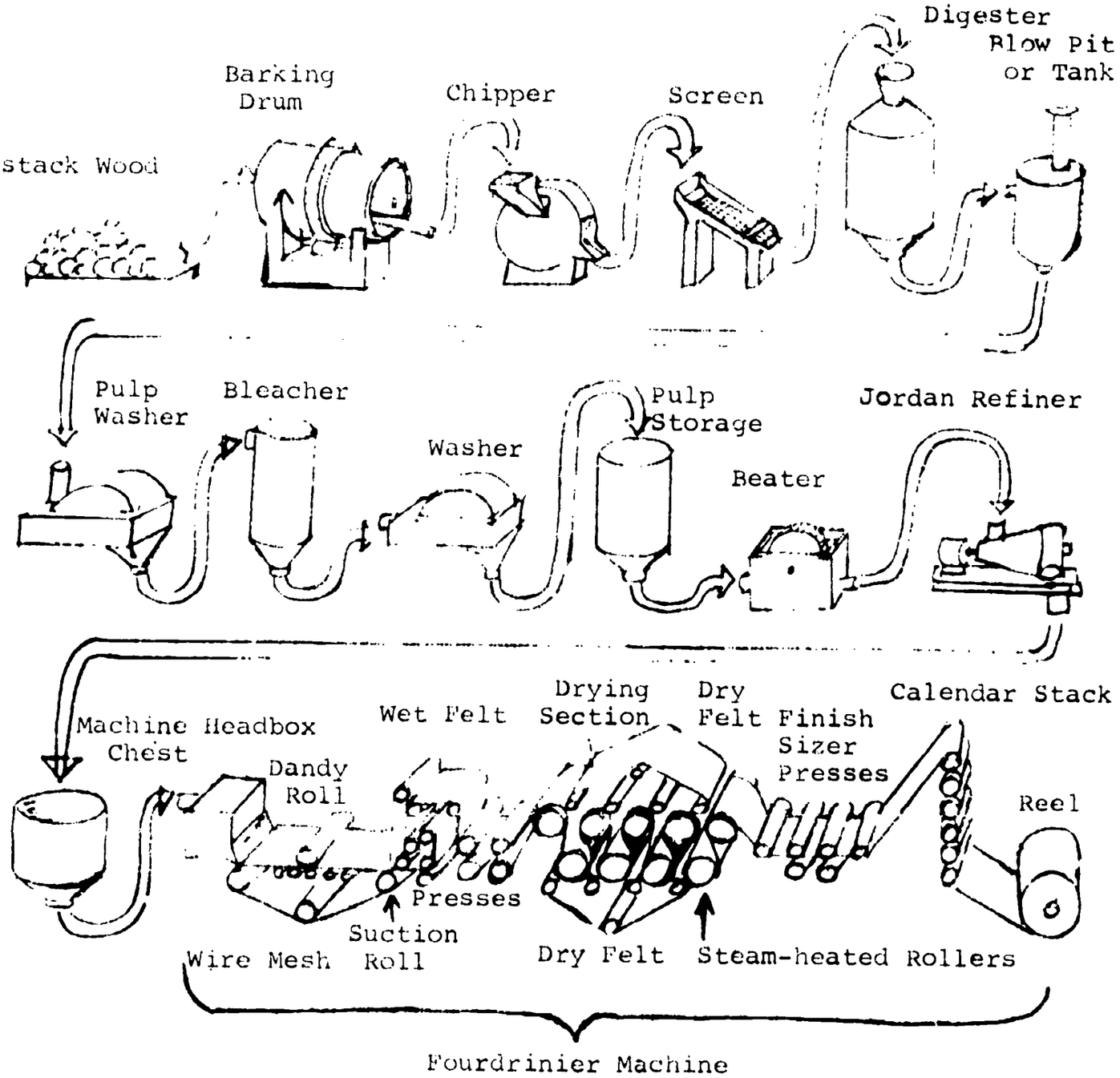


Both Sides



Taken from: Edwin Sutermeister
The Story of Papermaking

FLOW CHART OF PAPERMAKING



Taken from: Merit Students Encyclopedia, Nov. 14, 1968.

Recycling

Contrary to what many children may think, paper is not all alike when it comes to recycling. In a recycling center as Alton Box Company in Alton, Illinois, paper collected from residential and commercial establishments to be recycled is sorted according to color and texture. Sorting generally takes place before the paper reaches the plant. Newspapers, white wrapping paper, paper cups, and cardboard, etc., are all shredded and bundled into giant vats containing water and chemicals depending upon the type of recycled paper to be made. (i.e., newspaper and white paper are not mixed because the quality of old newspaper is inferior to the heavier, stark-white paper). The giant vats stir this shredded paper, and all foreign objects are removed by a magnet-type strainer apparatus. Once the old paper has been decomposed into a foam-like substance, it undergoes the same type of processing as other papermaking.

Recycling is very important, as 80 percent of the country's trash-disposal problems would be solved and the need for electric power would be significantly curtailed.

Bio-degradable

Bio-degradable is the term applied to any substance which can be reduced to its basic elemental components by biological action. For example, cellulose paper decomposes and returns naturally to the soil. The most frequent end products of this decomposition are carbon dioxide and water.

The paper industry uses the bio-degradable principle to treat waste products before they are released into streams and rivers in order to protect the environment.

BRIEF BACKGROUND ON THE ECONOMIC ASPECTS OF PAPER

There can be no doubt as to the value of paper in the United States economy as well as in that of the world. One has only to look around to see the paper products that have been manufactured, the machinery used to manufacture them, and the employees needed to run the companies. Our banking system, communications, consumer products, and educational system are but a few of the areas that are vitally dependent upon paper. The Yellow Pages of any telephone book will give a good indication of the tremendous number of companies and industries

connected either directly or indirectly with paper manufacturing, processing, and distribution.

The information which follows was prepared by the St. Regis Paper Company. It illustrates the economic importance of paper. A variety of mathematical problems may be constructed by using this chart.

THE PAPER INDUSTRY IN THE UNITED STATES

Source: Let's Make Paper, St. Regis Paper Co.

Total number of paper plants in the United States (est.)	5,500
States containing plants	48
Cities and towns with plants	1,258
Number of employees in paper industry	540,000
Wages and salaries paid annually (including fringe benefits)	$ 4 500,000,000
Annual value of shipments	$19,000,000,000
Federal taxes paid annually (includes est. for mills owned by non-industry firms)	$ 600,000,000
State and local taxes paid annually	$ 250,000,000
Capital spent for new plant and equipment between 1947 and 1955	$11,300,000,000
Paper and paperboard produced annually	43,600,000 tons
Amount of paper used annually by each person in the United States	500 pounds
Wood pulp produced annually	34,000,000 tons
Pulp produced annually from sources other than wood (straw, rags, cotton fiber, hemp, bagasse, and other grasses)	1,000,000 tons
Reused pulp fibres, i.e., waste paper	9,800,000 tons
Annual Payments for pulpwood	$ 1,000,000,000
Annual investment in research	$ 75,000,000

USES OF PULPWOOD IN THE UNITED STATES

Source: Farb, Peter and the Editors of Time, The Forest

	Tons
Paperboard container	15,634
Newsprint	2,010
Book paper	1,912
Construction board	1,782
Writing paper	1,771
Construction paper	1,350
Paper bags	1,247
Toilet paper	886
Wrapping paper	537
Paper towels	504
Rayon	387
Facial tissues	255
Napkins	232

SOURCES OF WOOD FOR PULP IN THE UNITED STATES

Source: Sutermeister, Edwin, The Story of Papermaking

Coniferous trees are preferred for pulp wood because of their long fibers. Deciduous trees have short fibers. In papermaking, long fibers are essential for stronger paper. Soil, water, tree cutting cell-wall structure, and chemical composition also control the length of fibers.

Area	Type of Wood
Noartheastern States (N.Y., Mass., Maine, Eastern Pa.)	a. white and red pine spruce, hemlock, and fir b. hardwoods (deciduous): beech, birch, maple poplar, basswood c. softwoods (coniferous): the best trees in this area have been depleted.
Southern States*	a. pines b. hardwoods: red gum tupelo sycamore, elm oak, etc.
*This area in 1950, produced 30% of the wood pulp in the U.S.	
Rocky Mountain States	No real growth

There is a tendency for various geographical regions to manufacture different grades of paper.

Example: a) Southern states - Kraft paper

b) Massachusetts - rag-content writing paper

c) Michigan - book grade paper

d) New York - ground wood specialities

CAREERS

This section is to serve as examples for the teacher.

Commercial Artist

A commercial artist is engaged in a wide variety of occupations. He can be salaried or work on a free-lance basis, selling his work to many different customers. Examples of the positions that may be held by a commercial artist are: illustrator, industrial designer dress designer, and interior decorator. The commercial artist may find reward in working as an illustrator for books or magazines, creating window displays, or designing new products. He may create greeting card illustrations or design a "new look" for a boxed product. The requirements for becoming a commercial artist are a natural artistic ability and training in the elements of design, balance, contrast, texture, and color. Among specific skills which may be required are lettering, chart-making, and technical drawing. The commercial artist is a large consumer of paper products. Additional information on careers in this field can be obtained from:

Philadelphia Museum School of Art
Broad and Pine Streets
Philadelphia, PA 19102

Artists' Guild, Inc.
129 East 10th Street
New York, NY 10003

Driver - Truck or Forklift

A responsible person who has a good driving record and has passed a state test for a driver's license can usually qualify for this position. He will also need to take a skill test in truck and forklift driving for the company who employs him.

Plant Operator

A possible career in the paper industry, including the field of recycling paper, is that of plant operator in a paper plant. Such a job involves grinding up waste paper and adding it to a repulping vat. Here paper is dissolved so that the useful fibers can be separated from the undesirable elements. To perform this job a person must learn to weigh materials and read instruments. Most likely a high school diploma would be required for such a position and on-the-job training would be given.

Salesman

With increased technology, more and more uses are being found for paper. Thus more salesmen will be needed to advertise and move these products. The salesman can be either retail (dealing directly with customers), wholesale (representing companies by selling to retailers) or manufacturer's salesman (selling products that are needed in the manufacture of other products). More training is required if the salesman is dealing in specialized and technical products. Advancement within a company is often achieved by starting from the lower position of shipper or clerk. Additional information on selling can be obtained by writing to:

Committee on Retailing Careers
National Retail Merchants' Association
100 West 31st Street
New York, NY 10001

National Association of Wholesalers
1725 K Street, N.W.
Washington, DC 20006

INSTRUCTIONAL SEQUENCE

Note: The amount of time allotted to each of the five topics is left up to the judgment of the teacher as each classroom's interests may vary.

Topic: History - Introduction to Paper

Teacher Preparation

1. The following materials and information must be ready for distribution and/or discussion preceeding the activities.

   a. Use maps and/or a time line with the overhead projector to trace the movement of papermaking from East to West. (See Background Information pp 16a)
   Each child may be given an individual map and/or time line as well.

   b. Display of early writing materials (clay, stone, leaves, bark, rags, silks, papyrus)

   c. List of people who have been important in the papermaking process

   d. List of terms with which the children probably are not familiar

ACTIVITIES

1. Have the students write biographies or plays about people who would not have been famous without paper. Examples: Walt Disney, Johann Gutenberg, Ben Franklin, or any authors, aritsts, musicians, etc.

2. Have the children research the origins of paper and papermaking. Have them trace on a map the civilizations that used paper.

3. Have students use an ancient writing material other than paper. They will have to create a tool to be used with this writing material. Suggestions: bricks bark, wood slate leaves, clay slabs. This activity lends itself well to the outdoors.

4. Discuss whether each of the following products adds another use for paper or competes with the uses of paper:

plastics, glass, wood, and metals. This activity may be done outdoors.

5. Have the students hypothesize about how paper might be used in the future. Will there be any new uses, and what will be the consequences of these new uses?

6. Have students research the process of the printing press. Make linoleum or wood block prints.

Topic: Process

Teacher Preparation

1. Give students the flow chart from Background Information. Go over the steps with them before seeing the film. Allow the students to fill in the chart. Explain each step.

2. Show a film called the Alton Story and/or Paper Making (see Bibliography).

3. Discuss the film with the children.

4. Complete any of the activities desired.

ACTIVITIES

1. Find a wasp's nest outdoors to show the class how wasp manufacture paper (Hanna Woods has a nest).

2. Have the students research the major steps in the papermkaing process. Fill in a flow chart. (The teacher can reporduce the chart without labels).

3. The children can research the forestry process. Go outdoors to observe whenever possible.

4. Have the students design a package for a hypothetical product. (Example: design a box for a new soap product.) If boxes are also to be made, sample is shown elsewhere in the instructions.

5. The students may bring examples of wrapping paper, decorated bags and consumer product packages from home and mount them on the bulletin board.

6. Obtain a speaker. Suggestions: a) forest ranger to discuss

maintenance of forests or reforestation; b) conservation department; c) employee of a packaging company.

7. Have students locate on a map the areas which they think supply our largest sources of wood. Also have the children point out those locations where paper mills would be located in relation to forests and water supplies.

8. Experiment in making paper. (Two experiments follow: Experiment II is simpler).

9. Research the derivations of various colors (from vegetable dyes, originally). See if the students can make their own dye colors outdoors. Then dye absorbent papers with the home-made dyes (onion skins may be boiled to extract a yellowish color; lichen can be boiled to give various shades of green, etc.)

HOW TO MAKE YOUR OWN PAPER

Experiment I. "Do It Yourself Papermaking Kit"

Source: Let's Make Paper, St. Regis Paper Company

The thrill of creating your own kit for papermaking can be yours just by following these simple instructions. A few inexpensive and easily available materials are needed to construct the kit. Use this list of materials as a guide:

_____ One piece window screen wire, 4" by 6"
_____ One strip of aluminum, 13 1/2" by 1" by 1/8" thick
_____ One strip of aluminum 22 1/2" by 1 1/2" by 1/8" thick
_____ Two baking pans, approximately 7 1/2" by 11" and about 1 1/2" thick
_____ One cellulose sponge, approximately 4" by 6"
_____ Two pieces of thick felt or closely-woven wool scraps, approximately 4" by 6"
_____ Two pieces of canvas (duck or denim will do), approximately 4" by "
_____ One mixing container, a plastic liquid container or milk carton
_____ One mixing beater, either rod or spring-type
_____ Two blocks of wood, 5" by 7" by 3/4"
_____ One electric iron
_____ Supply of pulp. For a supply of pulp, write to:

Public Relations Department
St. Regis Paper Company
P.O. Box 4910 or P.O. Box 1591
Jacksonville, Fl. 32201 Jacksonville, Fl. 32501

Frame A

Use the aluminum strip measuring 22 1/2" by 1 1/2" by 1/8". To be sure that the screen and frame will fit, the frame should be constructed first. Lay out the pattern for the frame on a sheet of paper following the illustration on page 39.

Mark a line 1/2" from the edge along the full length of the strip (Line E in the illustration). Now cut four triangular-shaped pieces along the edge up to Line E, spaced as shown on the illustration (A, B, C, D).

Place the paper pattern over the aluminum strip and trace the design on the metal. Use an awl or other sharp instrument for marking.

Cut the wedge-shaped pieces from the strip. Bend the strip along line E one section at a time, using a vice or straight edge. The strip can be easily bent if it is laid along the edge of a piece of lumber along Line E and bent into a right angle with another piece of wood.

After the angle has been formed bend the strip at each of the wedge-shaped slots (A, B, C, D) to form the rectangular-shaped frame. The 1/2" overlap will extend around the last corner making the frame rigid. See illustration on page 39.

Screen

The screen should fit inside Frame A resting on the lip formed around the bottom of the frame. Cut the screen wire so that it rests snuggly on the lip but can be easily removed.

Frame B

Use the aluminum strip measuring 1, 1/2" by 1" by 1/8". You will not need a paper pattern to make Frame B. Just measure and mark the sections directly on the aluminum strip (see illustration on page 39.

Now bend the strip at right angles at points A, B, C and D to form the rectangular frame. Here again a vise or straight edge will insure an accurate bend.

Wood Blocks

Using 3/4" board, cut two pieces measuring 5" by 3".

Felt and Canvas

You probably will be able to find scraps of felt or pieces of closely-woven, thick wool around the house large enough to make two pieces 4" by 5". Cut two 4" by 5" pieces of canvas; or, if this is not available, heavy duck, sailcloth, or denim will suffice. If the cloth is dyed, be sure it is colorfast; otherwise the color may transfer to your paper in the finishing process.

Note: It is not necessary to follow these instructions "to the letter" when constructing the parts for the papermaking kit. Satisfactory substitutions can be made for any of the parts with a little experimentation.

You may want to be a little more elaborate in the construction of the kit parts in your home or school workshop. This is not necessary, however, and will not affect the quality of the finished sheet of paper you make.

Directions

Step One: Place the screen inside Frame A. Place frame B on top of the screen. Soak the sponge and two pieces of felt in water; then squeeze out as much water as possible. Fill the mixing container with water to within 2" from the top.

Step Two: Drop a supply of pulp about the size of a ping pong ball into the mixing container and stir thoroughly with the beater. Holding the frame over one of the baking pans, immediately pour about two ounces of the pulp water mixture onto the wire screen inside frame B. (This duplicates the action of the paper machine head box, spreading the pulp mixture onto the Fourdrinier wire).

The mixture should be poured rapidly and distributed evenly over the screen leaving a mat of pulp with the fibers intertwined on the screen surface.

If the mat of pulp is unevenly distributed on the surface of the wire, slowly lower the wire into the pan of water and jiggle gently from side to side in the water. (This corresponds to the oscillating motion of the screen on a paper machine which serves to distribute pulp in an even layer and shakes off surface water.)

You may also obtain a smoother mat of pulp if you place frame A on one of the blocks of wood, then pour the pulp-water mixture onto the screen. In this manner the water will flow through the screen more slowly, giving you time to agitate the screen and resulting in a smoother layer of pulp.

Step Three: Lift frame A, containing the screen and frame B, and place the entire assembly on the sponge in the drypan.

Place a hand on each side of frame A and, exerting pressure on frame B and frame A, press down firmly and then release. The sponge will absorb much of the water from the mat of pulp. This step simulates the action of the air suction boxes beneath the screen wire on a paper machine, which literally pulls the water away from the billions of tiny wood fibers, leaving them in the form of a very wet sheet of paper.

Step Four: Carefully lift frame B from the wire screen and press the screen up from below, separating it from frame A. Lay the screen, with pulp side up, on one of the pieces of damp felt. Then spread the other damp felt smoothly over the wet sheet of pulp.

Step Five: Place the felt-covered screen between the two wooden blocks in the dry pan and press down <u>hard</u> to squeeze out as much water as possible. This performs the same function as the press section of a paper machine, which presses the sheet between the rollers.

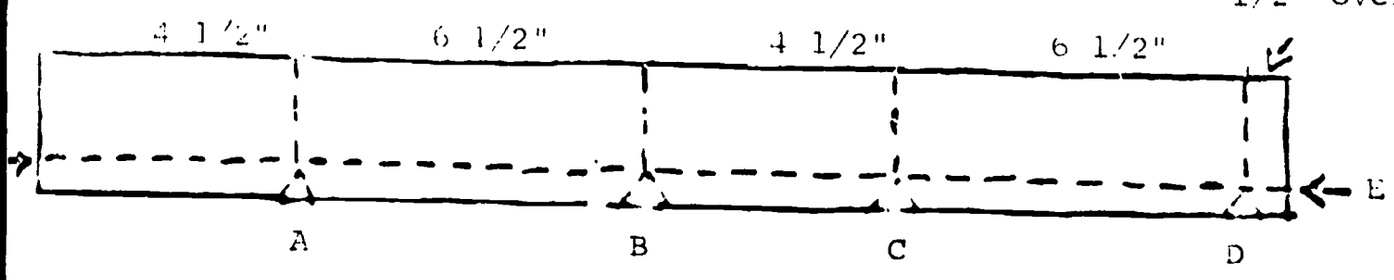
Step Six: Remove the top block of wood and carefully roll back the top piece of felt (the felt next to the pulp layer). The damp sheet of paper should now be sticking to this felt; if not help start it with your fingers.

Step Seven: Place a piece of the dry canvas on a wood block and lay the felt with the pulp side down, on top of the canvas. Place the other wood block on also and again press down <u>hard</u>, transferring the wet paper to the dry canvas. Be especially careful in peeling the felt off the wet paper. Here again it may be necessary to help start the paper sheet with your fingers. Now place the other piece of dry canvas on top of the wet paper sheet.

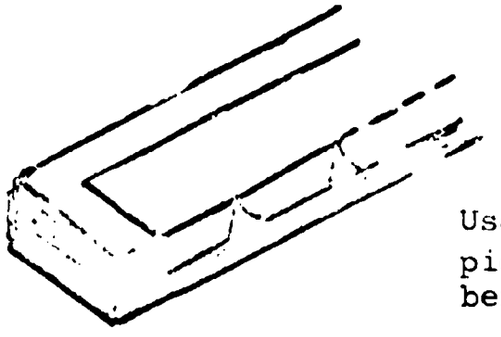
Step Eight: Place the pieces of canvas with wet paper in between on a block of wood. Pre-heat an electric iron to medium heat and iron the canvas until the sheet of paper is dry and crisp. This step simulates the dryer section of the paper machine where the sheet of paper passes through a long row of steam-heated rollers.

You have now completed the process of manufacturing a sheet of paper. To prove how successful you are as a papermaker write your name on your new sheet of paper with a ball point pen or pencil.

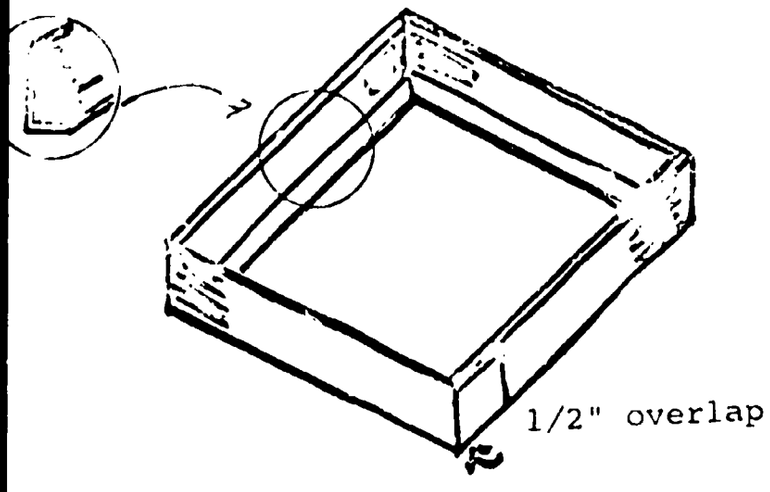
Illustrations for Papermaking Activity (Experiment I)
(Source: Let's Make Paper, St. Regis Paper Co.)



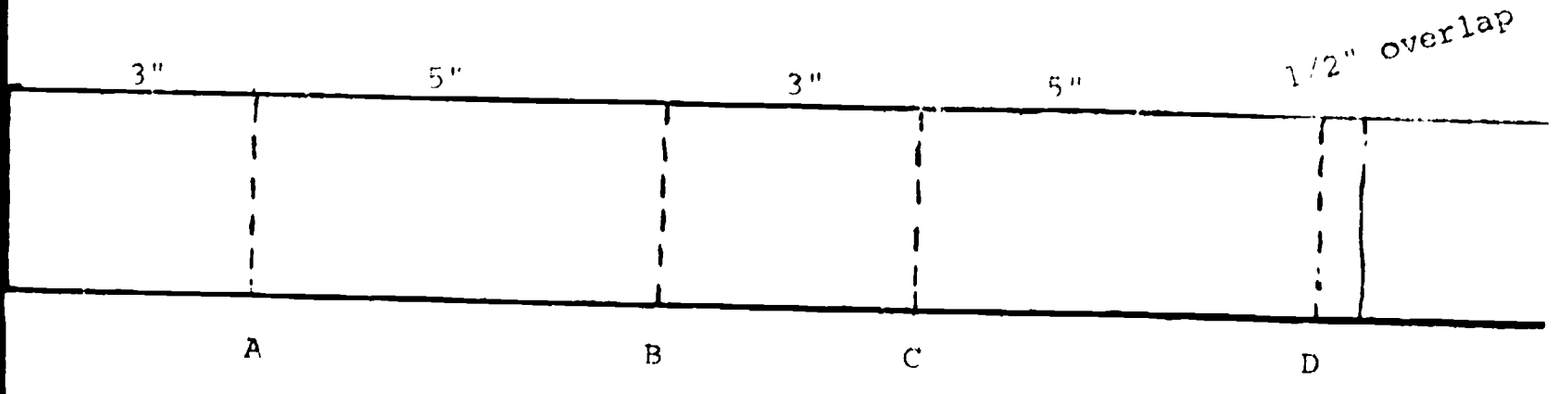
Frame A



Use the edge of a piece of lumber to bend the metal.



Frame B



Experiment II. "Simple Experiment in Papermaking"

Source: Herman and Nina Schneider, Science - Far and Near.

Materials needed:

Empty milk carton
Piece of nylon stocking
Stapler
Mixing bowl
Egg beater
Two blotters
Round glass jar
Paper handkerchief

Step One:

1. Cut off the top of the milk carton and discard.

2. Cut the bottom out of a milk carton, leaving a 1/2" border. The teacher should do this step, using a X-acto knife or other sharp instrument.

3. Cut the sides away following the illustration on page 42. This is the holder.

4. Cut another piece that fits the bottom. Cut out most of the piece, so it looks like a picture frame.

5. Stretch a piece of nylon stocking over this frame and staple it.

6. Put the frame in the holder.

Step Two:

Tear 2 1/2 paper handkerchiefs into bits and put them into a bowl containing a quart of water. Beat the mixture with an egg beater until it is smooth.

1. Dip the holder and frame into the bowl.

2. Keeping the holder straight up, lift it out slowly. Let the water drip out.

3. Gently lift out the frame from the holder.

4. Put a blotter on the frame.

5. Roll it with a round jar.

6. Turn the frame over and gently pick it up. Your newly-made paper should remain behind on the blotter.

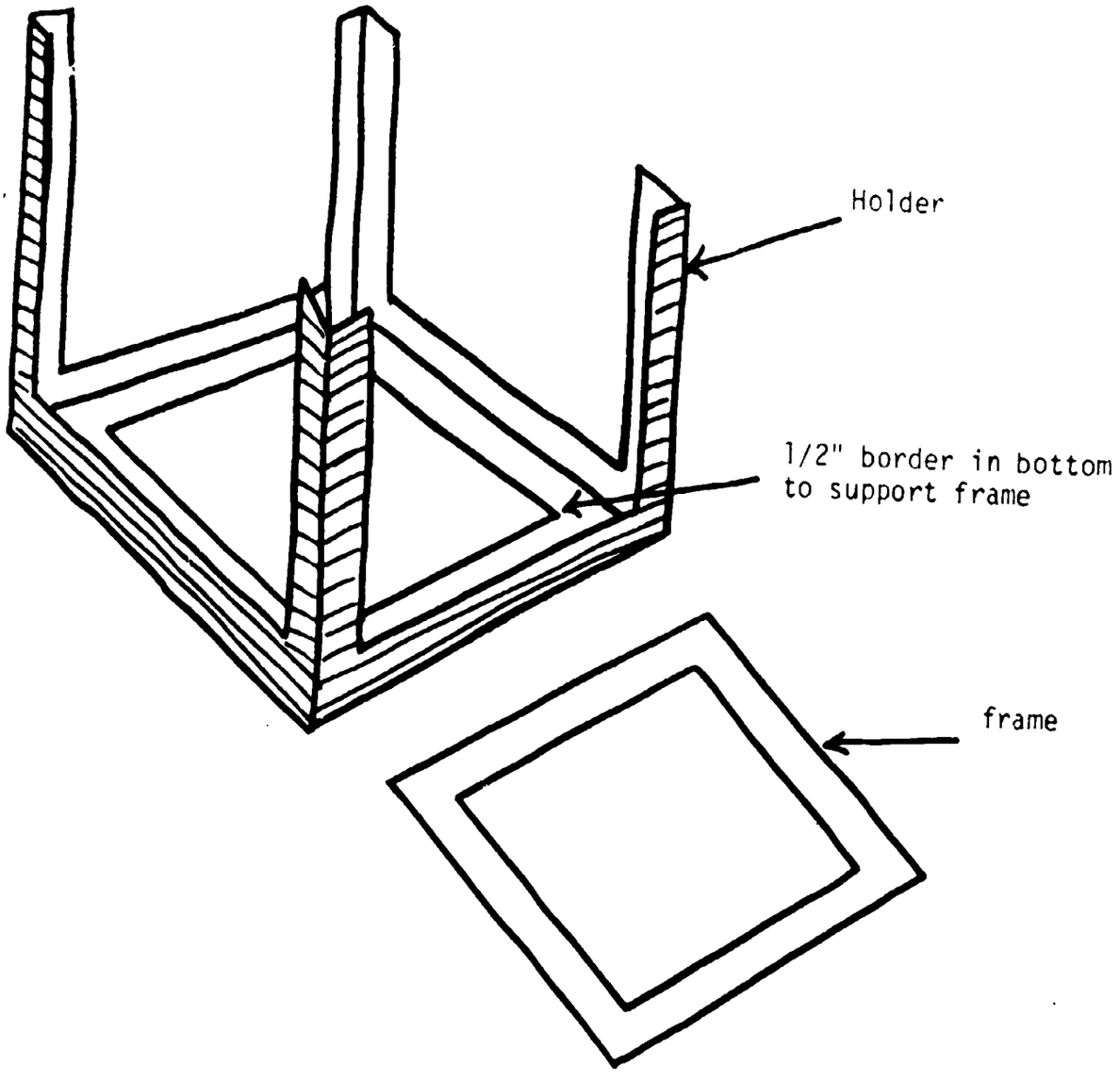
7. Put another blotter on the new paper.

8. Place a heavy book on top of the blotter. Allow your paper to dry for a day. You may speed up the process by pressing with an electric iron directly on top of the top blotter.

9. Pick up the top blotter. Lift the new paper from the lower blotter. You have made your own paper.

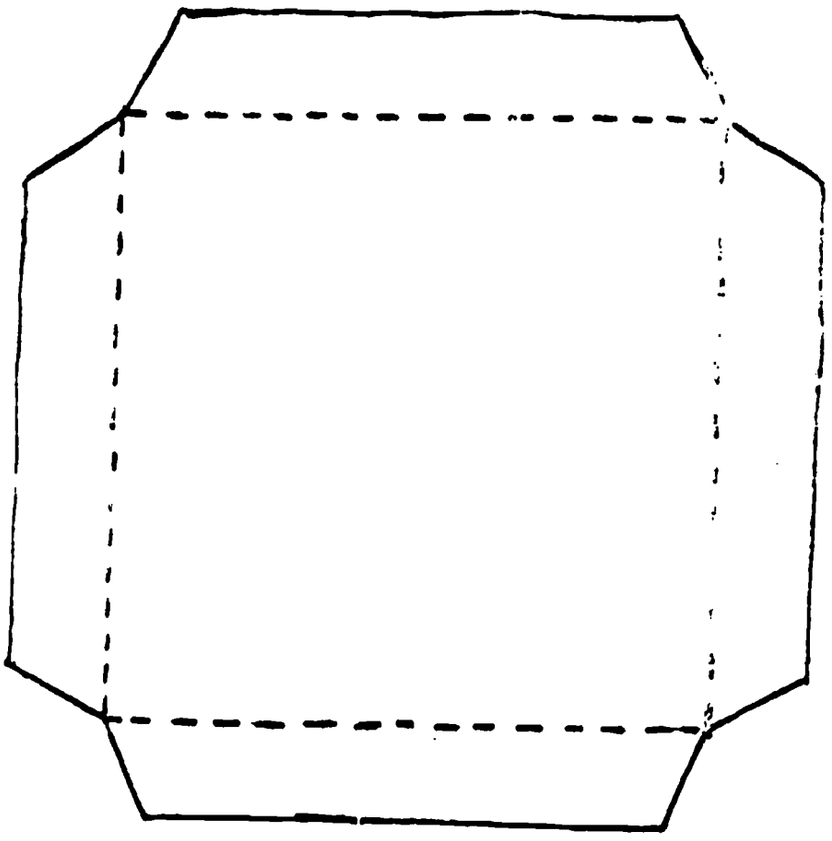
Variation: Add dye (color)
Add starch (smoothness)
Add gelatin powder (sheen)

ILLUSTRATION FOR PAPERMAKING PROCESS, EXPERIMENT II



INSTRUCTIONS FOR MAKING THREE-DIMENSIONAL OBJECTS

SQUARES

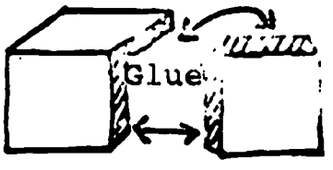


Make 6 squares.

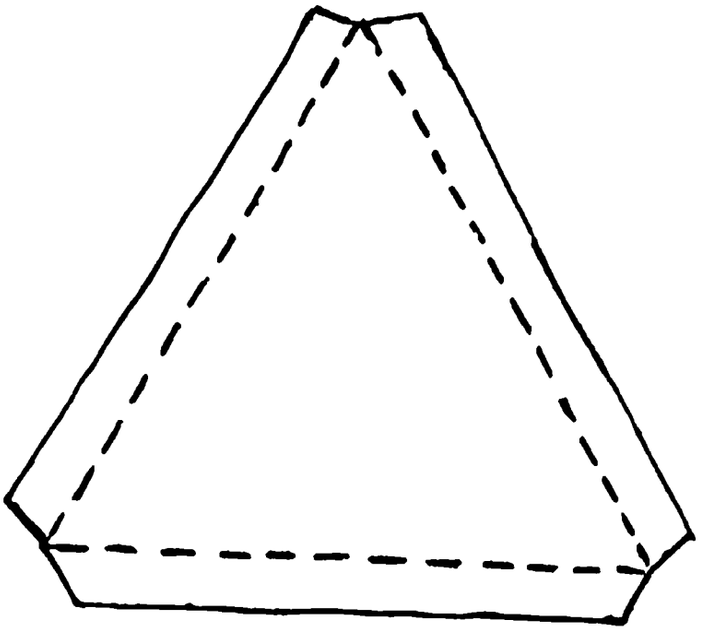
Fold along dotted lines.

Glue sides together.

Finished product-box.



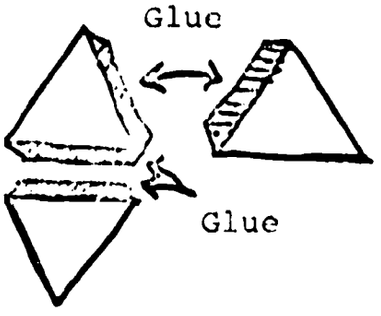
TRIANGLES



Make 4 triangles.

Fold along dotted lines.

Glue sides together.



Topic: Varieties and Uses of Paper

Teacher Preparation

1. Set up a display showing different kinds of materials made from paper. (Examples: boxes, writing papers, household products, building materials). Observe the different characteristics of the paper used for each purpose.

2. Set up a display of bio-degradable and non-bio-degradable paper materials.

3. Set up a display of the kinds of paper manufactured and the best use for each type.

ACTIVITIES

1. Show the film Paper in the Round. This is an art film depicting the different shapes and sizes of paper and how they can be used.

2. Discuss what a postal system would be like without paper. Plan a field trip to a post office.

3. Have the students construct a three-dimensional object with paper. What kind of paper must be used? Will your construction be strong enough to support light objects? (Note: This project is intended to show the students that all kinds of paper are not suitable for all purposes. Heavy, sturdy paper is needed to construct three-dimensional objects built to support small objects. For example, one-pound lightweight paper would collapse.)

4. Have the children make a musical instrument out of paper.

5. Encourage the students to invent or modify some physical education games played only with paper. (Outdoor activity)

6. Have the children devise a method of communicating on paper without a writing tool. For example, a code of punched holes or shapes can communicate. Explain a computer punch card, braille symbols, or quipus (used by the Incas). Place value (positioning) is important.

7. Plan research projects for the students on paper dwellings or paper products used in construction. Plan to visit a new housing development.

8. Have the children write a story hypothesizing what the world would be like without paper.

9. Motivate the students to make cartoons out of pads of paper.

10. Have the children pretend they are pieces of paper, describing all their qualities and abilities and stating their importance. (Outdoor activity)

11. Have the children write letters to paper companies and to the government (federal, state, or local) to find out what kinds of products they make.

12. Have the students list everything they can make of paper. (Outdoor activity)

13. Motivate the class to imagine the consequences if the entire world were made of paper. (Outdoor activity)

14. Have the students experiment with different weights of paper in folding origami (see Bibliography). Have the children use various kinds of paper for painting with water colors, fingerpainting, or drawing with crayons. Experiment with the various papers bags to determine which kinds are stronger. (These activities should indicate to the students that different papers have different uses.)

15. Compare the quality of paper in an expensive book as opposed to a paperback book. (Uses are important here for economy reasons.)

Topic: Economics

ACTIVITIES

1. Take the class on a thirty-minute "Paper Treasure Hunt" outside the school building. Bring back all paper refuse found.

   a. Sort out the refuse by types of paper: color, texture, finish, etc.

   b. Weigh the refuse, either altogether or as sorted.

   c. Discuss the following questions with the children:

      (1) How long do you suppose the paper was outside?
      (2) What type of person might have put or dropped it outdoors?

(3) Where do you think the paper came from originally (i.e., around a hamburger or cigarette pack)?
(4) Can you suggest ways that merchants who sell things wrapped in paper could help alleviate the littering problem?
(5) Do you suppose the paper will return naturally to the earth? How long do you presume the process will take?

2. As a class project, take an inventory of the amount and types of paper consumed per day in the school. The students can interview: custodians concerning paper products in lavatories, the lunchroom, etc.; secretaries about paper used in the office; teachers regarding paper used on ditto machine, etc.; other students; the principal; etc. Have the class try to think of ways to cut down on consumption. If necessary, ask such questions as, "Can we switch to reusable cloth for anything? Stop using paper trays at lunch?" Have children:
   a. Estimate the cost of the amount of paper used in the entire school in one day.
   b. Establish a ratio of number of sheets used to individuals in the school in order to figure out the approximate cost per person.

3. Suggest that the children live for one day in the classroom, or at home, or both, without using any paper or paper products. Follow by having the children relate their activities in a paperless environment.

4. Role Playing: Have a small group of children pretend they are trees and others pretend they are a river. Where would paper mills be located in relation to trees and rivers? (Outdoor activity)

5. Continue role play: Pretend that the trees have been cut down. Why must they be replaced? How many years will it take for the new saplings to mature? What would happen to soil if felled trees were not replaced? How would industry be affected? (Outdoor activity)

6. Play the game "Paper Mill." (See directions, page 57).

7. Have the students estimate the amount of board feet in a particular tree (see page 47 for directions). Judge the amount of wood pulp that a tree would supply and the volume of papering reams that could be produced.

Estimating Board Feet of Lumber

The math concept in this lesson is that the volume of lumber measured in the standard unit of "board feet" may be calculated for any standing tree. Two methods are suggested for constructing devices to measure a tree's diameter. Expand the follow-up activities to include tree identification and methods of determining the value of specific trees and wood types.

Objectives:

1. To determine the diameter of a tree at a distance of 4 1/2 feet above the ground.

2. To determine the number of board feet in a tree by using the diameter and the number of 16-foot lengths of usable lumber.

3. To determine the market value of a tree based on a given price per board foot.

Concepts:

1. In order to estimate the number of board feet in a standing tree, the diameter and number of usable 16-foot lengths of timber must be known.

2. A biltmore stick is an instrument used to measure the diameter of a tree.

3. Trees are sold according to the number of board feet measured by the forester.

Vocabulary:

1. Board foot - a unit of measure equal to 1" by 1" by 12".

2. Diameter at breast height (DBH) - a point 4 1/2 feet above ground level at which a forester measures the diameter of a tree.

Materials: A biltmore stick, a hypsometer, and a board foot chart (see chart, page 57)

Instructional Procedures and Activities:

Allow pupils to work in pairs or in small groups with each pupil having the opportunity to measure the tree while another records the data and assists. Ask the students to determine the diameter of a tree at a point 4 1/2 feet above the ground using either or both of the following methods:

Simplified Method:

Cut a piece of heavy paper or flexible cardboard at least 1 1/2 inches wide and about 45 inches long. Starting at one end of this measuring tool, mark off units 3.14 inches apart (approximately 3 and 3/16 inches) and number these units consecutively. Use this tape measure to obtain readings in inches of diameter. Before the students actually use the tape outdoors, allow time for practice in the classroom on waste baskets and other round objects. Discuss the results and compare measurements with those obtained using basic mathematical formula, $d=c/\pi$ (diameter equals circumference divided by 3.14) Be sure students understand why their tape measurements are accurate and know the underlying mathematical concept. (Suggestion: Two long pieces of masking tape with their sticky sides pressed together make a successful tape measure.)

Biltmore Stick Method:

Have the pupils cut out a heavy piece of paper the length and width of a yardstick. A piece of wide masking tape can be applied to a yardstick instead. Glue the paper onto the yardstick. If you wish, the stick can be varnished to make it weatherproof. Drill a hole through the center of the stick and insert a leather thong or piece of heavy twine. Knot both ends so that the distance between the knot is 25 inches. Hold the stick horizontally against the tree at a point 4 1/2 feet above ground level. Using the knotted cord as a measure, have pupils sight the diameter 25 inches away from the tree. Note where the left side of the tree lines up with the stick. This number indicates the diameter of the tree. Next, determine the height of usable timber with a hypsometer (see page 49). A forester usually measures from a point one foot above the ground to the point where the main trunk branches or twists.

Remember that a tree should be as straight as possible and free from damage to be valuable as lumber or as paper pulp. Using the measurements that have been obtained, refer to the board foot chart to determine the amount of usable lumber. Locate the number of 16-foot sawlogs along the left column and then find the diameter inches along the top column. The number at the point where the columns intersect indicates the number of board feet of lumber in the tree.

Hypsometers

Objectives:

1. To determine the height of an object with a hypsometer.

2. To compare various methods of measuring vertical distance.

Concepts:

1. A hypsometer is an instrument used for determining heights of objects.

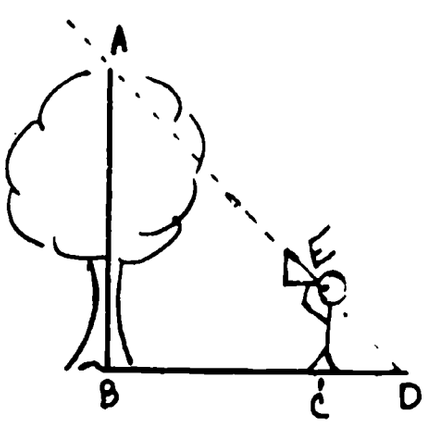
2. An isosceles right triangle is one in which the two sides (legs) adjacent to the right angle are of equal length.

Materials: Yardstick, 50-foot tape measure, isosceles right triangle cut from cardboard or some other cardboard hypsometer.

Isosceles Right Triangle Method:

Construct an isosceles right triangle of cardboard with dimensions of 5" by 5" by 7 1/16". Select a trial distance from the tree to be measured. Holding the longest side (hypotenuse) of your cardboard triangle to the eye, sight down the hypotenuse to the top of the tree. As you sight down the longest side, one of the equal legs of the triangle must be parallel with the tree trunk and the other leg should be paralled with the ground. Move forward or backward as needed until all the sides of the triangle are in position as described above.

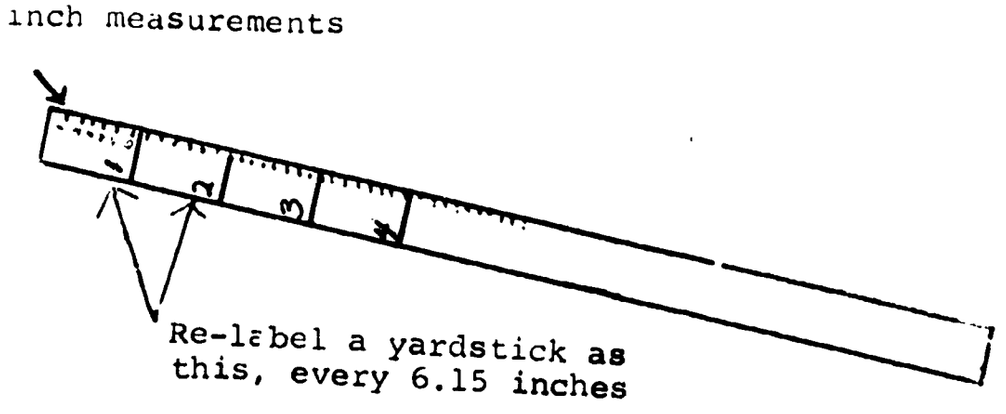
The height of the tree can be determined by measuring from the mid-base of the tree to where the sighting person is standing (the distance BC on sketch) plus the height this cardboard triangle is held above the ground (distance CE on sketch). Therefore AB=BC + CE.



Yardstick Method:

This is a relatively easy method that is usually successful with students who might become confused with some of the other concepts. Have the children work in pairs. Ask them to stand at a distance of 66 feet from object to be measured. Then hold a yardstick, which has been marked off and numbered every 6.15 inches, in a vertical position at a distance of 25 inches from the eye. Have another student assist in this determination. Slide the yardstick up or down until the top is in line with the top of the object. The position at which the lines of sight cross the yardstick marks the number of 16-foot lengths of the object. Multiply by 16 feet to obtain the height.

ILLUSTRATION OF HOW TO RE-LABEL YARDSTICK



BILTMORE STICK SCALE

Yardstick Mark	Tree Diameter
5 7/16"	6"
7"	8"
8 8/16"	10"
9 15/16"	12"
11 5/16"	14"
12 9/16"	16"
13 15/16"	18"
15"	20"
16 3/16"	22"
17 5/16"	24"
18 6/16"	26"
19 6/16"	28"
20 7/16"	30"

CHART TO ESTIMATE BOARD FEET

Tree Diameter in Inches

Number of Estimated 16' Sawlogs	10	11	12	13	14	16	18	20	22	24	26	28	30	32	34	36	38	40
1	39	49	59	71	83	110	140	180	220	270	320	370	420	480	550	620	690	770
1-1½	51	64	78	96	112	150	200	250	300	370	440	510	590	680	770	870	970	1090
2	63	80	98	120	141	190	250	310	390	470	560	650	760	870	990	1120	1260	1400
2-2½	72	92	112	1[illegible]	164	220	290	370	460	560	660	780	900	1040	1190	1350	1510	1690
3	--	--	127	156	186	260	340	430	530	640	770	900	1050	1210	1380	1570	1770	1980
3-3½	--	--	---	---	201	280	370	470	580	710	850	1000	1160	1350	1540	1750	1970	2200
4	--	--	---	---	---	300	400	510	640	770	930	1100	1270	1480	1690	1920	2170	2430

Topic: Recycling

1. Have the children decide how to set up a recycling center within the classroom. This can be an on-going project. A student data sheet can be kept to record the quantity of paper brought in by each student. If enough paper is collected, the students may take it to a Recycling Center or donate it to Scouts or other worthwhile organization.

2. Develop art projects with used paper products either brought from home or saved from classroom usage. (Refer to reference books in Bibliography for instructions).

   a. Origami - old papers, wrapping paper, colorful magazine pages

   b. Christmas tree - old Reader's Digests

   c. Collages - variety of old papers

   d. Paper maché - old newspapers

   e. Paper art show - assortment of as many different kinds of paper as can be found

   f. Giant sculpture - old magazines with pages rolled up like a tube and glued together. (Result may be compared to a giant toothpick sculpture.)

   g. Colored chalk (wet) - old newspapers.

   h. Shapes and sizes - construction paper scraps

3. Write a letter to your congressman trying to influence him to introduce or support legislation that would promote:

   a. Better recycling programs (more centers, collections)

   b. Removal from the market of colored tissue paper and toweling not dyed with vegetable dyes

4. Bring packaging materials from home.

   a. Discuss possible replacements or substitutes for these packaging products. How much waste is involved? Is recycling possible?

   b. Examine the packages to see if they are biodegradable or are not capable of being recycled.

Topic: Careers Related to Paper

Teacher Preparation

1. Read and otherwise acquire knowledge about potential careers related to the processing, consumption, and recycling of paper.

2. Set up classroom displays of materials and pamphlets available about some of these careers.

3. Obtain addresses where children may write to obtain additional information about careers that may interest them. (Merit Student Encyclopedia is an excellent source of such addresses.)

Activities

1. Have the students make a career study of one vocation related to paper.
   a. Make a picture scrapbook from magazines, etc.
   b. Illustrate the scrapbook with their own drawings.
   c. Collect information for reports from encyclopedias and books.

2. Arrange for a speaker in the area of forest management, or a forest ranger or conservation department employee.

3. Visit a forest ranger tower. (A small tower is available at Rockwood Reservation.)

4. Go into the woods. Have the students pretend that they are foresters who must select trees for cutting. The children will explain why they chose particular trees.

5. Encourage the children to:
   a. Design packages for new products to be put on the market. Consider color, appearance, shape, size, material, etc.
   b. After the packages have been designed, employ salesmen to sell the hypothetical products. Students can group for selling individual products. The salesmen can try to sell their imaginary products to their parents or neighbors. A questionnaire, such as a market research form, can be devised by the students to test the receptiveness of potential customers to their products.

6. Construct a forest-saw mill-river complex out of paper mache and materials collected from out-of-doors. (Outdoor activity)

7. Presume that a student has just been appointed Paper Recycling Director of a new environmental agency. One of his duties is to devise a system whereby schools can serve as collection agencies for paper to be recycled. The students can make a survey of the school, inside and outside, plan a good spot for the deposits, and design attractive receptacles for the paper.

At the end of this instructional sequence, give the Pre-post test again and fill out the form on the following page.

Return to:
Mr. Verlin Abbott
Administration Building
455 N. Woods Mill Road
Chesterfield, MO 63017

School_____

Teacher_____

Unit_____

Student post-test results will be grouped in the following manner:

Example:

Number of post-test questions given 14 .

Number of students	Number of questions answered correctly.
12	13
11	12
8	10

Number of post-test questions given._____

Number of Students	Number of Questions Answered Correctly

Number of post-test questions given._____

Number of Students	Number of Questions Answered Correctly

"PAPER MILL"
A Game for Four Players

Concepts:

1. Paper mills are usually located near the source of wood, the forests. They are generally situated on a river since water is used in the papermaking process, and in order to utilize the river as a source of transportation.

2. The papermaking process uses resources such as wood and water extensively. There are concurrent harmful effects to the environment, such as the disappearance of forests and possible pollution of the water.

3. There is a time lapse between the chopping and processing of the wood into paper. Many years are required to reforest the bulldozed woodlands.

4. It is necessary to reforest the land to keep it productive.

5. It is necessary and beneficial to keep a community balanced between families and forests.

6. Foresters and owners of paper mills must make long-range decisions in order to continue making a profit from their land.

Rules:

Object: The object of the game is twofold. Each player should make as much money as possible in the operation of his forests and paper mill, and at the same time, end up with as many mature trees as he can. The winner will be judged by translating each square of dark green, mature trees into $5,000, and adding that amount to the profits the player has acquired.

Families: Families each pay $2,000 upon entering the town (either at the beginning of the game or later), and each pay $500 rent on each player's turn. Hence, it is profitable to bring in families at the beginning of the game so that the players will acquire some capital with which to start up business. It is also beneficial to keep the families happy (not polluting, keeping a balanced community) so that they will not move away and thereby stop paying rent. Whenever a fortune card tells a player that a family has moved away, all rent from that red square is stopped, and a brown square is placed on that property. A player may bring in up to 20 families if desired, but this will

not result in making the most profits possible. (The initial revenue from families is good, but the rents are less.)

Trees: The complete game board is dark green at the beginning of the game, representing wild forests. When a family moves in, it is assumed the land is bulldozed for construction of homes. After a mill has been purchased, one square of mature (dark green) trees must be turned into the mill each time the player has a turn to keep it operating. The player has the choice of purchasing and planting new seedlings in that square at the cost of $1,000 per square, or of leaving the ground alone, which is cheaper at the time but could backfire later because of erosion, etc. When a player runs out of trees to feed the mill, he may purchase trees from other players at a cost of $500 times the number shown on the dice. If the player cannot afford to buy new trees from another player, his mill must close, and no revenues may be collected on that turn.

New Seedlings: New seedlings may be purchased, as mentioned above. They are not counted at the end of the game as $1,000. They mature into dark green trees only when the "mature" cards appear. There are eight mature cards in the game.

Paper Mills: The mills may be purchased either at the beginning of the game or later at a cost of $5,000 or $1,000 times the number shown on the dice. Only one mill may be built on each player's property. After the mill has been opened, is in full operation (no fortune cards, strikes, etc.), and is being fed one square of dark green trees each turn, the player may collect $2,000 on each turn from the mill. The mill must close if: 1) a fortune card says it must, 2) all families move away, 3) it is not fed dark green trees on a turn. Important: If the paper mill remains shut down for two consecutive turns, it is closed forever, and that player is out of the game.

Unproductive Land: The brown squares represent unproductive land. Once a square has been covered with brown it is out of the game, and can never be used for planting new trees, for families, or as any source of revenue.

Financial Transactions: Since there are so many financial transactions which take place on every player's turn, paper money is the easiest method to use. The teacher may reproduce page 63, the sheet of paper money, by thermofaxing it onto a ditto, and then running off 40 copies of the ditto. The sheets may then be cut into paper bills. In this way, each individual game will have 80 copies of each bill. If the teacher wishes to make several

game boards so that the entire class can play at the same time, the appropriate number of bills will have to be reproduced. It is suggested that a new thermofax copy be made for each game to insure printing clarity on the ditto machine.

One player in each game should be the banker. All transactions take place through the bank or "kitty." When the players earn money, through families' rent, revenues from the paper mill, a government purchase of property, etc., this money comes from the bank. When players pay fines or purchase new seedlings, that money goes into the bank. It would be too difficult and confusing for each player to operate a separate fund for families, paper mill, etc. The use of the bank as a source of funds should be readily comprehensible to the children since it it similar to the game, "Monopoly."

How to Play:

At the start of the game each player has no money.

1. Each player may decide how many families he desires to bring into his town, and he may collect $2,000 from each family.

2. Each player spins for a number; by multiplying $1,000 times the number shown, he finds the costs of a paper mill. Otherwise he may pay an outright price of $5,000. He must decide whether to pay $5,000 or spin before spinning, however. If he can afford a mill and desires it, he may buy one. He must feed it one square of dark green trees immediately. He may also purchase new seedlings right away.

3. Draw no cards the first turn. On the second turn, and all succeeding turns:
   a. Draw a card and follow the directions.
   b. Collect revenues from each family ($500 per square).
   c. Feed the paper mill, if owned, one square of dark green trees.
   d. Buy new seedlings at a cost of $1,000, if desired. Otherwise place a white square on property signifying unforested land.
   e. Collect revenues from the paper mill of $2,000, when it has been fed one square of trees.
   f. Place more families on the property if desired, and collect revenues.

4. The game ends when: The fortune cards run out; or when the paper mills of all players have closed down for two consecutive turns.

5. At the end of the game:
   a. Count up the number of squares of mature (dark green) trees remaining. Translate each square into $5,000.
   b. Count up the amount of money held by each player.
   c. Add the tree money to the money held. The person with the most money wins the game. He has made the largest profits and has finished with as many mature trees as possible.

Materials: The children may help the teacher make the parts for the game.

1. Game board: The game board should consist of four plots of land, each plot containing 20 one-inch squares. The board should be drawn on dark green construction paper to represent wild forests. A river runs through the center of the board, where the mills are placed when acquired. See page 64, example of the game board; it may be thermofaxed and run off on dark green construction paper.

2. Colored squares: each one-inch square
   60 red squares - represent families
   80 light green squares - represent new seedlings
   4 blue squares - represent the paper mills
   40 brown squares - represent the unproductive land; when these are placed on the game board that section is out of the game.
   40 white squares - represent unforested land

3. Dice or spinner: One die may be used if available. Otherwise a spinner may be constructed on a small card, with numbers going only up to six. (See page 65). A pin should be stuck into the card, with a spinning arrow attached to it.

4. Fortune cards: These may be reproduced on index cards or on small pieces of paper. Pages 61 to 62, which show samples of the fortune cards, may be thermofaxed and then run off on a ditto machine in whatever quantities the teacher desires, depending on the number of games she wishes to make.

The government offers to buy two squares of your forest to turn into a permanent National Wildlife Refuge. You may sell or keep the land. If you sell, you must place brown squares on that property. The Government will pay you $3000. (2)

RECESSION! SALES ARE DOWN!

If you have less than three families, collect no rent on this turn. (2)

GOVERNMENT REWARDS YOU FOR BALANCED COMMUNITY!

If you have at least 12 squares of forest and 4 squares of families, collect $3000. (2)

ALL NEW SEEDLINGS MATURE! (2)

THREE SQUARES OF NEW SEEDLINGS MATURE! (2)

FIRE AT THE PAPER MILL!

Pay repair costs of $1000 (if you own a paper mill) (2)

FOREST FIRES CONSUME TWO SQUARES OF YOUR PROPERTY!

Choices:
1. Leave the ground alone
2. Replant new seedlings at $1000 per square.
3. Move in new families and collect $2000.

(2)

Unforested area suffers erosion and becomes unproductive land. Place brown squares over the unforested property. It is out of the game. (4)

FUNGUS DESTROYS WOOD OF ONE OF TREES!

You may choose to do one of the following:
1. Replant new seedlings at a cost of $1000
2. Leave the ground unforested (no expense)
3. Move in a new family and collect $2000 (2)

TWO SQUARES OF NEW SEEDLINGS MATURE! (2)

ONE SQUARE OF NEW SEEDLINGS MATURES! (2)

OIL IS DISCOVERED ON YOUR PROPERTY!

You may choose one of the following:
1. Sell the square of forest to an oil company for $6000
2. Keep the forest.

(If you sell the land, place one brown square over the property.) (2)

*The number in parentheses in the lower right hand corner of each fortune card indicates the quantity of cards needed for each "Paper Mill" game board

PAPER MILL POLLUTES RIVER!

If you own a paper mill, you must choose one of the following:

1. Pay each square of families on your property $1000
2. Lose two families. Place brown squares over the properties. (2)

ROCK CONCERT ON YOUR PROPERTY!

Collect $2000 rent for the use of your area.

(2)

MERCURY FROM THE PAPER MILL POISONS FISH!

Choices:

1. Pay each square of families $1000
2. Lose two families; place brown squares over their properties (2)

STRIKE AT THE PAPER MILL!

Collect no revenue from the mill this turn. The mill is closed down for one turn.

(4)

PENALTY FOR UNBALANCED COMMUNITY!

If you have less than three squares of families, the families are dissatisfied.
Choices:

1. Lose one family, place brown square over their property
2. Pay each family $1000 (3)

If you have ten families or more, the government punishes you for having an unbalanced community. Pay the government $3000. (2)

LOG JAM ON THE RIVER!

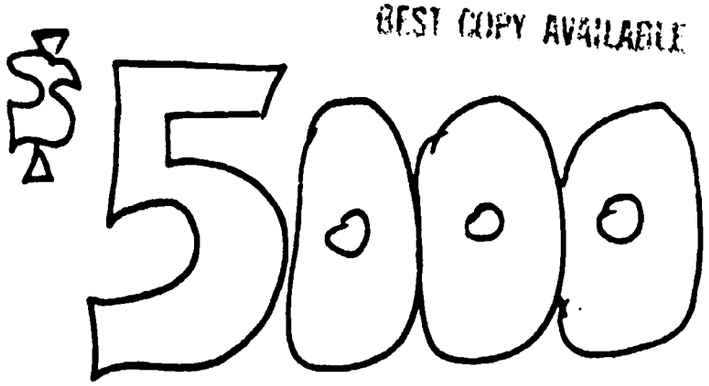
Choices:

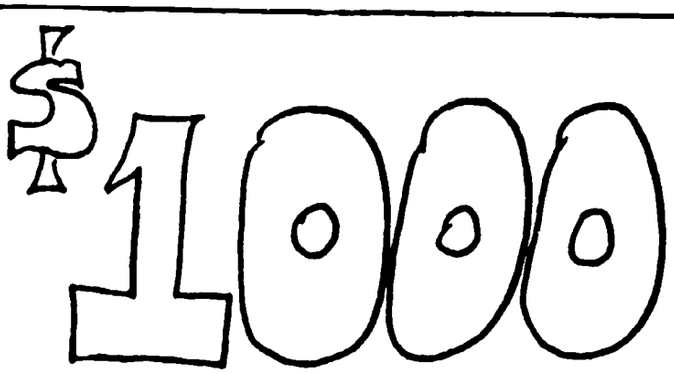
1. Pay overtime to workers to eliminate the jam. (Overtime is calculated by rolling the die and multiplying the amount shown by $500)
2. Close down the mill for one turn. Do not collect the revenues from the mill. You must make your choice before the die is rolled. (2)

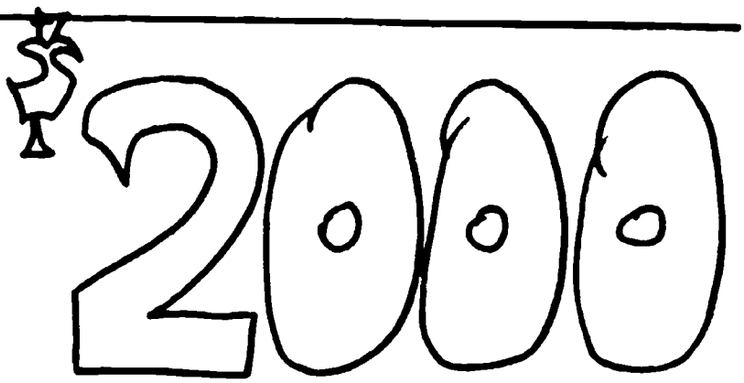
CAMPERS RENT YOUR PROPERTY!

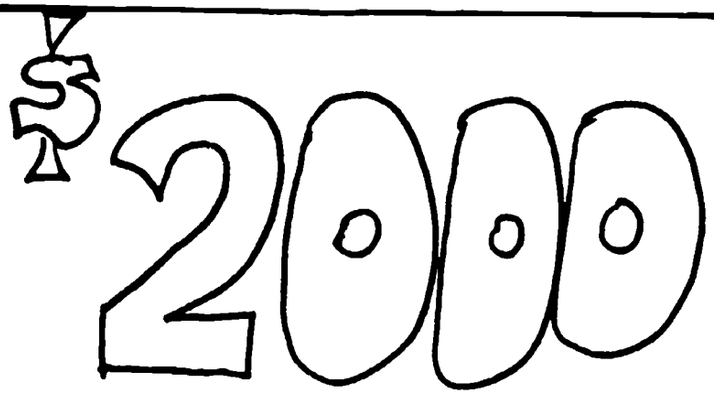
Collect $2000.

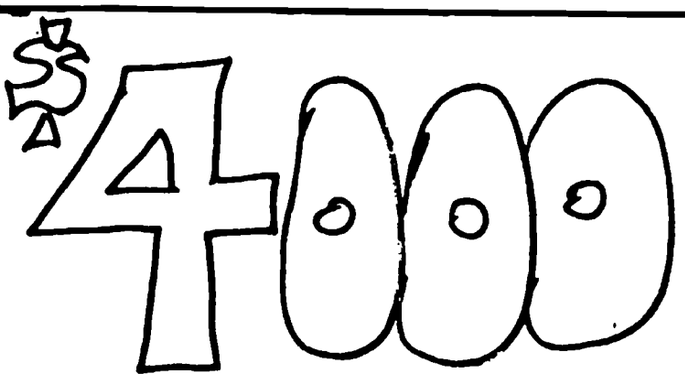
(2)

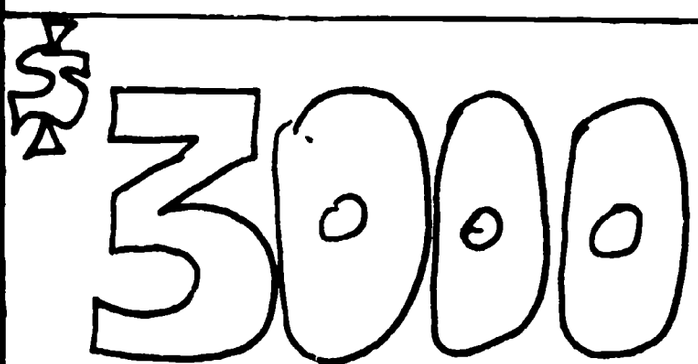


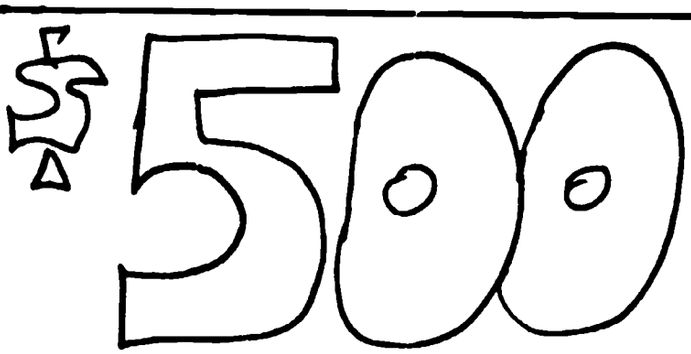


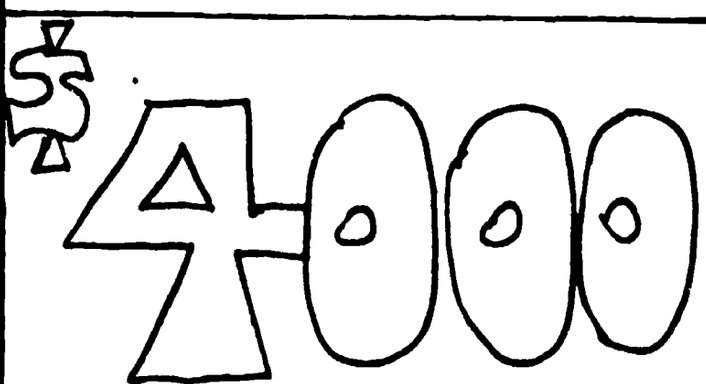


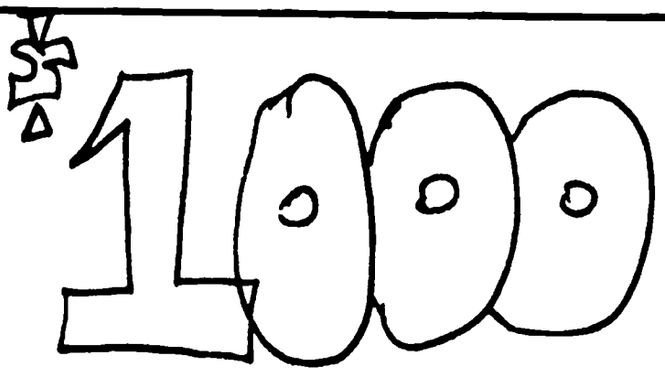




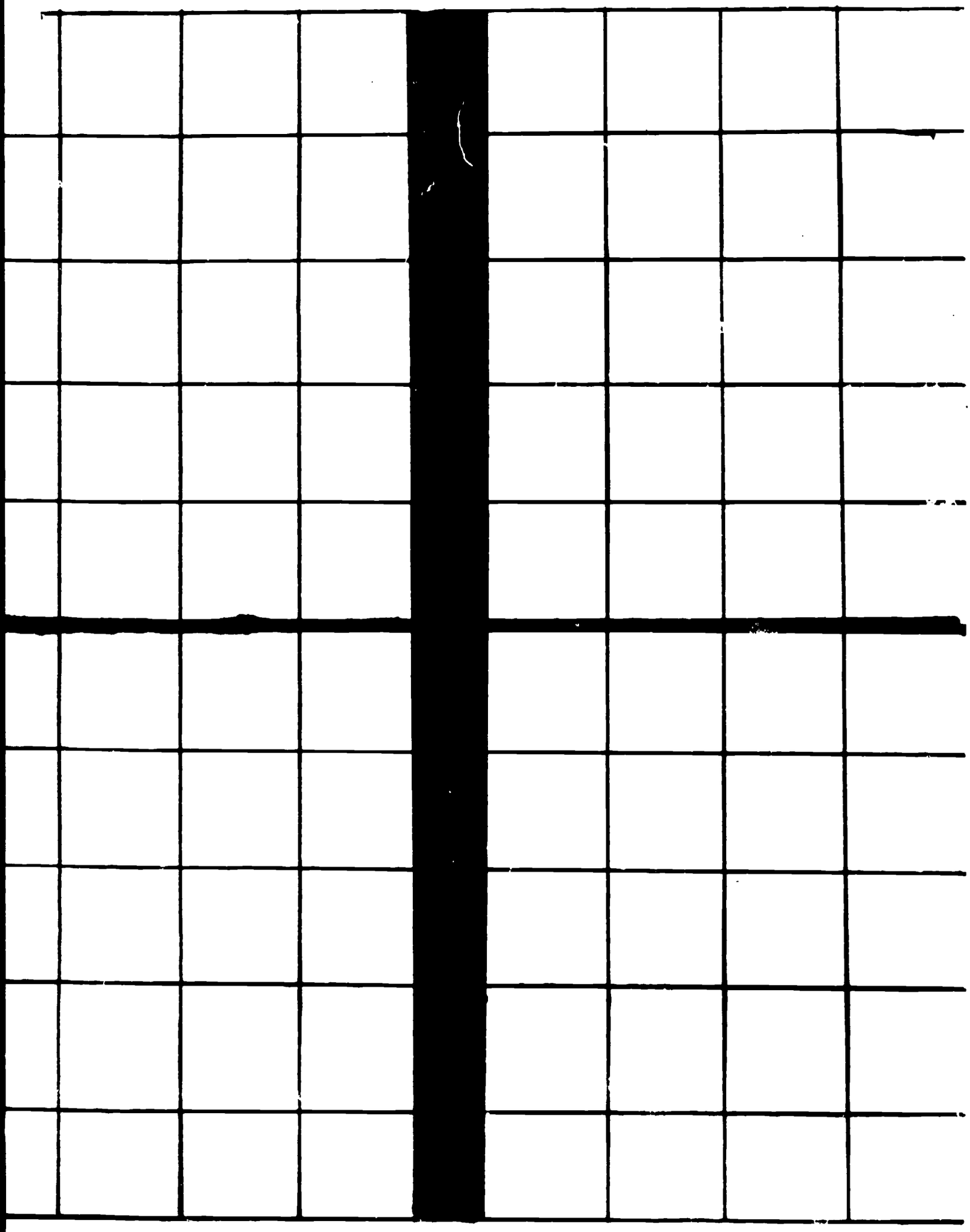




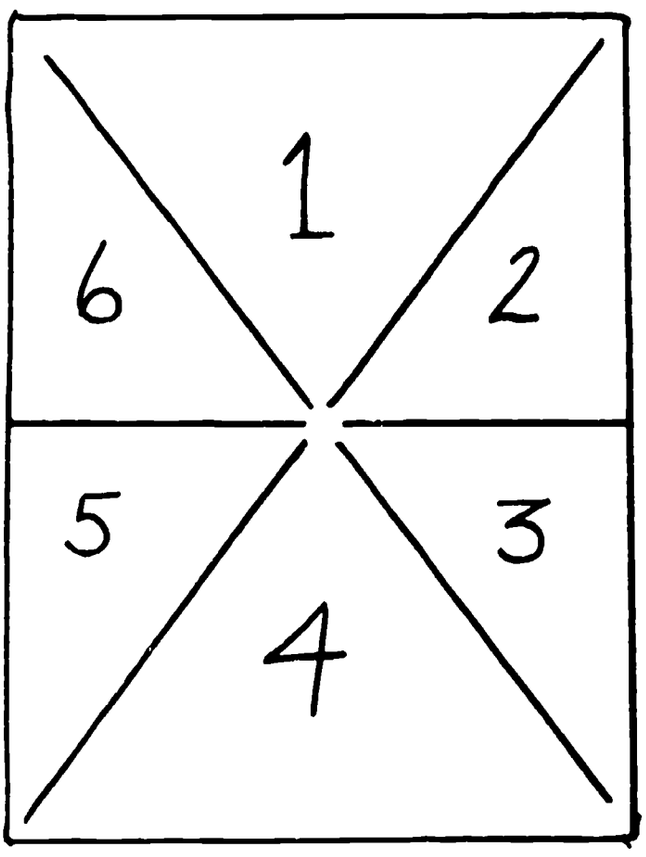




GAME BOARD



SPINNER CARD



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Sadler, Arthur, An Introduction to Paper Sculpture. London: Blandford Press, 1963.

16 mm. Sound Films

Paper in the Round (IJS; Art; Color; 11 minutes; McGraw Hill). Explains and demonstrates how paper can be folded, cut or bent, and then decorated to create many forms and shadows. Designed to motivate and demonstrate creativity in paper sculpture. Available from County Audiovisual Department.

Paper Making (IJ; SS; 22 minutes; Cor; BW) Relates the story of paper from logging operations in Michigan through the final testing of the finished product in research laboratories. Available from County AV Department.

Paper Sculpture (IJS; Art; Col; 6 minutes) Shows the possibilities of paper sculpture as a creative art form. Various states of this form of art are shown as well as the finished product. Available from County AV Department.

Trees to Paper. Available from Missouri Conservation Department. Demonstrates the making of paper from pulpwood. (12 minutes)

The Alton Story. Available by ordering from Mr. Jack Livingston, Alton Box Board Company, Public Relations Department, Alton, Illinois or phone 741-6650. Shows the entire process of paper-making from forest through designing for packaging of consumer products. Excellent.

Wealth of the Wasteland (F52851; Col; 28 minutes) Explains recycling of wastes. Available from County AV Department.

To obtain additional information write to:

American Forest Products Industries, Inc., 1816 N Street, N.W., Washington, DC 20036

American Paper Institues, 122 East 42nd Street, New York, NY 10017.

Southern Pulpwood Conservation Associations, 900 Peachtree Street, N.E. Atlanta, GA 30309.

To obtain a supply of pulp, address requests to:

Public Relations Department, St. Regis Paper Co., P.O. Box 4910, Jacksonville, FL 32201 or P.O. Box 1591, Pensacola, FL 32501.

INDIVIDUAL RECORDS

Name:

Paper from Home to be Recycled

Date	Amount Pounds/Ounces
Total	

Paper Used Per Day

Date	Amount lb./oz.
Total	

PAPER FROM HOME - TO BE RECYCLED*

CLASS CHART

udent	Mon. lb/oz	Tues. lb/oz	Wed. lb/oz	Thurs. lb/oz	Fri. lb/oz	Mon. lb/oz	Tues. lb/oz	Wed. lb/oz	Total lb/oz
own, Sara	3-4	5-2	0	0	0	5-7	0	1-3	14-13

A scale should be available to weigh the paper.

Week of _____ Number of sheets of paper used in a day

CLASS CHART

Student	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Brown, Sara	15	16	13	10	5	59