

# Paper Making

## Concepts:

1. Paper is a resource that has been used for centuries.
2. Renewable resources must be used at a sustainable level to remain available.
3. Awareness, knowledge, and appreciation of resource use leads to an understanding of human impacts.

## Outline:

### **I. Preparation Before Activity (20 min.)**

### **II. Introduction (10 min.)**

- A. Greeting, Grabbing, and Purpose
- B. Names and Introductions
- C. Activity Description
- D. Behavior Guidelines
- E. Task Analysis/Learner Assessment

### **III. A Paper Tale (10 min.)**

### **IV. Paper as a Resource (10 min.)**

### **V. Paper Making (55 min.)**

- A. Demonstration
- B. Paper Production

### **VI. Conclusion (5 min.)**

### **VII. Additional Activities**

- A. Write a Poem
- B. Paper Art Exhibition

### **VIII. Clean Up (20 min.)**

### **IX. Appendix**

- A. Equipment
- B. Glossary
- C. Activity and Safety Management
- D. References/Resources
- E. Data Sheets

# Paper Making

## I. Preparation Before Activity

In Paper Making, you will be leading the students through the process of how to make paper. Read through the lesson plan prior to class and talk to your liaison if you have any questions or concerns. For a two-hour class, you may begin by giving a brief history of how the process of papermaking was invented. Next, you may want to discuss paper as a resource and how we use paper. Finally, you should demonstrate the papermaking process for the students and supervise them while they make paper. For a one-hour class, you may only have time to demonstrate the papermaking process and then let the students try it.

Set up 2-4 tables in an assembly line fashion on which to place the equipment. Set out papermaking equipment in stations according to the instruction blocks, which will be placed at each station. Set out posters, the bald-faced hornet nest, and read over the curriculum.

## II. Introduction

**A. Greeting, Grabbing, and Purpose.** Greet the students as they enter the room. Bring out the bald-faced hornet nest and show it to the students. Ask them what they think it is and how it was made. Explain that hornets make their nests by chewing up plant material, mixing it with starch from their saliva, spitting it out, and flattening it into a thin layer. They allow the “paper” to dry, and then make more layers. Today, students will have the chance to make paper just as the hornets do by chewing up plants, spitting them out, and making paper! (Or is there another way?)

**B. Names and Introduction.** Introduce yourself and tell the class a little about yourself. Learn the names of the students with a method that works for you. Explain that you will be teaching the class and that other adults may be helping out.

**C. Activity Description.** In this activity, students will learn about paper as a resource and spend time making their own paper. The first 20 minutes will be spent discussing the history of paper and how it is used today. Then, you will briefly talk them through the papermaking process, step by step. Finally, the students will spend the last hour making their own paper. This activity is a chance for students to experiment, be creative, and have fun!

**D. Behavior Guidelines.** Discuss clearly and specifically which behaviors you expect from your students during the class. Explain the need for respect: for you, for each other, for ideas, for Eagle Bluff itself, and for the equipment.

**E. Task Analysis/Learner Assessment.** How has paper been used throughout history?

## III. A Paper Tale

Spend 10 minutes illustrating the history of paper by using the timeline poster. Provide basic information about the origins of papermaking and the spread of this art form throughout the world. Also, discuss how papermaking today is a technology as well by describing the “recipes” for different paper types.

Since humans have been recording written messages, ideas, and stories, many different types of writing surfaces have been used. Ask the students to brainstorm a list of possible writing surfaces. Some possibilities may include: cliffs, cave walls, bones and tusks, leaves, bark, cloth, clay, and animal skins. All these surfaces are suitable for writing or drawing, but not all of them are easy to use or practical.

- **2,000 B. C. Egyptians develop paper-like material.** The Egyptians were the first culture to develop a paper-like writing material (called papyrus) about 4,000 years ago. Papyrus is a type of reed that was woven into a mat and pounded into a thin, hard sheet. Paper, as we know it, was invented in China about 2,000 years after the Egyptians began using papyrus.
- **105 A. D. Paper developed in China.** An official in the court of the emperor of Cathay devised a writing material which replaced the bamboo strips and silk in use at that time. He shredded bark from mulberry trees and mixed the bark with scraps of linen and hemp. He then saturated (soaked) the mixture with water. This mixture was then beat into a pulpy blend, molded, and dried. This new “paper” launched a revolution in communication. One Chinese emperor had a library of 50,000 books—at a time when most great leaders in Europe could not even write their names.
- **1151 A. D. First paper mill in Europe.** As Muslims invaded China in 793 A. D., they captured a Chinese paper mill and acquired the art of papermaking. Traveling through Europe in the 12<sup>th</sup> century, the Muslims carried the process of papermaking with them. The first European paper mill was built in Xativa, Spain. Once the process reached Europe, paper replaced fine vellum (calf or lambskin) and parchment (sheep or goatskin) as writing materials. Many cities in Europe were producing paper in the late 1800s.
- **1580. Paper is brought to the New World.** The Spanish explorer, Cortez, is credited with bringing paper to the New World. The first paper mill on the North American continent was located at Culhuacan, Mexico. Though this was the first introduction of paper, a writing material made from fig tree bark, treated with lime to remove the sap, had been in use by the Mayans of Yucatan since about 500 A. D.
- **1690. Paper first produced in the United States.** Paper was first made in the United States in Germantown, Pennsylvania, at the Rittenhouse Mill. Until that time, the colonies had depended on England for their paper. The first paper made in Minnesota was manufactured in 1859 at the Island Paper Company in Minneapolis. These early papers were made from old rags.

Today, paper is made primarily from trees, though in other parts of the world, it is derived from non-wood sources like barley straw, sugar cane waste, bamboo, hemp, and kenaf plants.

Producing paper from trees requires a mixture of fibers from various kinds of trees, depending on what type of paper is being produced. Pine, spruce, and balsam are softwood tree species, which provide long fibers for strength. Aspen and birch are hardwoods that provide short fibers for body.

Every paper mill has its own recipe for making paper. Some products require a higher percentage of long fibers, while others use more short fibers. Paper grocery bags require more long fibers because they need to be strong; whereas, facial tissue uses more short fibers for softness.

When any type of paper is made, the two main components of wood in the tree, cellulose fibers and lignin (a glue-like substance in trees that holds the fibers together), must be separated in one of two ways: mechanical pulping or chemical pulping. Mechanical pulping requires high speed grinding and rubbing wood chips between stones or blades. It produces pulp that is good for printing, but still contains some lignin, a property that makes the paper weaker and prone to discoloration. Chemical pulping involves feeding wood chips into giant tanks called digesters. Chemicals are added and the whole mass is steamed. This process separates all the lignin from the fibers. Chemical pulping produces higher quality paper than mechanical pulping.

*Assessment:* Paper is a resource that has been used for centuries.

- Have the students summarize the history of papermaking. They can refer to the timeline if they need assistance.
- Ask the students, “How necessary was the invention of paper for cultures around the world? How different would our society be if paper was never invented?”

#### IV. Paper as a Resource

Spend about 10 minutes talking about paper as a resource. Lead the students into a discussion of the different types of paper resources that people use every day by doing a quick brainstorming activity and showing samples from the paper book. Discuss how each paper product is used and why they are made in different ways. Finally, discuss people’s paper consumption. Emphasize that, though trees are a renewable resource, everyone must use paper wisely for it to remain available.

Wood is a natural resource, or raw material, supplied by the earth. In particular, it is a renewable resource, one that can be replaced naturally. Therefore, wood products such as paper and lumber are sustainable; their supply can endure over time.

The sustainability of paper as a resource is very important because paper is used every day in a variety of ways. Ask the students to brainstorm a list of different types of paper products. Refer to the list of products made from paper and quiz the students. Are puzzles made from paper? How about accordions?

Human uses of paper are abundant; however, not all paper is created equally and understanding the differences among the types is important for sustaining paper as a resource. Some types of paper are produced using a variety of chemicals or extra energy and are less environmentally friendly. They cost more (economically and environmentally) to be produced and recycled. Bring out the paper samples and show them to the students. Some examples of paper products and how they are made are:

- **Corrugated box** (paperboard, etc.). Made with long fibers from softwood trees for strength and constructed with many layers of paper for stability.
- **Colored paper**. Made by chemical pulping with dyes added to make the colors.
- **Facial tissue** (toilet paper, paper towels, etc.). Made with short fibers from hardwood trees for body (which provides softness and absorbency).

- **Glossy paper.** Made with a lot of ink; special coatings gives the paper a glossy appearance.
- **Newspaper.** Made by mechanical pulping.
- **Paper grocery bag.** Made with long fibers for strength and produced by chemical pulping.
- **White office paper.** Made with a combination of long and short fibers by chemical pulping; the paper pulp is bleached to obtain the white color.

Paper is often used once and then just thrown away. In fact, it is the largest single component of landfills (40%) around the country. Until recently, very little paper has been recycled back into paper or other products, although people's demand for paper remains high. Americans use over 67 million tons of paper each year, an average of 600 lbs. per person. Our use has doubled since 1965 and may double again by the year 2010. Much paper is needed to fill this demand, but harvesting too many trees too quickly can damage forests. Although trees can be renewed, forest ecosystems take time to respond to disturbance and regain wood fiber content and their biodiversity. Some forests take over 200 years to renew their wood supply.

*Assessment:* Renewable resources must be used at a sustainable level to remain available.

- Recall two paper products and describe how they are made.
- Talk to the group about Eagle Bluff's Eagle Eye award. How are they doing? How does the award promote sustainable use of paper resources?
- Ask the group to list three ways they could use fewer paper products at school.

## V. Paper Making

Though some raw fibers must be used when making paper from recycled paper, it takes less energy (64% less) to make paper from paper than from trees! Therefore, understanding the process of papermaking is one small way that everyone can help reduce the amount of paper in landfills, the number of trees being felled for paper production, and the amount of energy needed to produce new paper products.

**A. Demonstration.** Demonstrate the process of papermaking for the students. Be sure to do each step thoroughly and answer questions along the way. The steps are as follows:

### 1. Tearing Paper

- Grab a food tray and rip about 1-3 sheets of paper into ½" pieces.
- Put ripped paper onto food tray.
- You should have enough paper to fill the blender to the black line.

### 2. Blending

- Fill blender with paper to the black line.
- Then, fill the blender with water to the red line.
- Put lid on tightly.
- Press "ON" button and blend for about one minute.
- Pour mixture into pitcher and take to station #3.

### 3. Deckles

- Place a deckle, screen side down, in one of the dishpans.
- Make sure the frame is above the water level.
- Pour paper and water mixture into the screen.

- Lightly dab mixture with finger to even the texture or shake the frame gently. If neither of these work, put mixture back into blender.
- Lift deckle straight out of the water.
- Place the deckle on a tray at station #4.

#### 4. Felt

- Take a piece of felt and place it on your wet paper still in the deckle.
- Gently press felt with your fingertips.
- When the felt no longer soaks up water, carefully pull it off. Wring water out of felt over the extra pan.
- Then, using the same piece of felt, repeat the process. Do this at least five or six times.

#### 5. Removing Felt

- Move your paper (still in deckle) to the next set of trays.
- Place a piece of felt on the paper.
- Grab the frame of the deckle and, with one quick motion, flip the frame over and slam it upside down on the tray. The paper should fall from the screen onto the tray with the felt underneath it.
- Take the deckle back to station #3 so others can use it.

#### 6. Drying Rack

- Carefully grab the felt/paper combo making sure to support it underneath.
- Place the felt/paper combo on the drying screen so the felt is touching the screen.
- Grab two corners of the felt and flip. The paper should now be touching the drying screen with the felt on top.
- Peel the felt off slowly.
- Write your name on a piece of paper and place it on the corner of your newly recycled paper.

**B. Paper Production.** Once you have finished the demonstration let the students make paper. Encourage them to experiment and be creative. They may use paper of all one color or different colors. Leaves can be pressed into the paper while using the felt at station 4. Plant parts can be ground in the blender to add texture or color. Another idea is to make designs on paper by pressing in big pieces of construction paper while the paper is still being blotted at station 4.

*Assessment:* Awareness, knowledge, and appreciation of resource use leads to an understanding of human impacts.

- Listen to student comments as they participate in the activity. Do they mention any other examples of resource use? The blenders? The lights? etc.
- When the group has finished the activity, congratulate them for reusing resources. Ask them to share ideas about what is an even better way to conserve paper resources?
- Have the group recommend four ways in which they can reduce paper use in their everyday lives.

## VI. Conclusion

Making paper is fun, easy, and economical. It can be used for stationery, journal pages, mounting pictures, coloring, and many other uses. Papermaking is also a great way to recycle used paper, thus cutting down on the amount of new paper being purchased and reducing the amount of paper in landfills. The following is from the American Forest & Paper Association website ([www.afandpa.org](http://www.afandpa.org)):

In 2003 the U.S. paper recovery rate achieved an all-time high of 50.3%. Paper recovery has increased steadily from 33.5% in 1990, to its present level of 50.3%. Total U.S. paper recovery reached 49.3 million tons in 2003, an increase of 3.4% from 2002, and 69% since 1990. This impressive accomplishment was made possible by the efforts of AF&PA member companies and millions of Americans who recycle at home, school, and at work. Paper recovery now averages 339 pounds for each man, woman, and child in the United States, up from 233 pounds per person in 1990.

Recycling generated impressive results in 2003. However, more needs to be done to boost the amount of recycled materials available to make new products, by continuing to increase the amount of paper and paperboard recovered for recycling. Export demand for U.S. recovered paper, particularly from nations with developing paper industries such as China and India, has been expanding rapidly, and by all indications will continue to increase. At the same time, with the U.S. paper industry pulling out of a multi-year slump, domestic mills will seek to maintain or increase their consumption of recovered paper.

With these considerations in mind, AF&PA, acting on behalf of its member companies, has established a goal to recover 55% of all paper consumed in the United States by 2012. This ambitious goal can only be achieved if individuals, businesses, communities, and the paper industry continue their efforts to recover more high quality paper for recycling.

This is a giant step in the right direction, but people must continue to use paper wisely. Not only can people recycle paper, but they can buy 100% recycled paper, use both sides of a piece of paper before recycling it, and reduce the amount of paper they use. Making paper is just one way to become aware of our paper use as well as an excellent example of using a resource wisely.

Review the concepts covered throughout the class. Have the students review the process of making paper. How are paper products used? How often do students use paper in their daily lives?

## **VII. Additional Activities**

**A. Write a Poem.** Before making a piece of paper, take a piece of paper that is smaller than the deckles and write a short poem or story on it. Place the poem on top of the paper mush before covering it with a piece of felt. The paper you made will be a frame for your poem!

**B. Paper Art Exhibition.** Announce to the group that there will be a paper art show occurring in twenty minutes (or any other specified time). Each student should have an entry for the show; they may use a piece of paper that they have already made or make a new one. Have each student place their entry on a food tray and place the trays in a circle around the room. The students may want to label their work of paper art with a title, the type of work it is, or with a signature. When the show “opens,” allow the students to freely walk around and observe one another’s paper art.

## **VIII. Clean Up**

Have students assist with cleaning up the papermaking materials. Rinse the pitchers, blenders, and deckles. Dump out and rinse the dishpans. Pick up any paper scraps lying on the tables or floors and put them back in the scrap paper container. Wipe down the tables and sink area and put the tables and chairs back where they were found. Inventory all equipment and put it away in labeled bins and cabinets.

## IX. Appendix

### A. Equipment

- Lesson Plan
- Blenders (2)
- Pitchers (2)
- Container of used paper
- Tubs (2)
- Felt rectangles (20)
- Food trays (20)
- Serving trays (5)
- Deckles (5)
- Instruction blocks (6)
- Drying racks (2)
- “How paper came to America” poster
- Paper time line poster
- The Paper Book
- Paper Samples Book
- Paper Products and Bi-products sheet

### B. Glossary

**Deckle:** a square or rectangular wooden frame with a screen attached across one side that is used as a mold for papermaking

**Lignin:** a glue-like substance in trees that holds the wood fibers together

**Non-renewable:** cannot be restored or replaced

**Paper:** a pliable substance usually made of vegetable matter and used to write or print on

**Papyrus:** paper made from papyrus pith

**Pulp:** a soft, moist mass; a material (from wood or rags) used in making paper

**Renewable:** can be replaced or restored

**Resource:** something that can be used

**Sustainable:** able to keep going or hold up; endure

**C. Activity and Safety Management.** It is important to monitor the use of the blender with all groups. If students are using it improperly or are too young, have an adult do the blending of the paper.

### D. References/Resources

“Environmental Assistance Grant Program Fact Sheet.” May 1998. St. Paul: Minnesota Office of Environmental Assistance.

“How Paper Came to America” poster.

“Paper Making.” Wolf Ridge Lesson Plan. Finland, MN. 1992.

Paper University. <http://www.tappi.org/paperu>

Saving For Tomorrow curriculum. 1998. Eagle Bluff ELC.

American Forests & Paper Association. <http://www.afandpa.org>

## **E. Data Sheets**

1. Paper Making Instructions
2. Paper Products
3. By-Products

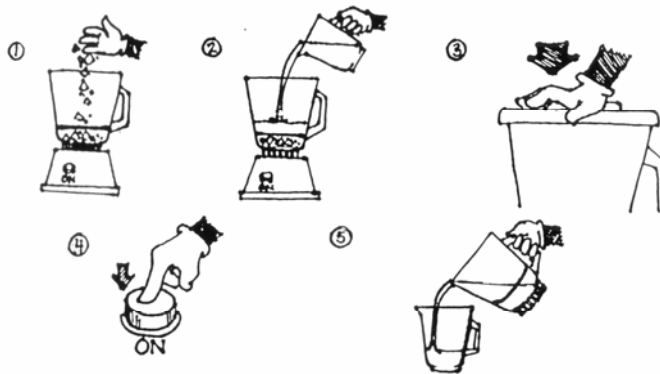
### Station # 1 TEARING PAPER

1. Grab a colored food tray and rip about 1-3 sheets of paper into  $\frac{1}{2}$ " pieces.
2. Put ripped paper onto food tray
3. You should have enough paper to fill the blender to the black line



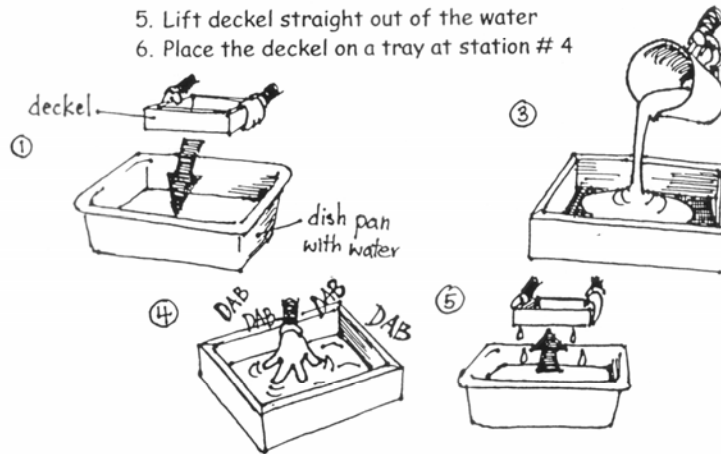
### Station #2 BLENDING

1. Fill blender with paper to the black line
2. Then, fill the blender with water to the red line
3. Put lid on tightly
4. Press "ON" button and blend for about one minute
5. Pour mixture into pitcher and take to station # 3



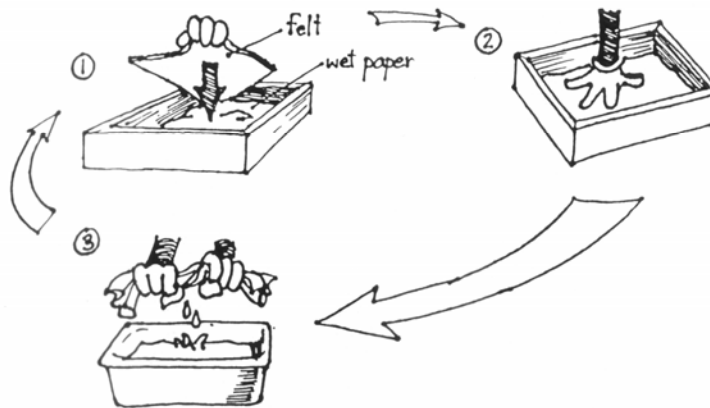
### Station #3 DECKELS

1. Place a deckel, screen side down, in one of the dish pans
2. Make sure the frame is above the water level
3. Pour paper and water mixture into the screen
4. Lightly dab mixture with finger to even the texture or shake the frame gently. If neither of these work, put mixture back into blender
5. Lift deckel straight out of the water
6. Place the deckel on a tray at station # 4



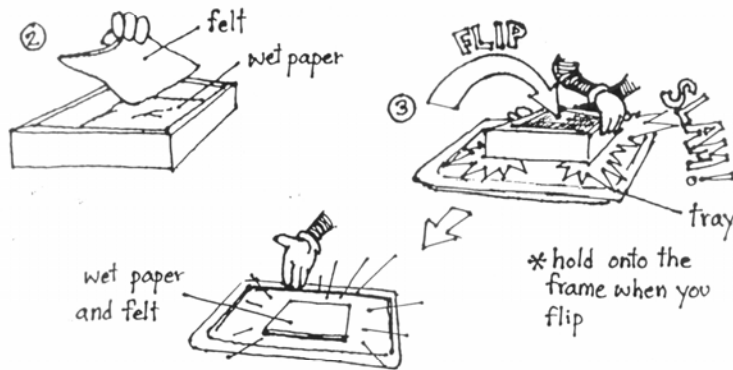
### Station # 4 FELT

1. Take a piece of felt and place it on your wet paper still in the deckel
2. Gently press felt with your finger tips
3. When the felt no longer soaks up water, carefully pull it off. Wring water out of felt over the extra pan
4. Then, using the same piece of felt, repeat the process. Do this at least 5 or 6 times



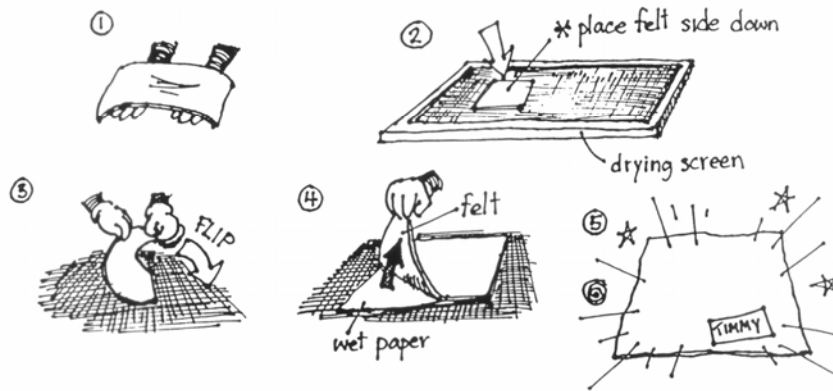
## Station #5 REMOVING FELT

1. Move your paper (still in deckel) to next set of trays.
2. Place a piece of felt on the paper
3. Grab the frame of the deckel and with one quick motion flip the frame over and slam it up-side-down on the tray. The paper should fall from the screen onto the tray with the felt underneath it.
4. Take the Deckel back to station 3 so others can use it.



## Station # 6 DRYING RACK

1. Carefully grab the felt/paper combo - making sure to support it underneath.
2. Place the felt/paper combo on the drying screen so the felt is touching the screen.
3. Grab to corners of the felt and flip. The paper should now be touching the drying screen with the felt on top.
4. Peel the felt off slowly.
5. Write your name on a piece of paper and place it on the corner of your newly recycled paper.



# Paper Products

Adapted from "Paper: It's a Piece of Our Lives." [www.tappi.org/paperu](http://www.tappi.org/paperu)

Accordions	Envelopes	Party hats and favors
Animal bedding	Facial and toilet tissue	Photographs
Baking cups	Fiber board	Pizza boxes
Bandages	Flame-resistant paper	Place mats
Bank checks	Flashlight batteries	Playing cards
Banners	Flooring	Pollen and dust masks
Bibs	Gauze	Popcorn bags
Board games	Greeting cards	Postage stamps
Books	Grocery bags	Poster board
Book marks	Gum wrappers	Prescription paper
Bottle labels	Gypsum board	Purifying filters
Braille paper	Hospital gowns	Report cards
Bumper stickers	Index cards	Ribbons and bows
Business cards	Insulation	Roadside flares
Butcher paper	Jigsaw puzzles	Roofing paper
Calendars	Kites	Sandpaper
Can labels	Laminates	Seedling planting pots
Candy wrappers	Lamp shades	Shipping containers
Car insulation	Library cards	Shoe boxes
Car gaskets and filters	Luggage	Stationary
Cash register receipts	Magazines	Stickers
Catalogues	Mailing tubes	Streamers
CD and tape inserts	Maps and globes	Surgical dressings
Cereal boxes	Masking tape	Sutures
Coasters	Medical charts	Table cloths
Coffee filters	Menus	Tags and labels
Coffins	Microwave food containers	Tar paper
Coloring books	Milk cartons	Tea bags
Computer paper	Carry-out food containers	Telephone directories
Confetti	Napkins	Tickets
Construction paper	Newspapers	Tracing paper
Counter-top laminates	Notebooks	Trading cards
Coupons	Notebook paper	Vacuum cleaner bags
Coveralls	Paper airplanes	Video cassette packaging
Crayon wrappers	Paper bags	Wall paper
Disposable diapers	Paper dolls	Window shades
Doilies	Paper flowers	Wrapping paper
Doll houses	Paper money	
Drinking straws	Paper plates and cups	
Egg cartons	Paper towels	
Election ballots	Papier-mache	
Emery boards		

# Products Made from the By-Products of the Paper Making Process

Adapted from "Paper: It's a Piece of Our Lives." [www.tappi.org/paperu](http://www.tappi.org/paperu)

Carpeting and upholstery backsideing  
Car wax  
Caulk  
Cellophane  
Cellulose sponges  
Chewing gum  
Combs and brush handles  
Concrete mix  
Crayons  
Eyeglass frames  
Fabric softener  
Food thickeners  
Furniture polish  
Hair spray  
Helmets (football, bicycle, and other sport helmets)  
Imitation leather  
Ink  
Lipstick and other cosmetics  
Liquid soap  
Paint and varnish  
Pine oil and other household cleaners  
Piping for irrigation systems  
Putty  
Rayon clothing  
Roofing shingles  
Rust preventative  
Sausage casing  
Shampoo thickeners  
Shaving cream  
Shoe polish  
Spray paint  
Suntan lotion  
Tool handles  
Tooth paste  
Turpentine