ART TO ZOO
APRIL/MAY 1978
NEWS FOR SCHOOLS FROM
THE SMITHSONIAN INSTITUTION
Office of Elementary and Secondary Education
Washington, D.C. 20560

Lift and Drag: Principles of Flight and the Soaring Imagination

Flights of fancy . . . dreams of flight: in the Smithsonian's National Air and Space Museum, the sky's the limit! Here young visitors can let their imaginations soar midst an unparalleled collection of airplanes, spacecraft, and other flying devices—and in the process gain a solid grounding in the principles of flight.

Flight may well be mankind's oldest dream, as for tens of thousands of years human beings struggled to achieve flight. The age of powered flight did not really begin, however, until 1903 when the Wright Brothers succeeded in flying a heavier-than-air-craft at Kitty Hawk, North Carolina. In the amazingly brief span since, this age-old dream of flight has taken us to the moon—and had an enormous influence on life here on earth.

Two important developments leading up to powered flight were the manned balloon and the manned glider of the 18th and 19th centuries, and it is on these two developments that this article focuses. The following suggestions *to help you introduce your students to basic principles of flight through a classroom study of balloons and gliders* are based primarily on materials by BONNIE SCHWARTZ, who teaches a special course on "Flight" for the Smithsonian Resident Young Associates Program.

Flights of Fancy

A good way to begin your study of balloons and gliders—or any unit on flight for that matter—is to have your students construct (from paper and scrap materials) devices that *they think* will fly. Provide the children with a wide variety of materials to choose from—feathers, balsa wood, cardboard, styrofoam, balloons, construction paper, popsicle sticks, plus whatever else you can think of to fire their imaginations.

And as a means of further inspiration, you might remind them that 400 years ago a famous artist and inventor had *his* flights of fancy too. The notebooks of Leonardo da Vinci are filled with ideas for flying machines, helicopters, and parachutes. And long before Leonardo's day, myths grew out of man's dreams of flight. One of the oldest of these stories is the Greek myth of Daedalus and his son, Icarus. Daedalus made wings for his son and himself by attaching feathers to their arms with wax, but Icarus flew too close to the sun: the wax melted, and Icarus fell into the Aegean Sea and drowned. Another famous Greek myth tells the story of Bellerophon and his winged horse, Pegasus; and Arabian myths are full of flying carpets and genies that can fly. Use your imagination to encourage your students to use their imaginations—to soar and glide and understand *and do!*

Air Show

When your students have finished constructing their models, have them stage an air show. This will give each child a chance to demonstrate what his or her model can do. Have students carefully observe the behavior of all the various entries in the air show and make sketches of the most successful designs. Because many children assume that regardless of shape, a model will fly if feathers or balloons are attached to it—or that virtually anything made of two crossed sticks will fly, regardless of wing design—the air show may reveal an abundance of surprises. When the demonstrations are over, see if students can reach any tentative conclusions as to why certain of the models did indeed fly whereas others did not.

Balloons

The Principle of Aerostatics

Hydrogen, helium, heated air, or any other gas less dense (and therefore lighter than) the ambient air will rise until the gas's density matches that of the surrounding atmosphere. When a large, lightweight container *like a balloon* is filled with such a gas, a buoyant vehicle is created that can rise and lift passengers and other payloads. This is the principle of aerostatics, which governs balloons behavior. To help explain this principle in your classroom, you can place in boiling water an empty soda bottle with a balloon stretched over its neck. As the air inside the bottle is heated by the water, the air will rise and inflate the balloon.

Balloon Facts

In the history of aeronautics, the period from June 1783 to June 1784 is known as the "Miraculous Year." It was during this time that mankind began the aeronautical age, which progressed from a few unmanned trial flights to sophisticated balloon flights and systems only a year later.

Man's very first flight took place on 21 November 1783 in a *hot-air balloon* designed by the French brothers, Joseph and Etienne Montgolfier (*see figure 1*) and for more than 100 years thereafter, flight was possible only in balloons and airships.

Heated air was pumped into the bottom of the Montgolfier balloon (which was made of linen backed with varnished paper) through a pipe connected to an open fire on the ground. Because there was no safe way to maintain the

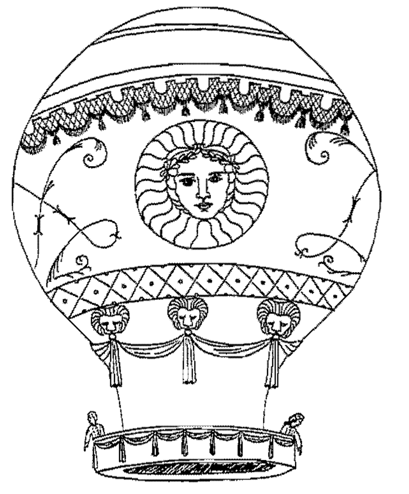

Figure 1. The Montgolfier balloon: drawing by Jean Estabrook, from the National Air and Space Museum scale model of the balloon.

Figure 2. In the Smithsonian's National Air and Space Museum, students trace the route of the Montgolfier brothers' landmark flight over Paris in 1783.

heat of the air inside the balloon after launch, the length of time that any early hot-air balloon like the Montgolfier could stay aloft was strictly limited. The Montgolfier flight lasted twenty-five minutes and covered approximately five and a half miles over the city of Paris, from the Bois de Boulogne to Butte-aux-Cailles (*see figure 2*).

Much longer hot-air balloon flights have been made possible since the early 1950s by the development of lightweight, fire-resistant fabrics and propane or butane burners. There are now around the world hundreds of hot-air balloons, used mostly for sport, and groups like the Balloon Federation of America have been formed to encourage ballooning for fun.

Early *gas balloons* were inflated with hydrogen made in large wooden containers, such as barrels, by dribbling sulphuric acid over iron filings. The impure hydrogen, under some pressure, was then piped directly into the balloon. The world's first manned gas balloon, the Charlière, was launched from Paris on 1 December 1783 on a twenty-seven mile flight lasting two hours. The Charlière (*see figure 3*) was made of rubberized silk with an open bottom that allowed the hydrogen gas to vent as it expanded.

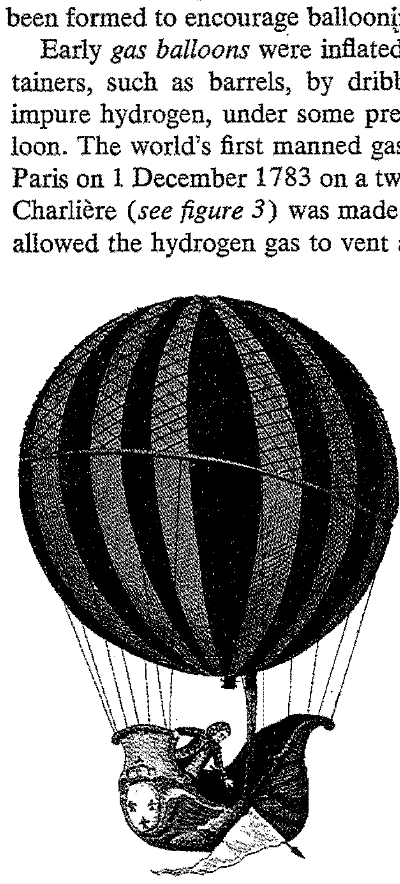

Figure 3. The Charlière balloon: artist's rendition by Margaret Brown, from the National Air and Space Museum's scale model of the balloon. Drawing used courtesy of Margaret Brown.

All modern gas balloons (used mostly in industry, scientific experiments, and weather forecasting) are filled with helium, which is much safer than hydrogen but extremely expensive. The helium is pumped into the balloon through a tube at the bottom. A valve at the top of the balloon allows adjustments to be made in the volume of helium during flight so that the balloon will not burst at high altitudes. A rip panel, also at the top of the balloon, can be opened by pulling a rip cord to enable the gas to escape rapidly when the time comes for the balloon to descend.

No sooner were balloons invented than aeronauts conceived and tried many schemes for adding *dirigibility* (the ability to steer and propel) to their balloons. But try as they might, balloons were then—and are still today—largely at the mercy of wind and air currents, although a balloon's altitude can be controlled by casting off ballast (weight) or by getting rid of air.

Balloon Activities

To demonstrate some of the problems of balloon navigation, you might have your students construct a model of an early gas balloon that would look

Continued on page two

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something like the National Air and Space Museum model of the Charlière (*see figure 4*). This may be done by attaching a small paper or cardboard basket to a toy helium balloon using string and tape as shown in *figure 5*. The children might then try raising and lowering the vehicle by casting off and adding on tiny bags of cornmeal or iron filings (the ballast). They might also try blowing on their model at different altitudes to see how the course of a balloon is affected by the wind.

Figure 4. In the Smithsonian's National Air and Space Museum, a student admires the scale model of the Charlière balloon.

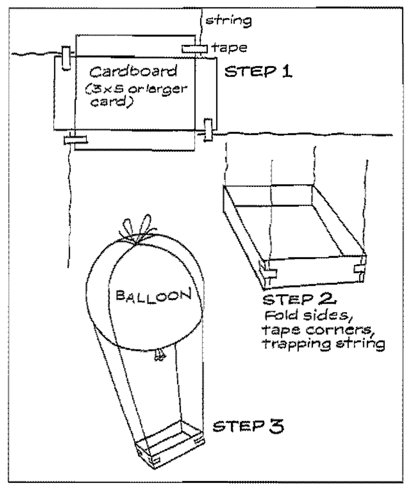

Figure 5. Instructions for making a model of an early gas balloon, using a cardboard box and a toy helium balloon.

Then the children might be ready to play at actually *becoming balloons themselves*. This pantomime game will require some sidecoaching on your part. The children start out pretending to be empty, limp balloons lying on the ground. Then suddenly through an imaginary hole in each child's right foot comes a rush of "helium." As this make-believe helium "moves" into the children's bodies rapidly, filling up their right legs and then their left legs and proceeding on upward, they feel themselves getting fatter and fatter and at the same time lighter. As the helium reaches their heads, they become so light they begin to float on air. Higher and higher they go into the atmosphere! Now along comes a wind from the left . . . and a wind from the right . . . and then another wind . . . and another . . . and another. Some of the winds encountered are giant gales; others are medium-sized gusts; others are gentle breezes. In between these winds, the children float peacefully in the air, bobbing . . . bobbing, until at last it is time to descend. When you touch their heads, their rip panels open and very quickly the air leaves their bodies. Now! (touch) . . . WOOSH . . . PHHT . . . No longer do they sway and bob. No longer do they float on air. Once again they are empty, limp balloons, lying on the ground.

Gliders

The men who built and flew hang gliders during the closing years of the 19th century laid the foundation for the first successful flying machines. German aeronautical pioneer Otto Lilienthal was the most influential of this group of early "test pilots" who sought to develop a stable glider as the first step toward powered flight.

The 1894 National Air and Space Museum glider (*see figure 6*) is considered the most successful of Lilienthal's designs. The wing and tail surfaces

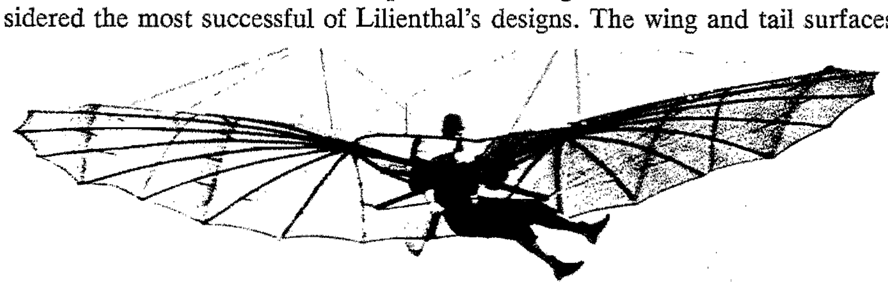

Figure 6. The 1894 Lilienthal glider. Photograph from the collection of the National Air and Space Museum, Washington, D.C.

are covered with cotton cloth, and a horizontal stabilizer is connected to the frame by a pivot at the front of the rudder. The wings are designed to fold for ease in transportation and storage. The pilot was suspended between the wings by bars that passed underneath his arms. By moving his legs and torso, he could alter the center of gravity location so as to maintain limited control. Lilienthal made glides of up to 350 meters (1150 feet) in gliders of this kind.

Lift and Drag

Two principles of flight basic to all gliders and airplanes are "lift" and "drag." The following explanation of these two principles is based on an interview with DR. RICHARD HALLION, Associate Curator of Science and Technology at the Smithsonian's National Air and Space Museum.

Lift is the force that acts on the wings of a glider or an airplane, causing the aircraft to rise into the air and stay there during flight. By studying a cross section of a typical airplane wing like the one shown in *figure 7*, your students should be able to see that the air flowing over the curved upper section of the wing must travel farther and therefore faster than the air passing under the flat, lower surface. This causes a pressure change which pulls the wing upward.

To see exactly how this principle works, *students might now try constructing an airfoil*. As suggested by National Air and Space Museum staff member NANCY MURPHY, this can be done by bending a 6″ x 1″ strip of paper around a pencil, fastening the end of the strip together with a piece of tape, and creasing the paper slightly where it touches the pencil (*see figure 8*). If you

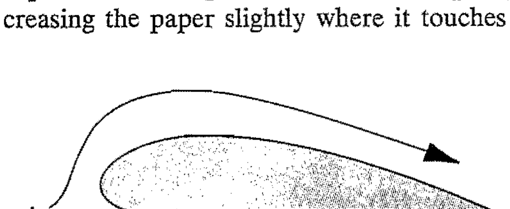

Figure 7. Cross section of a typical airplane wing.

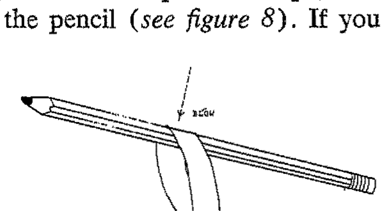

Figure 8. An airfoil, demonstrating LIFT.

then hold the pencil and blow directly down onto the bent part of the strip, the taped ends will rise, demonstrating that *lift* has been created by the difference in air pressure on the top and bottom surfaces of the airfoil.

Drag is the resistance of a solid body, like a glider or an airplane, to the air through which it moves. While airplanes and gliders are *streamlined* to reduce drag, they also have devices for deliberately creating drag when needed. For example, the "speed brakes" that slow down an airplane are in essence flat surfaces that can be extended to increase drag.

To learn more about the phenomenon of drag, the children might try playing "human airplane." By running across the schoolyard holding pieces of cardboard turned first against the wind on the flat side and then into the wind on edge, students will quickly get a feel for drag, the second important principle of flight. A third basic principle of flight is *thrust*, which in the case of an airplane is supplied by engine power.

The paper glider diagrammed in *figure 9* illustrates to some degree the first two basic principles of flight. The diagram is taken from the "Teacher's Guide" to *Flight: the Sky's the Limit*, a 1975 Smithsonian Institution television film by David Wolper and Associates. Either show the diagram to your students

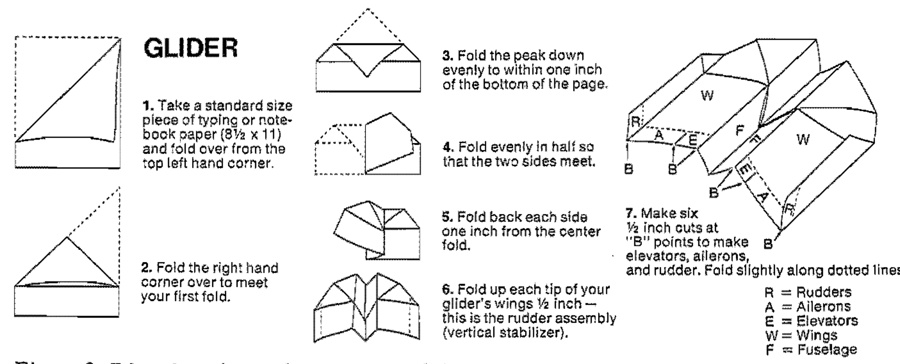

Figure 9. Directions for making a paper glider.

Figure 10. Students make paper gliders in a Smithsonian Resident Young Associates course on "Flight."

using an opaque projector, or duplicate it for classwide distribution. Then have the children carefully follow the accompanying *directions to make paper gliders* of their own. (For best results, a ruler should be used to measure the rudder, ailerons, and elevators of each glider before cutting and folding; *see figure 10.*)

In flying their gliders, students should know that the ability to remain stable and also to maneuver in flight is made possible by controlling the flow of air over the surface of a glider or an airplane. This is done by means of small moveable parts, which can be adjusted to alter the aircraft's movements. The gliders your students have built have ailerons and elevators on the wings, and a rudder on the vertical part of the tail. By moving the elevators up slightly, a student can make his glider climb; by moving the elevators up further he can make his glider fly in a loop. If he moves the elevators down, he can make his glider go into a nose dive.

With the elevators set slightly up, a student can move the right aileron slightly down and the left one slightly up, and the glider will roll to the left. By then moving the rudder to the left, a left turn can be executed. To turn the glider right, he can simply reverse this process. By experimenting with other small movements of these control surfaces, many other maneuvers can be accomplished. After some practice, the children should become expert at predicting—*prior to launch*—the paths that their models will take.

More Flight Activities

There are many other flight activities that children enjoy. Have them build and fly a kite. Make a cloth or paper parachute. Construct a cardboard boomerang.* Reenact import events in the history of flight. Visit a nearby airport to watch planes take off and land. Or invite someone from your local chapter of the Balloon Federation of America or the United States Hang Gliding Association (listed in your phone directory) to come to your classroom and share his or her true-life adventures in flying for fun.

Flights of fancy . . . dreams of flight. Only the sky's the limit when through active investigation with *real* materials, your students let their imaginations soar ↗ to gain a solid grounding in the principles of flight!

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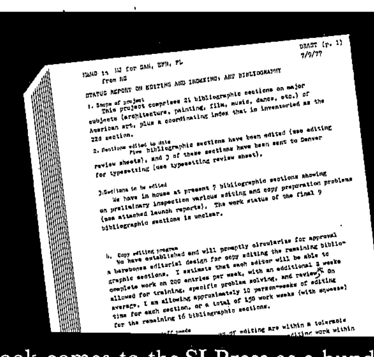
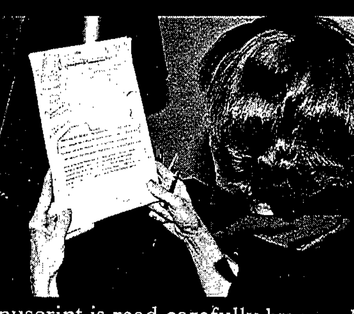
*To obtain your free set of instructions for making and launching a cardboard boomerang, write to Ann Bay, Office of Elementary and Secondary Education, A&I 1163, Smithsonian Institution, Washington, D.C., 20560.

A Book in the Making: Find Out Whoooo's Involved on a Bird's-Eye Tour of the SI Press

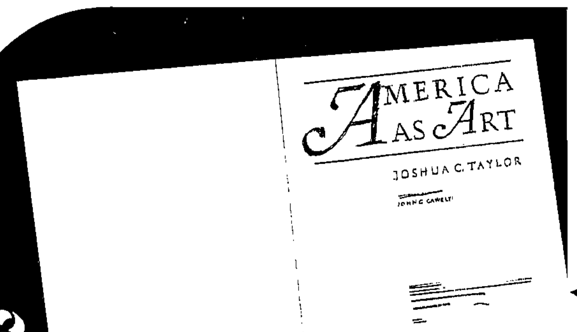
TEACHER'S NOTE: Dr. Edward S. Ayensu, interviewed on *page 4* of this issue of *Art to Zoo*, is just one of the many Smithsonian scholars whose books are published by the Smithsonian Institution (SI) Press. At the SI Press, manuscripts by Smithsonian scholars and other writers are made into books that achieve world-wide circulation. This photo essay showing the SI Press at work is designed to give your students a glimpse of the *basic steps involved in book production*, not only here at the SI Press but in other publishing houses too. The learned owl, who serves to guide our bird's-eye tour, is the official trademark of the SI Press.



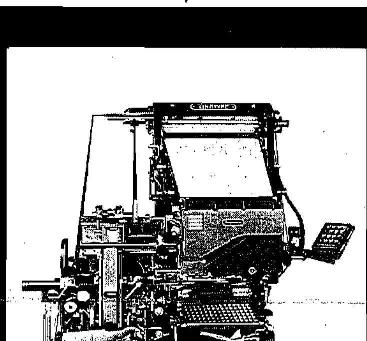
1 A book comes to the SI Press as a bundle of neatly typewritten pages. Often this *manuscript*, as the bundle is called, has taken the author many years to research and write.



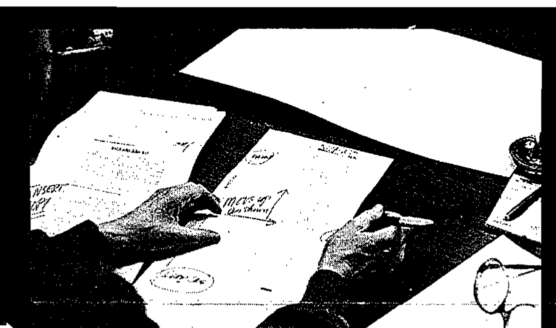
2 First the manuscript is read carefully by an *editor*, who looks with an experienced eye for ways that the copy might be improved. *(Photo credit: Jan Hahn.)* A word changed here, a paragraph changed there, a sentence made longer or shorter, can make a big difference in the over-all impression a book leaves on its reader. After any such corrections have been made . . .



3 . . . the manuscript is turned over to a *designer*, who chooses the style and size of lettering (or *type*) to be used in printing the manuscript and draws up a plan (or *dummy*) to show how each page of the book will look when printed.



4 Now the manuscript is sent to a *compositor*, where each word is *typeset*. Most books published by the SI Press are set in *hot* (or metal) type on big, noisy *linotype* machines like this one.



5 The typeset copy comes back to the editors at the SI Press on long, narrow sheets of paper called *galley proofs*. *(Photo credit: Jan Hahn.)* After the proofs have been checked for such errors in typesetting as upside down letters or misspelled words, and these mistakes have been marked for corrections, the proofs, along with any *illustrations* (drawings and photographs), are turned over to the designer . . .

6 . . . who prepares the *mechanicals* by pasting down sheets or columns of type and illustration-proof in final position onto heavy boards. *(Photo credit: Jan Hahn.)* Here careful measuring and precision are essential, since the mechanicals are what the printer photographs to make *negatives* and *plates* for printing the finished pages of the book.

7 The next step is *printing*. The pages of our book come rolling off the *printing presses* at the rate of up to 167 sheets a minute. *(Photo credit: Miller Western Corporation.)*

8 Then it's on to the *bindery*, where the sheets are folded into pages, sewn, and glued together, and each book is given its cover. *(Photo reprinted* from *Publishers Weekly* [Oct. 7, 1968]; published by R. R. Bowker, a Xerox company; copyright 1968 by Xerox Corp.)

9 On this the final stop of our bird's-eye tour, EDWARD F. RIVINUS, Director of the SI Press, holds up a sample copy of a 320-page, illustrated book entitled *America as Art* written by JOSHUA C. TAYLOR, Director of the Smithsonian's National Collection of Fine Arts. Here at last is our finished product!

Make Your Own Book

Now that you know wh*oooo* and what's involved in bookmaking, maybe you would like to make a book of your own. The words can be typed or neatly hand-printed; the illustrations can be ones you've drawn or photographed; the subject can be virtually anything at all that interests you. . . . And the following drawings by Stephen Kraft, Managing Designer of the SI Press, show how you can, quite easily, put it all together.

See page 4 for instructions on how to make your own book.

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TEACHER'S NOTE. This article, based on an interview with DR. EDWARD S. AYENSU, Director of the Endangered Species Program in the Smithsonian's National Museum of Natural History, has been written to be read *by your students*. It is the last in a series of interviews to be printed in *Art to Zoo* this school year. Through these interviews, we have hoped to give students some insight into what we do here at the Smithsonian—and why—in a format that can be worked into your curriculum in a variety of ways.

HELP!...for Plants in Trouble: Not Just Dying...but Dying Out

Edward S. Ayensu is a man who has (if you'll pardon the expression) a very thorny problem. And that problem, urgently stated, is this: How to make people realize—before it's too late—that *plants are in trouble*.

Many plants in the United States today are in critical danger of dying out forever, or *becoming extinct*. As a plant scientist for the Smithsonian's National Museum of Natural History, Dr. Ayensu is campaigning to save these endangered plants from extinction. But until people begin to realize that plants are in serious trouble, his chances are slim for saving endangered plants.

The first step is to make people see that plants are *important*. "Indeed, there is *no* plant that is *un*important," Dr. Ayensu told us in a recent interview. "Beautiful or obviously useful plants like roses or fruit trees are appreciated by almost everyone, but few people realize that *everyday plants* like grasses and dandelions count every bit as much within the 'web of life.' "

Maybe you already know about the "web of life." This is a term that helps to explain how all living things depend on one another for survival. Within the "web of life," plants are the *producers* of food, and animals (including people) are the *consumers*. When certain plants die out, the animals that eat those plants often die out too. Human beings depend very heavily on many different kinds of plants for all of life's basics, including food, clothing, shelter, medicine, and fuel.

How does a particular kind (or *species*) of plant become extinct? Throughout the course of the evolution of life on earth, some plants have disappeared, while others have managed to live on. Plants wiped out by the rising and sinking of the earth's crust, by flooding, and by changes in climate have been slowly replaced by *other* species suited to living under new conditions. When man came on the scene, this natural process was greatly speeded up by the effects of hunting, farming, and industry. Now there is no time for the plants destroyed by man's activities (like flooding an area to build a dam, or polluting the air with smoke from a factory) to be replaced by new species. This means that the number of kinds of plants in the world today is becoming smaller . . . and smaller . . . and smaller . . . at a very scary rate!

What can be done to save our plants in trouble? Most important is to keep the places where they live—like marshes and woodlands—from being destroyed. It is also important to let the public know how much damage can be done by transplanting rare plants and picking the flowers of these species. Sometimes people who make a living by buying and selling plants will come into an area and remove a rare species of plant by the truckload. This certainly must be stopped.

A book listing more than 1,000 plants in trouble throughout the United States has just been published by the Smithsonian Institution.* The idea of this book is to let people know exactly which plants are in trouble in various places so that campaigns can be begun *close to home* to save these species from extinction. And it is here, says Dr. Ayensu, that **you can help!**

"I strongly believe that the children of this country can play an extremely important part in this whole compaign," he says. "They can form an important corps for educating not only one another but also their teachers and their parents." He suggests creating posters to hang in public places so as to make people aware of the beauty, variety, and importance of the plants we see every day but often fail to appreciate. Posters can show what are the endangered plants in your area and remind people not to disturb those species. And for help in *saving plants in trouble*, have your mayor or other local official write to Office of Endangered Species, U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., 20240. PLANTS IN TROUBLE—a thorny problem that CAN be solved before it's too late, **if you help!**

*TEACHER'S NOTE: To obtain a copy of this 403-page illustrated book, *Endangered and Threatened Plants of the United States*, by Edward S. Ayensu and Robert A. DeFilipps, send a check or money order for $17.50 to the Smithsonian Institution Press, P.O. Box 1641, Washington, D.C., 20013.

ART TO ZOO

ART TO ZOO is a new publication, bringing news from the Smithsonian Institution to teachers of grades three through six. The purpose is to help you use museums, parks, libraries, zoos, and many other resources within your community to open up learning opportunities for your students.

Our reason for launching a publication dedicated *to promoting the use of community resources among students and teachers nationally* stems from a fundamental belief, shared by all of us here at the Smithsonian, in the power of objects. Working as we do with a vast collection of national treasures that literally contains the spectrum from "art" to "zoo," we believe that objects (be they works of art, natural history specimens, historical artifacts, or live animals) have a tremendous power to educate. We maintain that it is equally important for students to learn to use objects as research tools as it is for them to learn to use words and numbers—and you can find these objects close at hand, by drawing on the resources of your own community.

Our idea, then, in producing ART TO ZOO is to share with you — and you with us — methods of working with students and objects that Smithsonian education staff members have found successful. This is the fourth of four pilot issues published in October, December, February/March, and April of this school year.

You are one of approximately 30,000 teachers across the United States chosen to receive and respond critically to these four issues. With this issue, an evaluation form has been sent to you. To make it easier for you to know who we are, we have listed—here in the masthead—the Smithsonian museums and divisions whose education staff members contribute material regularly. Please read the articles carefully and be absolutely frank in stating your opinions. We're counting on your help.

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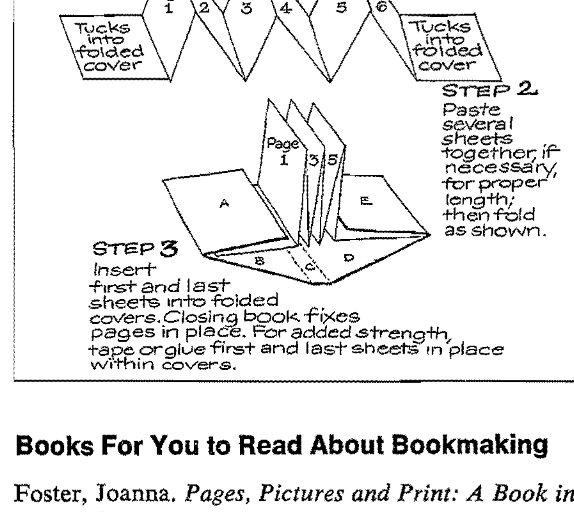

Books For You to Read About Bookmaking

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