ART TO ZOO

News for Schools from the Smithsonian Institution, Office of Elementary and Secondary Education, Washington, D.C. 20560

October 1990

Turn About's Fair Play!
Mirrors and How They Reflect

Courtesy Barbara Gloriod

Which is the real William Jenkins, in this multiple-reflection photograph made at Coney Island in the early 1900s?

Have you ever caught sight of yourself as you passed a mirror and thought, "so that's how others see me"? Or printed in mirror writing? Or wondered why the reflection of your room seemed like a room in a dream: full of everyday objects and yet somehow *foreign*?

Mirrors present an odd combination of the familiar and the strange. They feel magical, but they have a lot to tell about the real physical world—about light, for example, and about symmetry—which is why they are the topic of this ART TO ZOO.

This issue is organized differently from usual. It is set in the framework of a short fantasy-adventure given on the Pull-Out Page, which tells how the class gets caught inside a magic mirror and will remain prisoners there unless they can carry out Nine Challenges.

The Teacher's Section (these outside pages 1 through 4) suggests activities you can use to prepare your students to carry out these Challenges . . . and to begin to understand some of the principles involved in them.

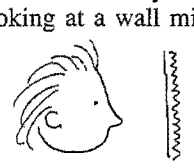
At intervals throughout the Teacher's Section, you will come across this symbol:

It indicates that now is a good time to do the Pull-Out Page Challenge whose number is given. The "Notes on the Challenges" on page 4 give the information you will need.

General Comments

Throughout this ART TO ZOO, by *mirror* we will mean *flat mirror*, and by *symmetry* we will mean *bilateral (two-sided) symmetry*. Curved mirrors and other types of symmetry are fascinating topics that interested children may want to explore as follow-ups; but we will not be discussing them here.

The symbol for mirror in the diagrams in this issue is . The straight line denotes the surface of the mirror, so you can tell which way it is facing. For example, a person looking at a wall mirror is represented like this:



Be sure to try out the activities that involve experimentation ahead of time, on your own.

Also, a warning: Most mirrors are made of glass. They can break and cut. The children are likely to treat them more roughly than you would. You will have to be the judge of how careful you think your particular students will be. Unbreakable mirrors are available (see Sources for Mirrors on page 4). But be sure to warn the children repeatedly that their mirrors at home are probably glass. They should check with their parents before experimenting with them.

To begin . . .

Before your students arrive on the day you want to begin this activity, set up a wall mirror facing the class. Do not explain why it is there. Instead, have the children read the Pull-Out Page story, "Trapped in the Mirror!" Then tell them: Don't try yet to understand what the Challenges mean, and don't do the Pull-Out Page picture activity. . . . First we have to do some thinking about mirrors and reflections, then I'll explain more about what the Challenges involve.

Part I: How Mirrors Bend Light

Bouncing Balls and Bending Light Beams

Throwing a ball against a wall can help you understand how reflections work. Draw an X on the chalkboard, *at your students' shoulder height*: this is the target.

Ask: Where do you stand if you want to bounce a ball against this target and have the ball come back to you, so you can catch it yourself? (You stand directly in front of the target. Have a child come to the front of the class and demonstrate this.)

What happens if you stand off to the side, closer to the wall, and throw the ball against the target at an angle? (Have the children predict, and then ask one child to demonstrate. After it hits the wall, the ball bounces off to the opposite side.)

Now you are going to "throw" a beam of light against a mirror. Does it act the way the ball does?

The children work in pairs. First they lay a sheet of dark paper on a table. Child A holds a mirror upright on the paper, while Child B shines a flashlight into the mirror, holding the light so it is lying more or less flat on the tabletop. What path does the beam of light take, before and after it hits the mirror?

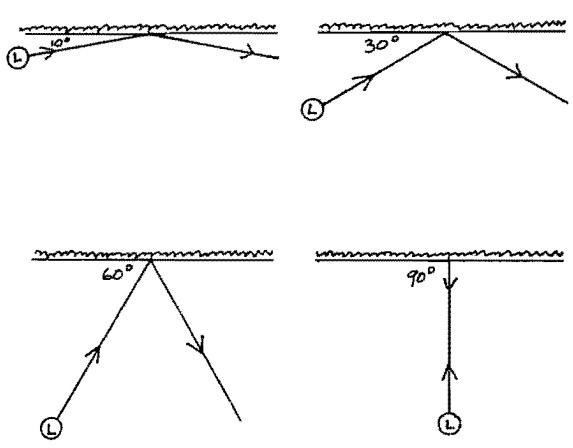
The children should make their observations *from above*, looking directly down at the *edge* of the mirror and at the ingoing and outgoing beams. This viewpoint is important, because it allows the kids to see the path of the beams without being distracted by reflections in the mirror (which would make the situation too complicated and confusing).

Continued on page 2

Continued from page 1

First give the kids a chance to experiment freely with the beam, shining the flashlight so it hits the mirror at different angles and noticing how this affects the path of the outgoing beam. Then have them be more systematic, shining the flashlight so its beam hits the mirror at four different angles—first, so the beam hits at 10°, then at 30°, then at 60°, and finally at 90°. (Simply *show* younger children how you want them to hold the light. Older children can measure out the exact angle at which to hold the flashlight.)

For each position, ask the students to draw the beam's incoming and outgoing path . . . by simply tracing the line of light they see on the paper. The beam they see will be wider than the line their pen makes; they should just draw their line along the middle of the beam. If the kids put down a new sheet of dark paper for each position, they should end up with a series of drawings that look something like this (L is the light source, their flashlight):



Have the class discuss what these diagrams show. Make sure the children notice that the light beams travel through the air in straight lines. Have them compare the direction of the light beam as it moves toward the mirror to the direction of the light beam as it moves away from the mirror. Younger children can simply notice that the angle between the mirror and the incoming light beam is about the same as the angle between the mirror and the outgoing light beam*; older children can actually measure the angles and compare these measurements.

How to make this activity work:

Creating a bright and narrow beam can sometimes be a little tricky, so it's particularly important to try out this activity on your own ahead of time.

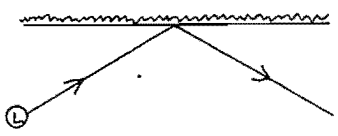
Two-battery penlights usually work the best. To narrow the beam, make a cone-shaped cover out of black construction paper—like a witch's hat with the tip cut off. Put the penlight inside the cone (so the narrow end of the cone is at the bulb end of the flashlight). Experiment with several flashlights and cone shapes to see which works best. You (and your students) will also need to fiddle with the exact position of the flashlight, to see how to create the sharpest, narrowest beam on the paper.

The darker the room, the better the beam of light will show up. A very dark space like a windowless storage closet is best, but on a gray day even a regular classroom with the shades down should be dark enough (check ahead of time).

From Light Beams to Reflected Things

Tell the class: Knowing which way a light beam goes after it hits a mirror will help you understand how reflections work . . . and you need to understand how reflections work to figure out Reflecto's Challenges (which you will be starting on soon).

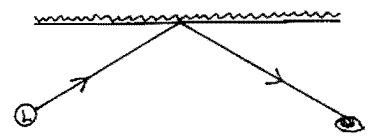
Let's look at one of your diagrams again. (Draw one on the board, like this:



Remind the class that the L stands for the flashlight that is producing the beam.)

Now let's put you—or more specifically, your eye—into the diagram. If you stood in the incoming beam, what could you see? (Draw an eye in the left-hand beam, the one that shows the light traveling from the flashlight to the mirror. If you stood here, you could see the part of the beam between the flashlight and your eye. But you could *not* see the *reflection* of this particular beam, because you would be blocking the beam so it never got to the mirror. (The kids can try this with their previous set-up, by putting a hand in the beam, between flashlight and mirror. Their hand will block the light so there is no outgoing beam. Their eye—and head—does the same thing.)

For you to see the *reflection* of this particular beam, light from the beam *after* it has struck the mirror must enter your eye—that is, your eye must be in the outgoing beam. (Draw in an eye.)



So far, we've been talking about single beams of light. But of course what you normally look at is not light beams, but things.

What are you actually seeing when you look at a thing? (Lots of light beams coming from that thing into your eyes . . . so it's no surprise that reflections of things act like reflections of single light beams.)

Look at our diagram again, and imagine that instead of a light beam, the L stands for a thing—a lemon, for instance. Where does one of your eyes have to be to see the reflection of this lemon? (In the outgoing beam, for the same reason that it had to be there to see the reflection of the light beam.)

Since many, many light rays bounce off a thing, you can stand in many places and still see the reflection of the lemon . . . But, *wherever you stand, if you can see the reflection of the lemon, then light rays must be coming from it to the mirror, and then out from the mirror into your eye, as in the diagram.* This is very important. It determines what part of your surroundings you will see when you look into a mirror.

Here are a couple of short activities the kids can do to play around with this.

With a Mirror on the End of Your Nose . . .

Have the children all hold a small mirror straight up and down, at the tip of their nose, with the mirror's reflecting side facing to the right. Check to make sure that everyone is doing this correctly.

Say: In a moment, move the far end of the mirror (as if it were on a hinge at the place where it touches your nose). But before you do, guess what part of the room you will see when you first begin to move the mirror. Remember the bouncing ball. Remember the light beam and the mirror. At what angle are you going to look into the mirror? What part of the room is at the same angle on the other side?

Have the kids bring the mirror around in 3 or 4 steps, predicting each time which part of the room will appear next, and then checking with an actual look into the mirror. In its final position the mirror will be lying against each child's right cheekbone and he will be looking into the reflection of his own eye.

Aim and Look

Number about 8 pieces of paper and put them around the classroom walls. The children will be using small mirrors to look at these numbers' reflections. Try this out yourself ahead of time, to make sure that all the numbers are within mirror range, and that they are far enough apart so your students will pick up only one at a time in their mirrors.

Tell the kids: Cover your mirror with your hand, and try to figure out how to hold the mirror so you can see the reflection of the first number. Then take your hand off, check what you see, and make any necessary adjustments in the mirror's position.

Repeat this procedure with each number in order. Your accuracy will improve with practice—but it's hard to aim *exactly* right!

Two-Mirror Reflections

How can you see yourself in profile, or look at the back of your head? (With two mirrors, of course. Use the second mirror to look at what is reflected in the first one. Have the kids experiment with this now.)

After they have had a chance to play around, tell them that they are now going to explore two-mirror reflections more systematically, and pass out copies of the worksheet on this page.

On this worksheet the children can record how an object's reflections in two mirrors change as the angle between the mirrors is changed. The mirror positions are shown in the left column. Make the worksheet large enough so the kids can set up their mirrors by simply standing them on the guidelines.

Show the children how they can use small pieces of clay to hold their mirrors upright: Roll the clay into a little blob, stick the mirror into it, and make necessary adjustments so the mirrors are straight. (Use unbreakable mirrors if possible. The children are likely to be rougher than necessary when they squish the mirrors into the clay. Warn them to be careful!)

It may be hard to align the mirrors perfectly along their common edge. Inexpensive mirrors are often not quite in square. If they are not in square they cannot be lined up without a gap. Lack of alignment will interfere the most at 90°: when the mirrors line up exactly, you get a perfect non-reversed image; but when they don't, the image is lopsided and may have a gap in the middle. Just tell the kids to do the best they can. They will see the essentials in any case.

The object to be reflected in the mirrors should be a small container that has lettering on it, like a bottle of correction fluid or of nail polish. The lettering is essential, as an indicator of reversals.

It would be too complicated to try to explain to the children exactly why these reflections look the way they do. But here are some general comments for you to make after the children have finished the worksheet:

- At 180° the two mirrors form the shape of a single longer mirror, so they reflect like one.
- As you begin to turn the mirrors toward each other, each mirror begins to *reflect the other's reflection*.
- That's what the center bottle at 90° is made of: two half reflections-of-reflections.

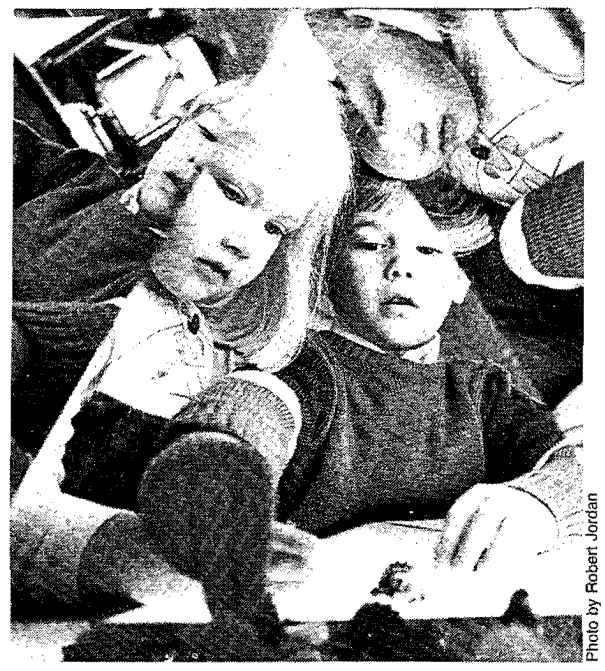
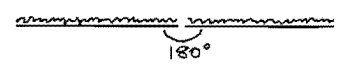
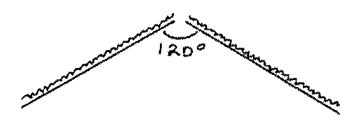
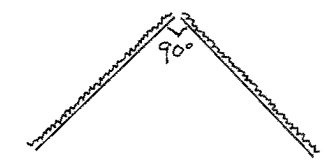
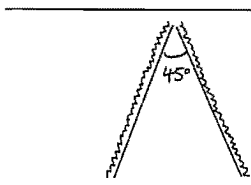
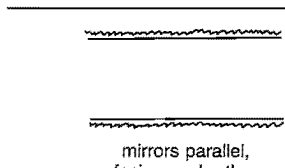


Photo by Robert Jordan

Children playing with a kaleidoscope that is part of the Smithsonian Institution Traveling Exhibition Service show, "Kaleidoscopes: Reflections of Science and Art." Your own students may want to experiment with kaleidoscopes of their own.

WORKSHEET ON TWO-

Angle between mirrors	How many reflected bottles do you see? (May vary depending on where you set bottle. If so, explain in Comments column.)
	
	
	
	
 mirrors parallel, facing each other	

*This is similar to what you learned in school as *angle of incidence = angle of reflection*. (It is not exactly the same, because these terms referred to the angles between light beams and a line perpendicular to the mirror, an approach that is unnecessarily complicated for our purposes.)

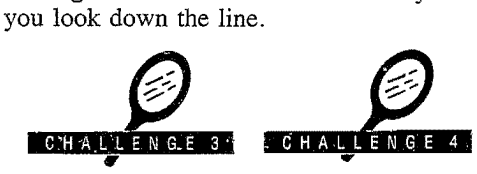
There is no need to use such technical terms with young students. In fact, doing so distracts the children from the reality of what they are seeing—whereas *the underlying purpose of these activities is to increase the children's confidence in their ability to understand things for themselves, on the basis of their own observations.*

MIRROR REFLECTIONS

Is writing on bottles reversed?	Comments

- The lettering gives a clue to what's going on. As you know, lettering looks backwards in a mirror (have the kids check this now) . . . so every time the reflected lettering looks normal, you are seeing the reflection of a reflection . . . or, more generally, you are seeing lettering that has been reflected *an even number of times*. (When it is reflected once, it looks reversed. Reflect that reversed reflection, and the second reflection looks normal again. But if you reflect that second reflection, it will be reversed again. And so on. . . .)
- This is what's happening many, many times when the mirrors are facing each other. See how every other reflection in the line is backwards?
- Notice also in this line how the reflections get dimmer. This is because, though a mirror *reflects* most of the light that strikes it, the mirror also *absorbs* a little of the light.

  So far we have paid no attention to this bit of light that is absorbed, because when there is only one reflection, the difference in brightness that it causes is too slight to notice. But in a series of reflections-of-reflections like the one created by two mirrors facing each other, these small differences add up, making the reflections become visibly dimmer as you look down the line.



Part II: How Mirrors Make Things Look Reversed

Part II is about mirror reversals and symmetry. Its approach is more intuitive than that used in Part I.

It's quite easy to understand how a mirror bends light, so the Part I activities did a lot of *explaining*.

Explanations about what mirrors seem to reverse, however, are notoriously confusing . . . so Part II does as little explaining as possible. Its activities aim rather at helping your students develop a feeling in their own bodies of what is reversed and of what symmetry means. The reliability of this bodily feeling is constantly tested against the reality of what an actual mirror shows.

Introduce this part by saying: One of the things you were noticing in the activity with the two mirrors was how writing looks backwards in a mirror.

Is it just writing that mirrors reverse? (Of course not. Mirrors treat everything the same way. Writing just makes reversals particularly noticeable.)

To make sure that all the children realize this, have them check how their own reflections are reversed. Divide the class into pairs of children. The first child in each pair holds up her right hand. Her reflection, of course, holds up a hand on the same side.

But is this the reflection's *right* hand? To find out, have the second child in each pair stand next to the mirror, facing the same way as it is, and imitate the reflection. Then, with hand still raised, have this second child turn and face the same way the first child is facing. It will now be obvious that they do not have the same hand raised.

The next activity gives the children a chance to explore this more fully.

Human Mirrors

Have the kids work in threes. The first child is the Real Person, the second the Reflection, and the third the Observer.

The Real Person moves around freely, but not fast, in front of a chalk line on the floor. This line represents a mirror facing the Real Person. The Reflection faces her on the other side of the line and at the same distance from it, and reflects back her motions the way a real mirror would. The Observer monitors whether the reflections are the same as a real mirror would produce, and corrects the Reflection's movements if he thinks they are wrong. When in doubt, he freezes the action and checks in a real mirror.

Give the children plenty of time to experiment freely. (They will subsequently be drawing on their memories of this activity.) You too will want to monitor their movements. You are likely to need to ask the Real People to slow down, so the Reflections have time to think and follow.

After a while, have the children switch roles, so everyone eventually has a chance to play each part.

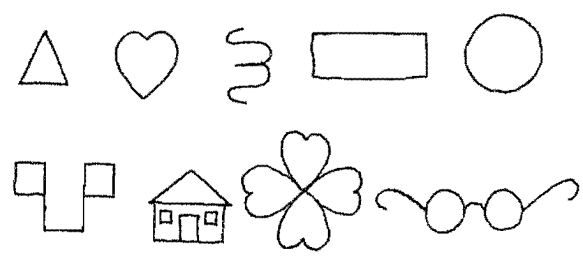
Then ask the children to discuss how they moved as Reflections. With your guidance, they should gradually focus in on the essentials:

- As your partner moves toward the mirror, so do you.
- As *part* of your partner moves toward the mirror, so does the same part of you. . . .
- That part of you is on the same side (visually) as your partner's part. For example, if your partner stretches her *left* hand toward the mirror, you stretch your hand on the same side toward it. (This will be your *right* hand, as you saw earlier.)
- If your partner's movement is *away from* the mirror, so is yours. But sideways movements are still—are always—on the same visual side.

Mirror Symmetry

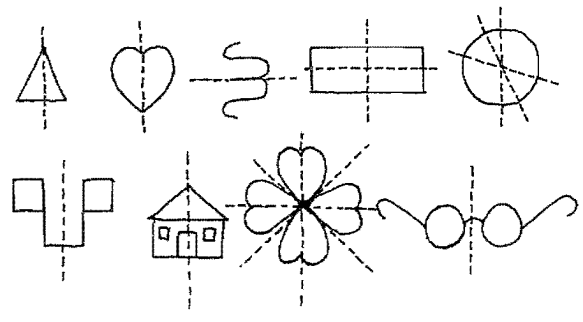
Now it's time for the children to learn what symmetry is. They will put the concept of symmetry to use in countless contexts in the future: when they wrap packages, do geometry problems, recognize patterns, build furniture, study DNA. . . . More immediately, they will use it at the end of this section, when they work on mirror writing.

Say: Fold a paper once, and make a paperdoll by cutting out half a person and then opening up the paper. Stand a mirror upright along the fold line: the half doll plus its reflection looks just like the real whole doll. This kind of shape, whose two halves are mirror images of each other, is called *symmetrical*. Here are some other symmetrical shapes (draw them on the board):



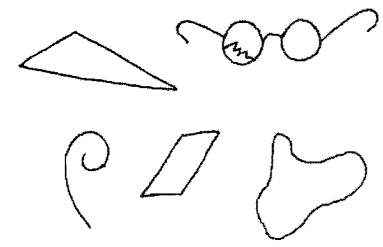
The fold of your doll is called the *line of symmetry*. If a drawing is symmetrical, you can recreate the whole shape by standing a mirror along its line of symmetry, the way you did with the paper doll.

Where is the line of symmetry of the shapes on the chalkboard? Have kids come up and draw them, as dotted lines:



They will see that some shapes have more than one line of symmetry. The rectangle, for example, has two. The four-leaf clover has four. And the circle has an infinite number (all the lines that pass through its center).

Then draw on the board some examples of shapes that are *not* symmetrical:



Discuss how these are different from the symmetrical shapes. Have the children draw these shapes that are not symmetrical, and experiment with a mirror to make sure they really have no line of symmetry.

Are *You* Symmetrical?

Three-dimensional things too can be symmetrical. You yourself are a good example.

The outside of your body is, overall, symmetrical. What parts, for example? (Your hands, feet, elbows, ears, and eyes, for example, occur in symmetrical pairs; while your nose, mouth, and chin are symmetrical around their midline.)

Is this symmetry perfect—is every detail exactly symmetrical, the way every detail is in a mirror image?

Examine, for example, your two hands. They are like mirror images in overall shape, but the details are different. Compare the marks on your skin, your freckles, scars, the shape of your nails. Are your two hands exactly the same size? Are your fingerprints on both sides identical?

What about your insides? Are they symmetrical too? Some parts are, like your kidneys. But many, like your heart and liver, are not. (If you wish, have the children look at anatomical diagrams of their insides and comment on where they see symmetry and where they do not.)

Of course, you can't use a mirror to check whether a three-dimensional object is symmetrical—the mirror would have to cut through the thing . . . so our own experiments are mostly with drawings and writing.

Finally, as homework, have the kids do "Questionable Reflections" on the Pull-Out Page.

Mirror Writing

Begin by giving each child a copy of the alphabet that you have prepared in advance. It should be written in block letters like these, only bigger:

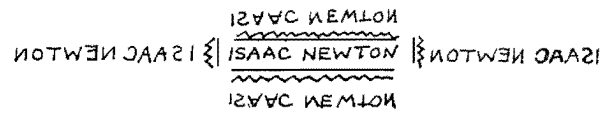
A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

It's best to use letters like these because they are as simple and symmetrical as possible. Make them as regular as you can. For example, the O should be circular, not oval; and both loops of the B should be the same size. The children should use this kind of printing whenever they play with mirror-writing. They can use the letters on the sheet as models.

Isaac Newton and You

Print **ISAAC NEWTON** on the board and ask the children to do the same in the middle of a piece of paper. Say: hold this paper up to your mirror and examine the letters. Do they look different from usual? Do *all* the letters look different from usual? Does where you hold the mirror affect which letters look unusual?

Have the children stand the mirror upright in 4 positions around the name and draw the 4 reflections this creates:



Ask: Which reflections are the same? How do they compare with the reflection you see when you hold the mirror in the air facing the paper?

Can you write this name in mirror-writing now *without using the mirror*? Write **ISAAC NEWTON** again on another sheet and try. When you get stuck, think back to how you moved as a human mirror to make the "reflection" right.

When you're done, check your efforts with a real mirror. Then practice on your own name and on your classmates'. Exchange letters in mirror writing. The more you practice, the easier it will get!

HELP US CONTINUE ART TO ZOO!

ART TO ZOO, like many Smithsonian programs, is supported by federal funding. This year, because of cuts in the Institution's federal budget, the Office of Elementary and Secondary Education has been forced to reduce the number of copies of ART TO ZOO that each school will receive . . . and we may have to cut back as well on the number of issues that we produce.

Your letters of support would be helpful to us as we seek to find ways to continue publishing ART TO ZOO.

Notes on the Challenges

1. Decide: Can you see without being seen?
The children work in pairs to figure out whether there is a position that allows child A to see the point between child B's eyes, without B's being able to see the point between A's. They try to do this looking at each other in a large mirror that is hanging straight up and down.

First the kids should discuss; then predict; then experiment. No tricks: For example, it doesn't count to have one child close her eyes. . . . The answer is that the challenge is not possible. Light can follow the path between A's eyes and B's eyes in either direction . . . so if A can see B, B can see A.

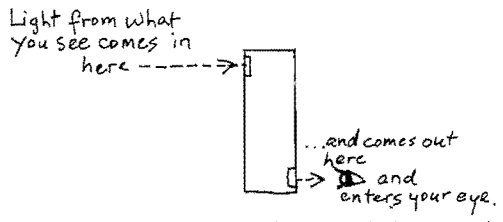
2. Turn your surroundings upside down . . .
. . . using only a mirror. The solution is to hold the mirror horizontal. It can face either up or down.

From the point of view of discovery, the best way for the kids to do this is as homework. If they do it in class, as soon as one child figures out the answer, all the others will see what she did—and lose the opportunity to make the discovery for themselves.

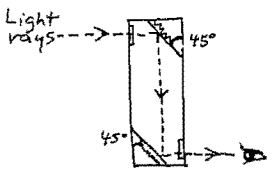
However, holding mirrors upside-down or laying them on the floor can be dangerous. Decide whether your students can be trusted to follow instructions when they are away from you. If they work at home, it should be under the supervision of an adult . . . or with an unbreakable mirror *only*.

3. Stand in line with yourself.
Stand two large mirrors on the ground so they are perfectly vertical. They should be a few feet from each other, parallel, and facing each other. Make sure they are secure. Each child takes a turn sitting between them so he can see himself reflected over and over, as the bottle was.

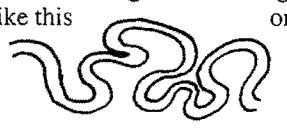
4. See over a wall that is taller than you.
A periscope makes this possible. Make a simple diagram of one:



Tell the kids: What makes this possible is two mirrors set up inside the periscope. As homework, see if you can figure out what the position of these two mirrors must be. Then, in class, have the kids discuss their findings and reach a conclusion about the mirrors' position. They should be set up like this:



Finally, the children can construct an actual periscope, in a box about a foot long; the mirrors can be fastened in with tape. Experiment yourself ahead of time. The exact positioning of the mirrors is essential. Try to provide unbreakable mirrors; if you can't, be sure the mirrors are *very* securely fastened.

5. Stay on the mirror-path
Hand out copies of a drawing of a twisting, turning path (something like this  only larger and longer). This path should be at least ¼ inch wide (wider for younger children). The challenge is to draw a pencil line that stays on the path, while looking only at the path's reflection.

The children work in pairs. Child A holds up a stiff paper so it blocks child B's view of the path. B holds a mirror, adjusted so she can see the path's reflection in it. Looking at this reflection, she moves a pencil along the path with her other hand. Then the children switch roles.

6. Decide which of these shapes are symmetrical.
The symmetrical ones are, of course, the diamond, the cross, and the scissors. Have the kids check them with a mirror.

7. Flip this guy in different directions.
- Use one mirror to make him look at himself and face away from himself.
- Use two mirrors to make him stand in line.
- Use one mirror to make his reflection lie on its stomach, lie on its back, and stand on its head.

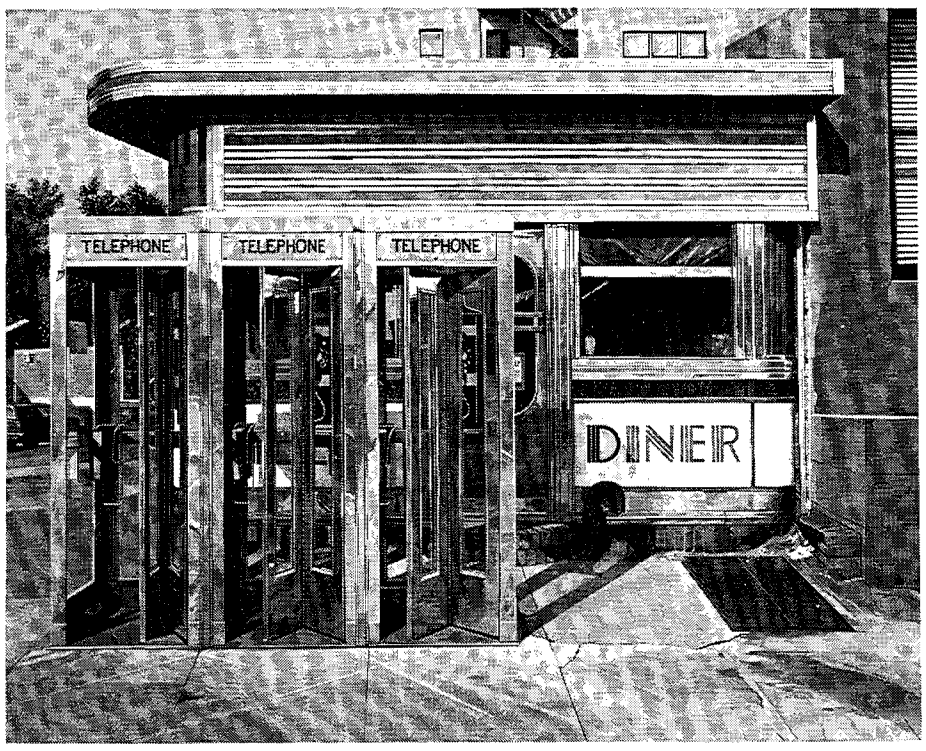
8. Answer this message in the same kind of writing.
Read the message by standing a mirror above the writing: The answer-words have to be made only of letters that have a horizontal axis of symmetry: B, C, D, E, H, I, K, O, X. Answers include: BOOK, OX, HIDE, CHOKE, CODE, EEK, DECK, HIKE, etc.

9. Write your name in Forehead Writing.
This is simply a technique for producing mirror writing that works surprisingly well and gives the user a certain weird direct insight into what is happening when a mirror reverses things.

Here's how to do it: Hold a pad of paper with a stiff backing against your forehead. Write your name on the pad, starting on your left and moving toward your right. Now look at what you have written: it will be in mirror writing. Check with a mirror and see.

When you see things in a mirror, you are viewing the world from a point of view that isn't physically possible. Forehead writing—in which you "see" the *back* of the writing—brings you about as close as you can be to experiencing directly what the mirror is doing that makes things look reversed.

But warn the children: don't try to put what's happening into words. It will just turn confusing!



We are surrounded by objects—like the diner and the phone booths in this picture—that act as mirrors.

Painting by Richard Estes. *Diner*, 1971. Hirshhorn Museum and Sculpture Garden, Smithsonian Institution

New Resource Guide for Teachers

This 90-page guide describes over 300 resources available from the Smithsonian. More than half of these resources are free or are available for a nominal fee.

You'll find posters, recordings, newsletters, bibliographies, books and booklets, kits, and video programs to use in your classroom. Send a check or money order for $4.95 to Smithsonian Institution/OESE, Department 0561, Washington, DC 20073-0561.

Bibliography

For teachers

Elementary Science Study (ESS). *Mirror Cards*. New York: McGraw-Hill, 1975. (Also available on-line, or on microfiche or photocopy, for a fee, from: ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Ohio State University, 1200 Chambers Road, Third Floor, Columbus, OH 43212. Tel. (614) 292-6717.

Gardner, Martin. *The New Ambidextrous Universe: Symmetry and Asymmetry from Mirror Reflections to Superstrings*. New York: W. H. Freeman, 1990.

Morris, Janet P. "Investigating Symmetry in the Primary Grades." *The Arithmetic Teacher*, March 1977.

For students

Ardley, Neil. *Sun and Light*. London and New York: Franklin Watts, 1983.

Walpole, Brenda. *Light*. London and New York: Warwick Press, 1987.

Walter, Marion. *The Mirror Puzzle Book*. New York: Tarquin Publications, 1985.

Sources for Mirrors

You may be able to borrow a set of unbreakable rectangular mirrors from a high school laboratory or purchase them from a scientific supply house. Here are just a couple with recent prices, which may be out-of-date by the time you read this ART TO ZOO.

Delta Education, Inc., P.O. Box M, Nashua, NH 03061-6012. Tel. (800) 258-1302, (603) 889-8899. 3″ x 5″ unbreakable plastic mirrors, package of 30 for $29.00 (#53-130-3280).

Learning Things, Inc., 68A Broadway, P.O. Box 436, Arlington, MA 02174. Tel. (617) 646-0093. 2½″ x 3½″ rectangular metal mirrors, $1.40.

ART TO ZOO
is a publication of the
Office of Elementary and Secondary Education
Smithsonian Institution, Washington, D.C. 20560.
Write to this address if you want your school to be placed, free of charge, on the ART TO ZOO mailing list.

Editor: Betsy Eisendrath (202) 357-2404

Regular Contributors:
ANACOSTIA NEIGHBORHOOD MUSEUM
ARTHUR M. SACKLER GALLERY
COOPER-HEWITT MUSEUM
FREER GALLERY OF ART
HIRSHHORN MUSEUM AND SCULPTURE GARDEN
NATIONAL MUSEUM OF AFRICAN ART
NATIONAL AIR AND SPACE MUSEUM
NATIONAL MUSEUM OF AMERICAN ART
and RENWICK GALLERY
NATIONAL MUSEUM OF AMERICAN HISTORY
NATIONAL MUSEUM OF NATURAL HISTORY
NATIONAL PORTRAIT GALLERY
NATIONAL ZOOLOGICAL PARK
SMITHSONIAN ENVIRONMENTAL RESEARCH CENTER
SMITHSONIAN TROPICAL RESEARCH INSTITUTE
Designer: The Watermark Design Office

Many thanks to the following people at the Smithsonian for their help in preparing this issue of ART TO ZOO:

Hirshhorn Museum and Sculpture Garden: Sandra Lehovich and Lee Stalsworth.

National Museum of American History, Division of Photographic History: Mary Grassick.

National Science Resources Center: Judy Grumbacher.

Smithsonian Institution Traveling Exhibition Service: Freddie Adelman, Betsy Hennings, and Miriam Springuel.

Office of Elementary and Secondary Education: Teresa Mora and Michelle Smith.

ART TO ZOO October 1990
News for Schools from the Smithsonian Institution

PULL-OUT PAGE

Trapped in the Mirror!

It's one of those last few days before vacation, when the school hours go by so slowly you can hardly stand it.

There is a mirror in your classroom. To pass the time, you make faces into it. You look at your classmates' reflections. You notice how the reflected room looks familiar yet strange.

How much longer? You glance at your watch . . . But there is no watch! It isn't where it usually is, on your left wrist.

Then you see it, on your *right* wrist. How did it—?

"A good catch today," a voice says. "A whole crowd of young whippersnappers . . . and a grown-up too!"

The speaker is pale, and short and wide like a suitcase. He seems to have a floor-length beard, but it is strangely hard to see him clearly: he flickers and changes all the time.

"Who are you?" someone asks.

"I'm Reflecto," the creature says. "The Guardian of the Mirror."

. . . of the mirror? Then you remember your watch—on the wrong arm. And the book on your desk—its print is backwards! "The mirror," you exclaim. "We're in the mirror!"

"Of course you're in the Mirror," Reflecto says.

"What mirror?" one of your classmates asks.

"What mirror? What mirror?" Reflecto echoes scornfully. "This is typical. No one notices. No one looks. No one has respect for mirrors. They think that just because reflections are made of light, mirrors aren't important."

He whirls around and looks right at you.

"Respect, that's what I want. Respect for mirrors! Respect for reflections! Enough of being taken for granted."

He's crazy, everyone is thinking. But here you all are, stuck inside this mirror.

One kid begins to cry. "I want to go home . . ."

"How did we get in here?" your teacher asks. "I've been looking into mirrors for a good many years now, and this has never happened to me before."

"You've just been lucky," Reflecto snickers. "You've looked into regular mirrors before . . . but this is the Exit Mirror, the one door between the world of reflections and the world of objects you can touch.

"Most people never come across the Exit Mirror . . . but you have. And you will have to stay here in the reflection—unless you dare to try the Nine Challenges."

"I want to go home," the same kid is crying.

"Of course you're going home," your teacher says. "Reflecto, are you saying that if we can carry out the Nine Challenges, we can go back to our own world?"

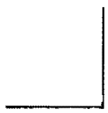
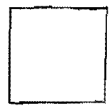
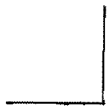
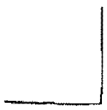
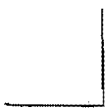
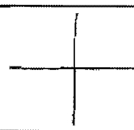
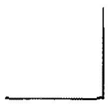
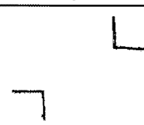
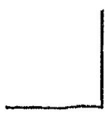
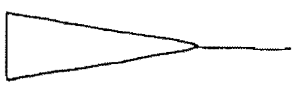
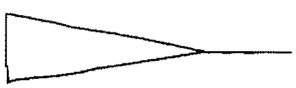
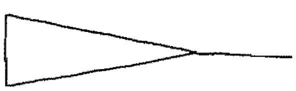
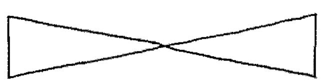
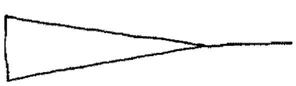
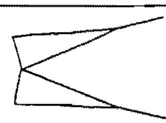
"*If* you can . . ." he sneers.

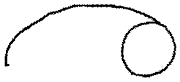
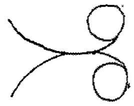
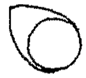
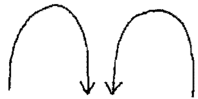
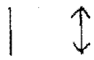
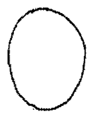
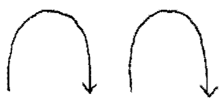
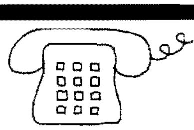
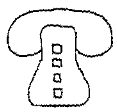
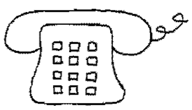
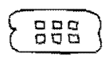
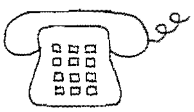
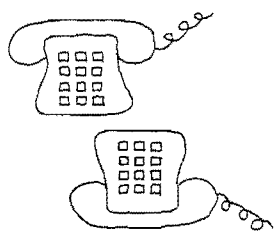
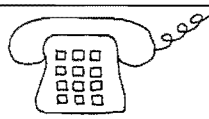
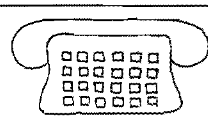
"Then hand them over!"

Questionable Reflections

Using a mirror, which left-hand pictures can you change into right-hand pictures?

- Stand your mirror either *on* or *near* the left-hand picture.
- The piece of this picture that is in front of the mirror . . . plus this piece's reflection . . . together count as the right-hand picture.
- You *will* be able to make some of the right-hand pictures; for these, check the "Yes" column. Others you *won't* be able to make, no matter where you stand the mirror; for these, check the "No" column.
- When you and all your classmates have gone through all the pictures, your teacher will give you a chance to compare answers.

Using a mirror, can you turn this . . .	**. . . into this?**	**Yes**	**No**
			
			
			
			
			
			
			
			
			
			
			

Using a mirror, can you turn this . . .	. . . into this?	Yes	No
			
			
			
			
			
			
			
			
			
			
			
			

THE NINE CHALLENGES

(You need to use a mirror—or mirrors—to carry out each of these. Your teacher will explain more about them later on.)

1. Decide: Can you see without being seen?

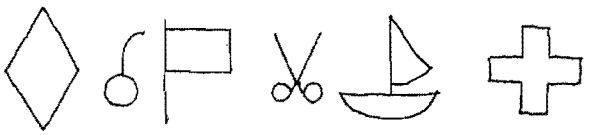
2. Turn your surroundings upside down.

3. Stand in line with yourself.

4. See over a wall that is taller than you.

5. Stay on the mirror-path.

6. Decide which of these shapes are symmetrical:



7. Flip this guy in different directions.

8. Answer this message in the same kind of writing:

MIRROR AS ON YOUR PAPER.
MILL LOOK THE SAME IN THE
CAN YOU WRITE 3 WORDS THAT
THE QUESTION IS TRICKY:

9. Write your name in Forehead Writing.

Division of Photographic History, National Museum of American History, Smithsonian Institution

Mirrors can be made of many materials, but most consist of a sheet of polished glass with a silvered backing.

Del Arte al Zoologico Octubre 1990
Noticias para las escuelas
del Instituto Smithsonian

PULL-OUT PAGE

¡Atrapado en el Espejo!

Es uno de esos últimos días antes de las vacaciones, cuando las horas en la escuela pasan tan lentamente que apenas las puedes soportar.

Hay un espejo en tu salón de clases. Mientras dejas pasar el tiempo, haces muecas frente a él. Miras las imágenes reflejadas de tus compañeros. Observas como la imagen del salon luce familiar aunque algo extraña.

¿Cuánto tiempo mas hay que esperar? Le das una mirada a tu reloj. Pero ¡no tienes reloj!. No está donde generalmente está, *so*bre tu muñeca izquierda.

De pronto lo ves, está sobre tu muñeca *derecha*. ¿Cómo sucedió?

"Una buena pesca la de hoy", dice una voz. "¡Una cantidad enorme de mequetrefes jóvenes y un adulto también!"

El vocero es pálido y corto y ancho como una maleta. Parece tener una barba larga que le llega al piso, pero es muy difícil verlo claramente: oscila y cambia todo el tiempo.

"¿Quién eres?" alguien pregunta.

"Soy Reflecto", dice la criatura. "El guardián del espejo".

¿Del espejo? Te acuerdas en ese momento de tu reloj sobre el brazo equivocado. Y el libro sobre tu escritorio tiene la impresión ¡al revés!. "El espejo", exclamas. "¡Estamos en el espejo!".

"Por supuesto que estás en el espejo", dice Reflecto.

"¿Cuál espejo?" dice uno de tus compañeros.

"¿Cuál espejo? ¿Cuál espejo?" Dice Reflecto despreciativamente. "Esto es típico. Nadie se da cuenta. Nadie observa. Nadie respeta a los espejos. Piensan que como los reflejos están hechos de luz, los espejos no son importantes".

El se da una vuelta y te mira directamente.

"Respeto, eso es lo que quiero. ¡Respeto para los espejos! ¡Respeto para los reflejos! Ya es suficiente de no ser apreciado".

Está loco, piensa cada uno. Pero aquí están todos, sujetos dentro de este espejo.

"Un niño empieza a llorar. "Quiero ir a casa".

"¿Cómo nos metimos aquí?" pregunta tu maestro. "Yo he estado mirando en espejos hace bastantes años y esto nunca antes me había sucedido".

"Tú sólo has sido afortunado", se burla Reflecto. "Tú sólo has mirado a espejos comunes, pero éste es el espejo de salida, la puerta entre el mundo de los reflejos y el mundo de los objetos que puedes tocar".

"La mayoría de la gente nunca se encuentra con el espejo de salida, pero tú lo has hecho. Y tú tienes que quedarte aquí en el reflejo, a menos que te atrevas a resolver los nueve retos".

"Quiero ir a casa", sigue llorando el mismo niño.

"Por supuesto que irás a casa", dice tu maestro.

"¿Estás diciendo Reflecto, que si resolvemos los nueve retos, podemos regresar a nuestro mundo?".

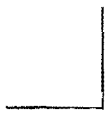
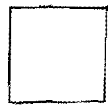
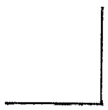
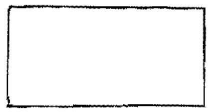
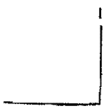
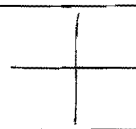
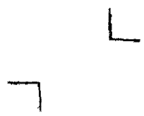
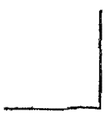
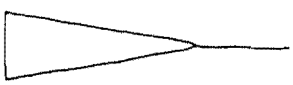
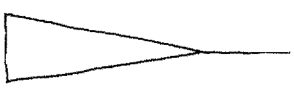
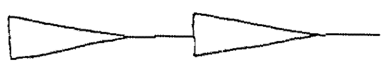
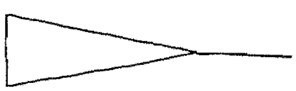
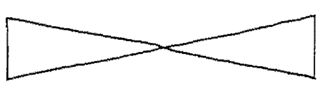
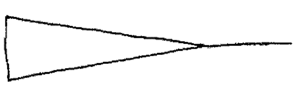
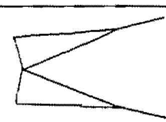
"*Sí* ustedes pueden", se burla él.

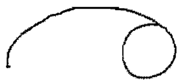
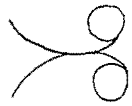
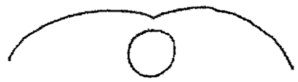
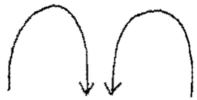
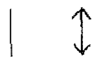
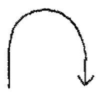
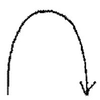
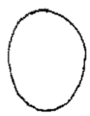
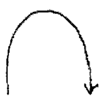
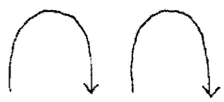
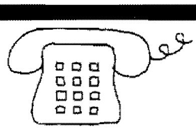
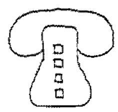
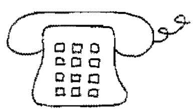
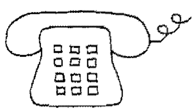
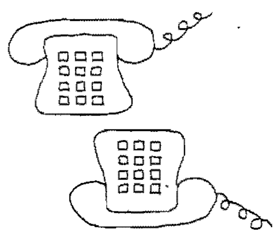
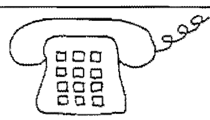
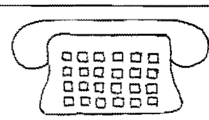
"Entonces ¡dánoslos!

Reflejos dudosos

Con el uso de un espejo ¿cuáles imágenes de la izquierda puedes cambiar en imágenes a la derecha?

- Coloca tu espejo bien *sobre* o *cerca* de la imagen de la izquierda.
- La parte de esta imagen que está en frente del espejo mas el reflejo de ella forman la imagen de la derecha.
- *Podrás* hacer algunas de las imágenes de la derecha; en este caso marca la columna ''sí''. *No podrás* hacer otras imágenes, no importa donde coloques el espejo: en este otro caso marca la columna ''no''
- Cuando tú y tus compañeros hayan revisado todas las imágenes, tu maestro te dará la oportunidad de comparar tus respuestas.

Al usar un espejo ¿puedes cambiar esto . . .	**. . . en esto?**	**Sí**	**No**
			
			
			
			
			
			
			
			
			
			
			

Al usar un espejo, puedes cambiar esto . . .	. . . en esto?	Sí	No
			
			
			
			
			
			
			
			
			
			
			
			

Página para separar

TRADUCCION DE TERESA L. MORA

LOS NUEVE RETOS

(Tú maestro te explicará mas acerca de ellos después)

1. Decide: ¿Puedes ver sin ser visto?

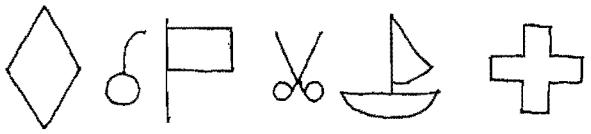
2. Voltea lo que te rodea al revés.

3. Ponte en línea contigo mismo.

4. Mira a través de una pared que es mas alta que tú.

5. Mántente en el área del espejo.

6. Decide cuál de estas formas son simétricas:



7. Mueve a este tipo en diferentes direcciones:

8. Contesta este mensaje en el mismo tipo de letra:

EN EL PAPEL?
PARECIAN LA MISMA EN EL ESPEJO Y
¿PUEDES ESCRIBIR TRES PALABRAS QUE
LA PREGUNTA ES ENGAÑOSA:

9. Escribe tu nombre en escritura invertida.

(División de Historia de la Fotografía, National Museum of American History, Smithsonian Institution).

Los espejos se pueden hacer de muchos materiales, pero la mayoría consiste de una hoja de vidrio pulido con la parte de atrás plateada.