Part 4
FOOLING YOUR EYES AND BRAIN

Your eyes gather the light that comes in from the outside world, but it's your brain that makes sense of it.

Sometimes what you see and what you think you see don't match up. When that happens, you may see an illusion—the result of your brain "misreading" the clues it gets. When visual information is not clear or complete, you may catch your brain jumping to impossible conclusions or making wrong decisions about what you're seeing. It's when your visual system makes mistakes that you can learn the most about it.

The information and activities in this section explore how your eyes and brain work together. You'll discover your ability to see faces where there are none, watch people seem to shrink and grow, see colors that aren't really there, and more.

ACTIVITY:
Hat Trick

What You Need

- A small mirror
- Paper
- Pencil or pen
- A baseball cap
- Masking tape or other strong tape

What to Do

1. Tape the mirror to the underside of the cap's brim, using enough tape to hold the mirror on tight.
2. Seat yourself at a table with a piece of paper and a pen or pencil in front of you. Put on the cap and look up into the mirror. Adjust the cap so that when you look up into the mirror, you can see the paper on the table.
3. Watching your hand in the mirror, try to print your name on the paper. Don't look down at the paper! Print your name so you can read the letters in the mirror.
4. Still looking in the mirror, try drawing something simple, like a house or a smiley face.

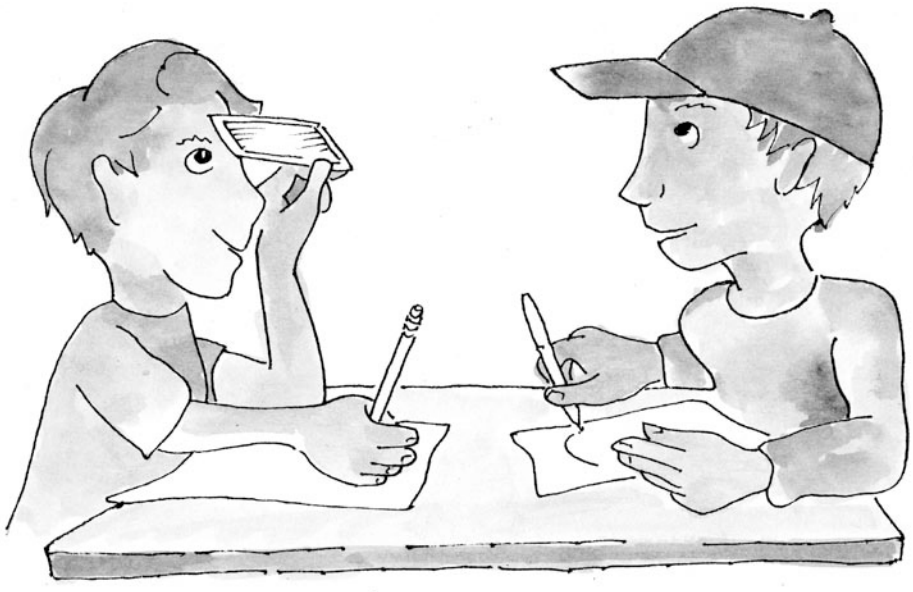
What's Happening?

Writing and drawing while looking in the mirror will probably be harder than you thought it would be.

Why? Because most of the time when you write and draw, your eyes and hands work together. But when you look in the mirror, what your eyes see doesn't match what your hands do.

When you look up into the mirror, what you see on the paper is upside down. When you try to move your hand up, the mirror shows it moving down. The usual signals your brain sends to your hand cause you to move your hand in the wrong direction.

You can learn to write in a mirror world, but it isn't easy.



ACTIVITY:
Colored Words

What You Need

- Five different-colored crayons or markers (such as red, green, blue, purple, and yellow); any colors will work
- Plain paper (if you have a color printer, you can simply print out this page to use)
- A partner

What to Do

1. Use your crayons to write the names of different colors on your paper—but don't write the name of the color you're using. For instance, write "BLUE" with your red crayon; write "PURPLE" with your yellow crayon; write "RED" with your green crayon, and so on. Fill up the paper with lots of color words.

2. When you're done, give your paper to your partner and ask him or her to "read" the colors of the words. Tell your partner not to read the words, but instead name the colors the words are printed in.

3. Switch places with your partner and try to do it yourself.

What's Happening?

Even though we told you not to read the words, you probably couldn't help it. Saying the color instead of the word is hard!

When you do this activity, your eyes and brain are at odds with one another. Even before you can name the color of a word, your brain has already deciphered what it says. That's why it's easier to read each word than to name the color it's printed in.

Your brain was expecting the word "red" to be red, but you encountered something unexpected: the word "red" was green. Or yellow. Or purple. When your brain gets mixed messages like that, it takes longer to make the right choice.

This phenomenon, called the Stroop Effect, is named after scientist J. Ridley Stroop. In 1935, Stroop discovered that people take longer to name a color when the word and color don't match.

ACTIVITY:
Whirling Colors

What You Need

- A copy of the black-and-white disk on the next page
- A stiff piece of cardboard the same size as the disk
- Glue
- A pencil with a fresh eraser on its end
- A pushpin
- A bright light

What to Do

1. Cut out the photocopied disk.
2. Place the paper disk on the cardboard. Trace around it, then cut out that piece of cardboard.
3. Glue the paper disk to the cardboard disk.
4. With the pushpin, attach the center of the disk firmly to the pencil's eraser end. Make sure that the patterned side of the disk is facing upward.
5. Hold the pencil upright between the palms of your hands so that the disk is flat under the bright light. Roll the pencil slowly back and forth to make the disk spin. What do you see on the disk? Try spinning it more slowly (or quickly). Now change directions. Do you see something different when the disk is spinning clockwise or counterclockwise?

What's Happening?

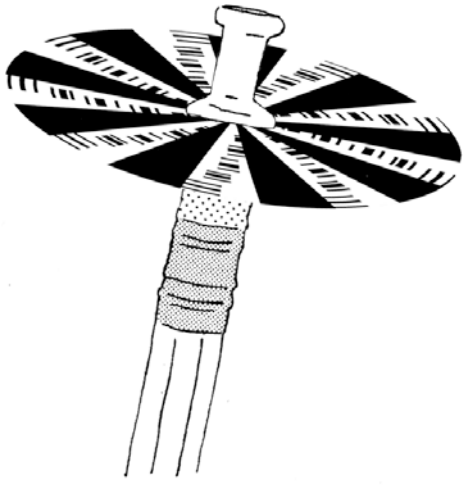
As the disk spins at the end of the pencil, you'll probably see bands of colors. Spin the disk in the opposite direction, and the colors will reverse their order. But why do we see color in this black-and-white spinning pattern?

Scientists aren't entirely sure how this illusion works, but it can be explained in part by looking closely at the color-vision cells in your eyes.

The color-detecting cells in your eyes are called cones. They come in three varieties: one is sensitive to red light, one to green light, and one to blue light.

Each type of cone has a different latency time, the time it takes to respond to a color. Each also has a different persistence of response time, the time it keeps responding after the stimulus has been removed. Blue cones, for example, are the slowest to respond (they have the longest latency time), and they keep responding the longest (they have the longest persistence time).

When you gaze at one place on the spinning disk, you are looking at alternating flashes of black and white. When a white flash goes by, all three types of cones respond. Normally, your eyes and brain see the color white when all three types of cones respond—but only when they respond equally. With this striped pattern flashing by, your cones are not stimulated equally. Because some types of cones respond more quickly than others, and because some respond for longer periods of time than others, the result is an imbalance that partly explains why you see the colors in the spinning disk.



continued

ACTIVITY:
Whirling Colors

ACTIVITY:

Seeing Faces Everywhere

What You Need

- Your eyes
- Your imagination

What to Do

1. Walk around your home, your school, or your neighborhood.

2. See how many "faces" you find around you.

What's Happening?

Have you ever seen a shadow on a wall that looked like a scary face or a cornflake that looked like someone you knew? Research shows that most people see faces even in things that don't have them.

Our brains are hardwired to put together bits and pieces to create something we perceive as a face. Lots of us look for the man in the moon whenever the moon is full, and some people have picked the car they drive because it had a friendly "face."

People have even found faces in groups of punctuation marks. Put together a semi-colon, a hyphen, and the right side of parentheses, and you can make a face like this: **;-)**

It may be a sideways face, and it's not attached to a head, but we all know that it's winking and smiling at us. You may have even smiled back when you looked at this funny thing, called an "emoticon."

Try looking for faces in the things around your house. A set of headphones on a table could look like two eyes and a big smile. Some people find faces in electric outlets. Maybe, from the outside, even your house looks like a face.

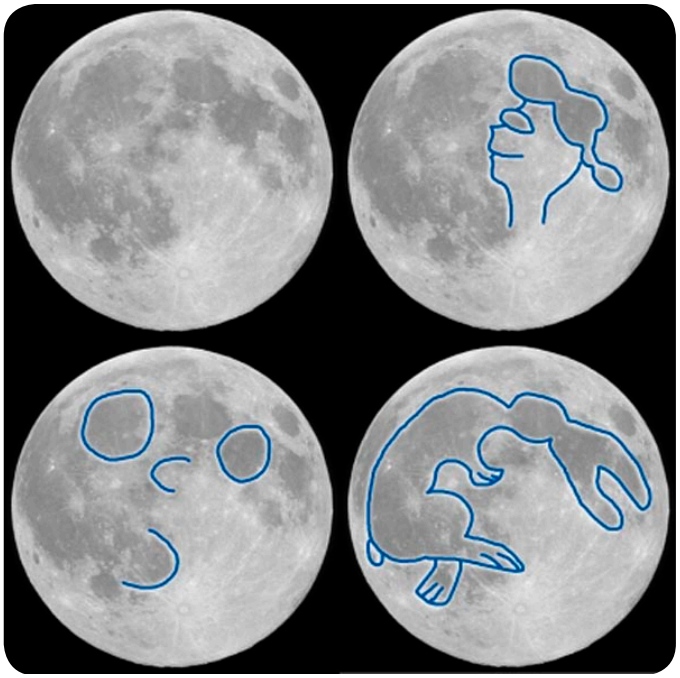
The Man in the Moon May Be a Rabbit

What do you see when you look at the full moon? Even if at first you see nothing but a round object reflecting light, look long enough and you might make out a face or a figure. Astronomer Carl Sagan explained it this way:

"We make out a configuration of irregular bright and dark markings—not a close representation of any familiar object. But, almost irresistibly, our eyes connect the markings, emphasizing some, ignoring others. We seek a pattern, and we find one."

The patterns we find run the gamut from a man's face to the Arabic letters representing the name of the prophet Muhammad's son-in-law. Both the Chinese and the Aztecs in Mexico saw a rabbit in the moon. Moonwatchers in the England of Shakespeare's time saw either a witch carrying wood on her back, or an old man with a lantern. Other cultures have seen a woman, a frog, a moose, or a dragon with its head and mouth to the right and its body and wings to the left.

Next time the moon is full, make a point of taking a good long look. You may see something no one else has ever seen.



ACTIVITY:
Arc Illusion

What You Need

- A plain piece of paper
- Pencil
- Scissors

What to Do

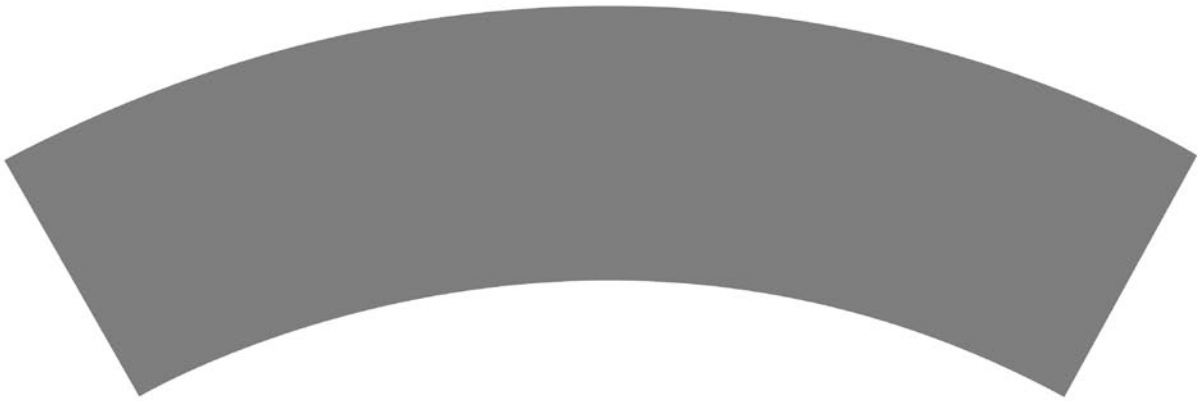
1. Trace this arc shape onto one half of your piece of paper. Fold the paper in half and cut out two arc shapes that are exactly the same.
2. Place the two arcs side by side. Do they look the same size?
3. Now place the arcs one above the other. Do they still look the same size?

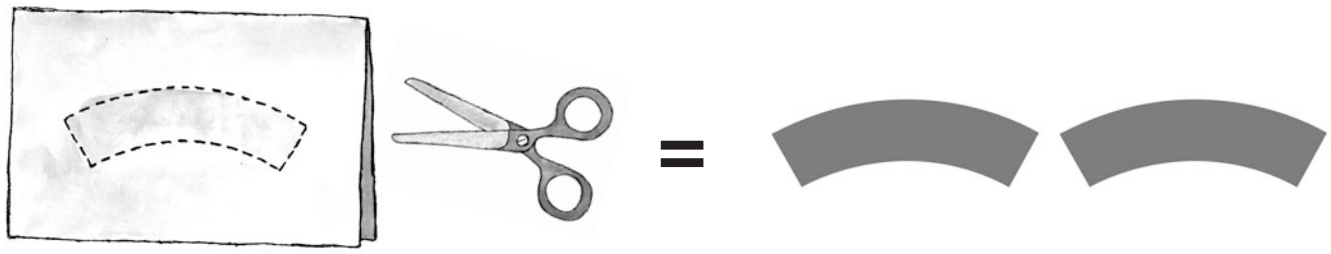
What's Happening?

When these two identical arcs are placed one above the other, the top one may look shorter than the bottom one.

You know that these arcs are the same size and shape, since you cut them out together. So why do they look different?

This optical illusion happens when you visually compare the shorter side of the one arc with the longer side of another. This activity shows how certain comparisons can give you false results.





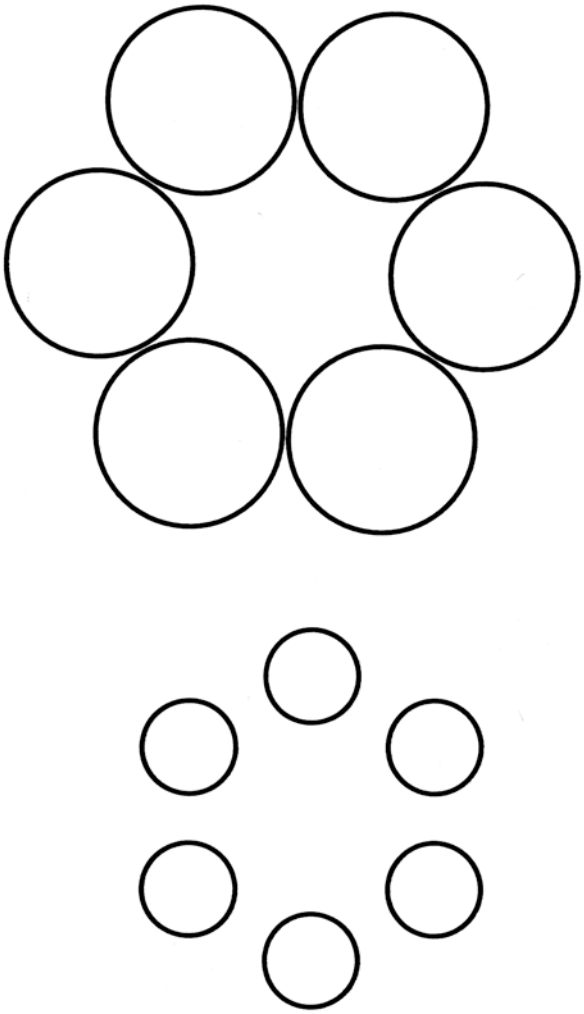
ACTIVITY:
Dime Illusion

What You Need

- The diagram on this page
- A dime
- A pencil

What to Do

1. Place the dime in the middle of the top cluster of circles, making sure that each circle is the same distance from the edge of the dime. Trace around the coin, then remove it from the cluster. Carefully shade in the new middle circle.
2. Do the same thing with the bottom cluster of circles.
3. When both middle circles are shaded in, compare their sizes.



What's Happening?

Even though you know that both circles are the same size, one seems smaller than the other. Visual illusions trick your eyes and brain into making false conclusions about what you see. In this case, the size of surrounding shapes influences how you see the shape in the middle. The cluster of big circles makes the middle spot seem smaller than the spot surrounded by little circles.

ACTIVITY:

The Amazing Shrinking Person

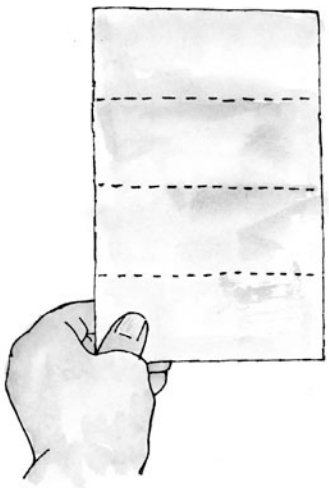
What You Need

- A piece of 8.5" x 11" paper
- Pen or pencil
- Chalk or several small sticks
- A partner
- A lot of space—a long hallway or open space outdoors
- A measuring tape (optional)

What to Do

1. Pick a partner. One of you will be the Measurer, and the other will be the Amazing Shrinking Person. (Later, you can switch roles.)

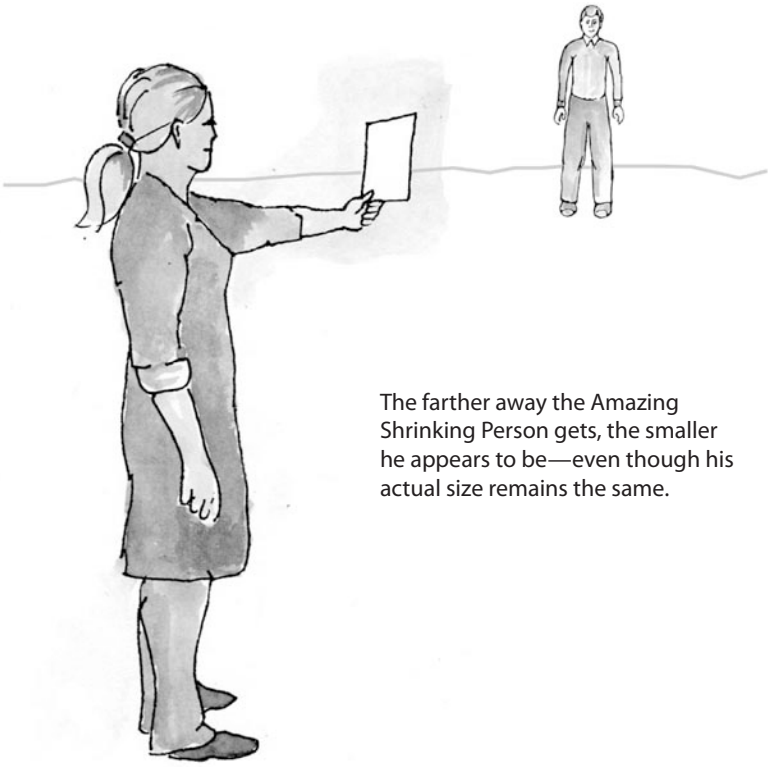
2. Cut the paper in half so you have two 8.5" x 5.5" pieces. Make it into a measuring device by drawing lines to divide it into four equal sections, as shown.



3. Go outside or into the hallway with your partner. Take the measuring device and chalk (or sticks) with you.

4. Face each other as you begin. The Measurer should hold the measuring device (the marked-up paper) at arm's length, locking his or her elbow in place and making sure not to move out of position during the activity. When the Measurer is ready, he or she should tell the Amazing Shrinking Person to start slowly walking backward.

5. When the Amazing Shrinking Person gets far enough away, he or she will fit the height of all four sections of the measuring device. At this point, the Measurer should tell the Amazing Shrinking Person to mark the position of his or her feet (using a chalk mark or a stick).



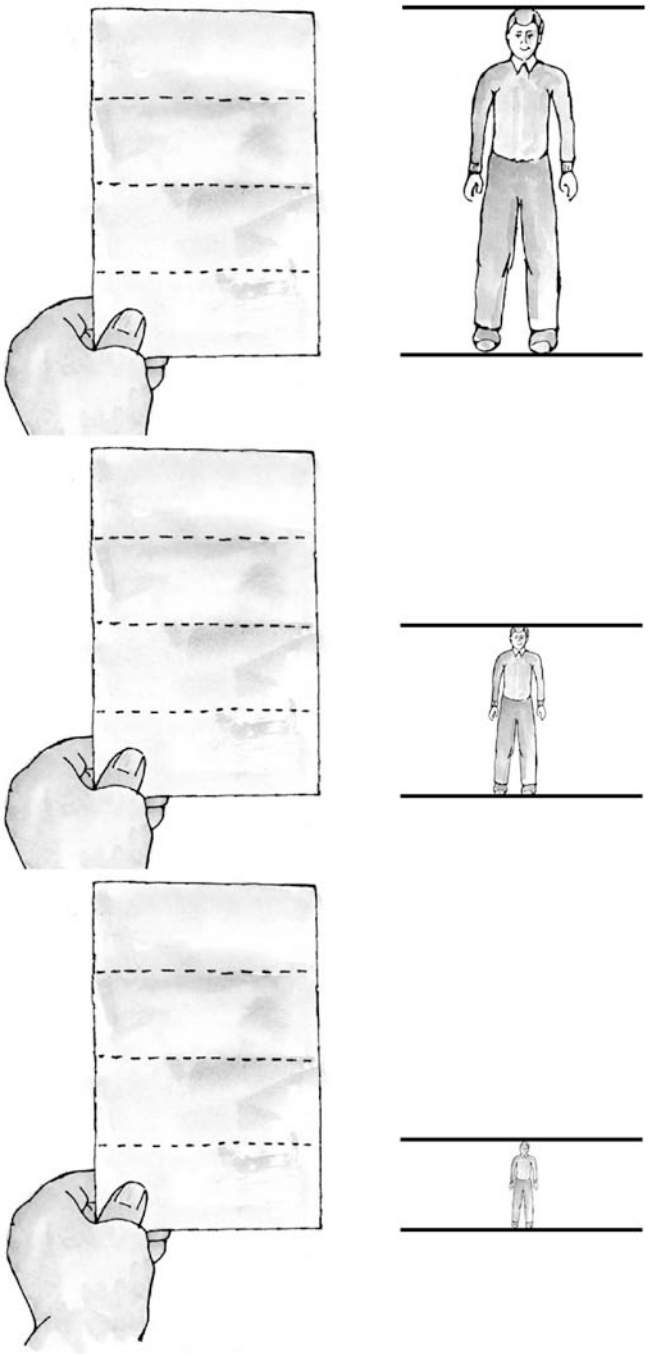
The farther away the Amazing Shrinking Person gets, the smaller he appears to be—even though his actual size remains the same.

continued

ACTIVITY:
The Amazing Shrinking Person

6. As the Amazing Shrinking Person continues to walk slowly backward, he or she will shrink to fit into 3/4 of the measuring device, then 1/2, then just 1/4. Each of these positions should be marked. The position of the Measurer should also be marked.

7. Use a measuring tape (or pace off) how far the Amazing Shrinking Person was from the Measurer at each stage of the activity. Exchange roles and repeat the process.



What's Happening?

Experience with our surroundings teaches us to perceive size by distance, and distance by size. If you have no experience seeing things from a distance, your perception of size and distance might be very different.

In his book *The Forest People*, Colin Turnbull describes the experience of an African BaMbuti Pygmy who, for the first time, saw buffalo grazing in the distance. The Pygmy had always lived in the thick brush, so he had never seen anything from far away, much less a buffalo. The Pygmy perceived the buffalo as tiny insects when they were far off on the savannah. He refused to believe that they were actually large animals in the distance.

Acknowledgments and Credits

Acknowledgments

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The Exploratorium, a hands-on museum of science, art, and human perception, is world-renowned for its innovative exhibits and activities and a trailblazer for other hands-on science museums around the globe. Founded by Frank Oppenheimer in 1969, the Exploratorium continues to be a prototype for museums that encourage visitors to learn by experimenting. Today, the Exploratorium hosts more than half a million visitors each year at its home base in San Francisco. The museum also serves as a teaching and research center and sends touring exhibitions all over the world. In addition, the museum's award-winning Web site at **www.exploratorium.edu** features more than 20,000 pages of explorations on topics ranging from the art and science of cooking to Webcasts of scientists stationed in Antarctica.

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Credits

This activity guide was created using activities developed and refined by the staff at the Exploratorium, and tested on young explorers by the hundreds of teachers who have worked with us over the years.

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The Science Explorer: Family science experiments from the world's favorite hands-on museum (Exploratorium, 2002)

Human Body Explorations: Hands-on investigations of what makes us tick (Kendall-Hunt, 2000)