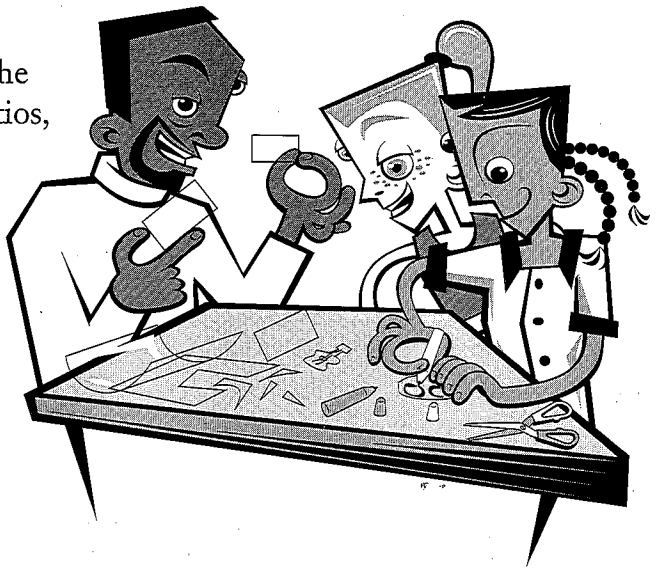
ACTIVITY 16

Incredible Shrinking Shapes

Your group can shrink plastic recycled from deli containers to make medallions and earrings. In the process, people learn about area, volume, and ratios, important concepts in middle school math.



Preparation and Materials

For this activity, you will need:

- a toaster oven or standard oven heated to 350°F (170°C) in a well-ventilated area, a cookie sheet or aluminum foil, a spatula, and a pot holder
- polystyrene (recyclable number 6) plastic (1 piece per person) (*Do not use other types of plastic;* they may emit toxic fumes when heated.)
- fine-tipped permanent markers, preferably in assorted colors (at least 1 per person)
- a hole punch, scissors (1 pair per person), metric rulers (1 per person), and calculators (enough to share)
- copies of *Incredible Shrinking Shapes Data Sheet* and *Grid Paper* (see page 204)

If you want your group to determine how the thickness of the plastic changes when it shrinks (see page 136), each person will also need a clothespin or a binder clip.

Using This Activity

Obtain the plastic by collecting clear-plastic salad bar and deli containers and clear yogurt lids. To make sure you've got the right type, look for this symbol:

Start collecting plastic a few weeks in advance. If you need more than you can collect, you can buy clear plastic containers at restaurant supply stores.

More tips on how to use *Incredible Shrinking Shapes* start on page 133.

Planning chart

Introduction	5 minutes
Cutting out and coloring shapes, and filling out data sheet	10–15 minutes
Shrinking shapes	10–15 min*
Measuring shrunken shapes and filling out data sheet	15 minutes
Continued experimentation and jewelry making	open-ended

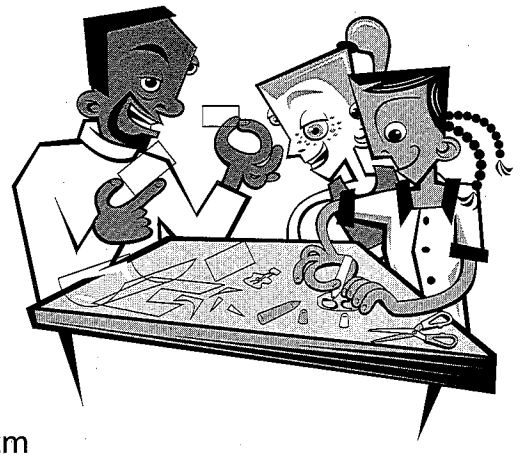
* The time it takes to shrink all the shapes will depend on the size of your group and the size of the oven. You can fit 3 or 4 pieces in a toaster oven at one time. They need to be in for about 1 minute.

Explorer's Notebook

Explorer's Name: Date:

Incredible Shrinking Shapes Data Sheet

Make cool jewelry from plastic deli containers!



What Do I Do?

Step 1 Trim away any parts of your plastic that aren't flat. Lay your plastic on the grid paper. The grid is marked off in square centimeters (cm^2).

Step 2 Using a ruler and marker, trace the lines of the grid to draw two identical squares or rectangles. Make them at least 4 cm by 4 cm but smaller than 8 cm by 8 cm. Cut out your shapes.

Step 3 Measure the length and width of your shape:

Length = _____ cm **Width = _____ cm**

Step 4 Calculate the area of the shape:

$$\underset{\text{(length)}}{\_\_\_\_\_}\ \text{cm} \times \underset{\text{(width)}}{\_\_\_\_\_}\ \text{cm} = \underset{\text{(area)}}{\_\_\_\_\_}\ \text{cm}^2$$

Step 5 Decorate your shapes using permanent markers. If you want to make pendants, earrings, or zipper pulls, make holes in the shapes using a hole punch.

Step 6 Take one of your shapes to the oven, where the group leader will shrink it.

Step 7 Compare your shrunken shape to the unshrunken shape. Measure the length and width of your shrunken shape. Then calculate its area:

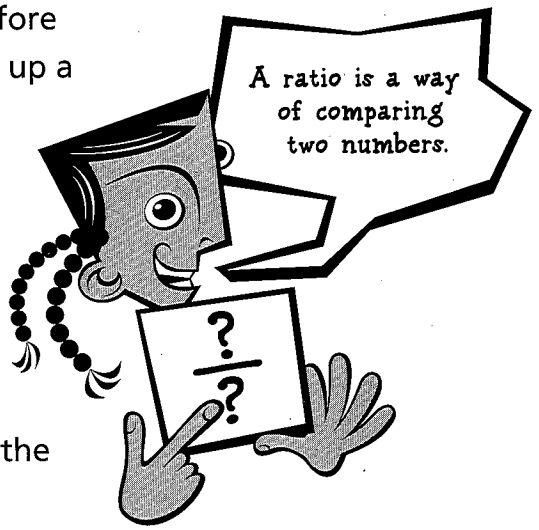
Length = _____ cm **Width = _____ cm**

$$\underset{\text{(length)}}{\_\_\_\_\_}\ \text{cm} \times \underset{\text{(width)}}{\_\_\_\_\_}\ \text{cm} = \underset{\text{(area)}}{\_\_\_\_\_}\ \text{cm}^2$$

Explorer's Name: Date:

Incredible Shrinking Shapes Data Sheet (page 2)

Step 8 Now compare the length of your shape before shrinking with the length after shrinking by setting up a *ratio*. Fill in the circles in this equation:



$$\frac{\text{Length before shrinking}}{\text{Length after shrinking}} = \frac{\bigcirc \text{ cm}}{\bigcirc \text{ cm}} = \bigcirc$$

Divide the *length before shrinking* by the *length after shrinking*. Round your answer to the nearest tenth. Write the answer in the last circle in the equation. This is your *length ratio*.

Your length ratio is probably between 2 and 3. If your length ratio is 2, it means the original shape was 2 times the length of the shrunken shape.

Step 9 Now compare the width of your shape before shrinking with the width after shrinking. Fill in the circles in this equation:

$$\frac{\text{Width before shrinking}}{\text{Width after shrinking}} = \frac{\bigcirc \text{ cm}}{\bigcirc \text{ cm}} = \bigcirc$$

Divide the *width before shrinking* by the *width after shrinking*. Round your answer to the nearest tenth to get the *width ratio*.

Step 10 You know what happened to the length and width of your shape. Now you will find out what happened to the area.

Set up one more ratio, comparing the *area before shrinking* with the *area after shrinking:*

$$\frac{\textbf{Area before shrinking}}{\textbf{Area after shrinking}} = \frac{\bigcirc\ \text{cm}^2}{\bigcirc\ \text{cm}^2} = \bigcirc$$

Divide the *area before shrinking* by the *area after shrinking.* Round the answer to the nearest tenth. Write your result in the last circle in the equation. This is your *area ratio.*

If your area ratio is 7, it means your original shape had an area 7 times the area of your shrunken shape.

Compare your shrunken shape with your unshrunken shape. How many shrunken shapes would it take to completely cover the unshrunken shape? That number should be the same as your area ratio.

Step 11 Which is greatest—your area ratio, your length ratio, or your width ratio? Why might this be? Talk with your group about this.

Step 12 If there's time, shrink your second shape—and experiment with other shapes.

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Tips for Leaders

Making *Incredible Shrinking Shapes*

This activity gives people hands-on experience with ratios and scaling, important concepts in middle school math. At the same time, members of your group can make their own jewelry

Before You Begin

A Note of Caution

Start by preheating the oven to 350°F (170°C). Do not turn the oven up any higher. Cooking this type of plastic is considered safe at 350°F, but toxic fumes may be released if the plastic is exposed to temperatures of 400°F or higher. For safety's sake, do this activity in a well-ventilated area.

A Chance to Play

Jeanne D'Arcy, a teacher who runs an after-school program, says that her group loved this activity. Rather than starting with the math, she gave her group a chance to experiment with the materials and to make some shrinking shapes before she introduced the concept of ratios. Jeanne also suggests putting the materials needed for this activity in different areas so that people have to walk around the room to get what they need. After a long day at school, many students don't want to sit still.

Introduction of Square Centimeters

If you haven't done any activities involving centimeters (cm), you might want to mention that the lines on the grid paper are spaced 1 centimeter apart.

Where's the Math?

When centimeters are multiplied by centimeters, the result is square centimeters, or cm^2, which are used to measure area. The 2 is an *exponent*. An exponent is a small number written above and to the right of another number or term that is called the *base*. The exponent indicates how many times the base is used as a factor. The unit cm^2 means this:

$$\mathbf{cm \times cm}$$

The unit cm^3 means this:

$$\mathbf{cm \times cm \times cm}$$

Cubic centimeters, or cm^3, are used to measure volume. Exponents can be used with numbers as well. For example:

$$5^2 = 5 \times 5$$

$$5^3 = 5 \times 5 \times 5$$

$$5^4 = 5 \times 5 \times 5 \times 5$$

Ask your group what units they get when they multiply centimeters by centimeters. (They get square centimeters, or cm^2.)

Cutting Out Shapes

When your group is working with the *Incredible Shrinking Shapes Data Sheet*, we suggest having everyone make a square or a rectangle. It's tough to calculate the areas of irregular shapes.

Shrinking the Shapes

To shrink the shapes, place them on a clean cookie sheet or a clean, flat sheet of aluminum foil doubled over. Make sure no shape is touching any other shape. (If they touch, they may melt together.) Shrink only one shape per person.

Put the shapes in the oven, preheated to 350°F. *Watch the shapes carefully.* In less than a minute, they will curl and shrink, and then uncurl.

When the shapes have uncurled, take them out of the oven using the pot holder. Remove them from the cookie sheet or aluminum foil with the spatula. If they are still a bit curled, press them flat between a countertop and a pot holder as soon as you remove them from the oven. Let them cool for a minute before returning them to their owners. Let the cookie sheet or foil cool for a few minutes between batches.

Using the Data Sheet

How Advanced Is Your Group?

Some middle school students are comfortable with the concepts of area and ratios; others have not yet been introduced to these concepts. If your group needs practice measuring and needs to learn about area, we suggest that you distribute only the first page of the *Incredible Shrinking Shapes Data Sheet.*

If your group already understands what area is and how to calculate it, consider giving out all three pages and introducing the concept of ratios.

About Area

Area is a measure of the size of a surface, using square units such as square inches or square centimeters. The *Incredible Shrinking Shapes Data Sheet* explains how to calculate the area of a rectangle: multiply its length by its width.

Area takes two dimensions—length and width—into account. That can make comparing the size of the shrunken shape with the size of the original shape a little tricky.

Ask your group to compare the length of the original shape to the length of the shrunken shape. The original shape probably has a length that's 2 to 3 times that of the shrunken shape.

Ask your group to compare the width of the original shape with the width of the shrunken shape. The original shape probably has a width that's also 2 to 3 times that of the shrunken shape.

Here comes the tricky part. Ask your group to compare the area of the original shape with the area of the shrunken shape. People might think that a square that is twice as tall and twice as wide as another square will have twice the area—but that's not so! Area takes both length and width into account—and so a square that is twice as wide and twice as tall as another square has 4 times the area!

This is an important concept for middle schoolers. You can show your group how this works by using an ordinary rectangular piece of paper as shown in the following steps.

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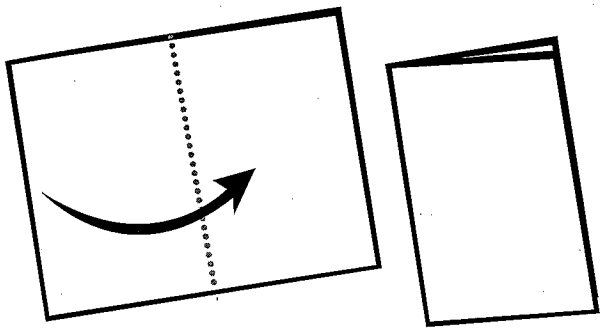
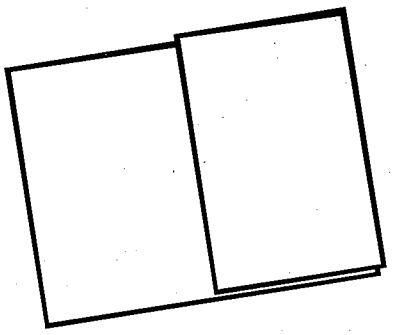
Tips for Leaders

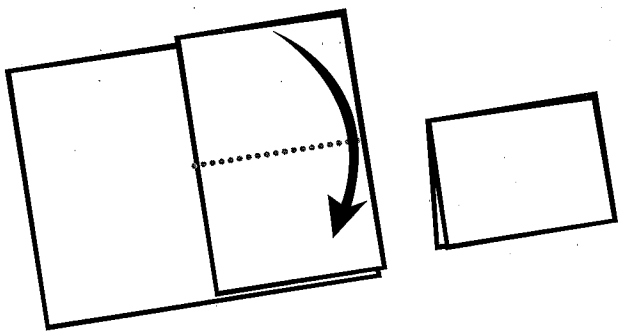
Step 1 Fold the paper in half in one direction, like this:



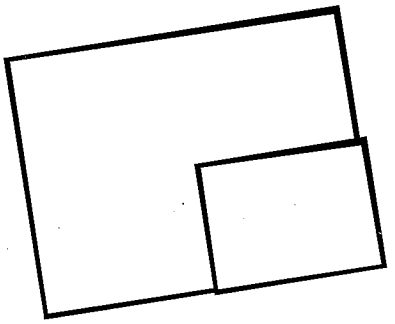
Step 2 Ask the group how many copies of the folded sheet will fit onto the original sheet without overlapping. Show the group that you can fit two folded rectangles onto the original sheet. The original sheet has twice the area of the folded sheet:



Step 3 Now fold the folded rectangle once more, like this:



Step 4 Ask the group how many copies of your new rectangle will fit onto the original sheet without overlapping. Show the group that you can fit four folded rectangles onto the original sheet. The original sheet thus has 4 times the area of the twice-folded sheet:



Each time you folded the rectangle, you divided a side by 2. You made the rectangle half as long. Then you made it half as wide. The area of the final rectangle is one fourth that of the original rectangle.

About Ratios

If your group is ready, you can introduce the concept of ratios using the second and third pages of the *Incredible Shrinking Shapes Data Sheet.* A *ratio* is a way of comparing two numbers. In *Incredible Shrinking Shapes,* ratios let people give a quantitative answer to this question: How much smaller is the shrunken shape?

Members of your group can compare the length of the original shape with the length of the shrunken shape. If they use calculators to find the ratio, you may have to talk to them about rounding their answers. (For a discussion of rounding, see page 183.)

The resulting ratio reveals the length of the original shape compared with that of the shrunken shape. The length of the shrunken shape, multiplied by the length ratio, gives the length of the original shape.

This ratio has no units of measurement. When you divide centimeters by centimeters, the centimeters cancel out. The length ratio will probably be between 2 and 3.

People can also compare the width of the original shape with the width of the shrunken shape. This type of plastic often shrinks a little more in one direction than the other. But, generally, the width ratio will be similar to the length ratio—between 2 and 3.

Finally, people can compare the area of the original shape with the area of the shrunken shape. Ask group members to look at their ratios. Can they figure out some mathematical relationship that lets them use the length ratio and the width ratio to get the area ratio?

If they're stumped, ask them how they calculated the area of their rectangle. Area is length multiplied by width. And the area ratio is the length ratio multiplied by the width ratio.

Where's the Science?

Where Did the Plastic Go?

If you have time, ask group members where they think the plastic went when the shapes shrank.

Suggest that they compare the shrunken shapes with the original plastic. Is the new shape thicker? How much thicker? Members of your group can answer this question by stacking pieces of unheated plastic, clamping them together with a clothespin or a binder clip, and comparing the thickness of this stack of plastic with that of the shrunken pieces.

If someone's area ratio is 7, they should find that seven pieces of stacked, unshrunken plastic have about the same thickness as their shrunken piece.

If your group has access to an accurate scale, people can weigh the plastic before and after heating. They will find that its weight doesn't change. One of the laws of nature is that matter can't be created or destroyed. In this activity, matter changes shape, but it doesn't go away. Matter never goes away.

Why Does the Plastic Shrink?

Plastic is made up of long chains of molecules. Up close, these molecules look like a lot of spaghetti. But unlike spaghetti, each chain of molecules is attached to other chains at certain points.

When this plastic was made into a salad tray or a deli container, it was heated and stretched thin over a mold. In that process, the long chains were pulled and stretched, but they were still attached to each other. Heating the plastic in the oven lets the chains "unstretch" and pull back together again. This causes the plastic to shrink.

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