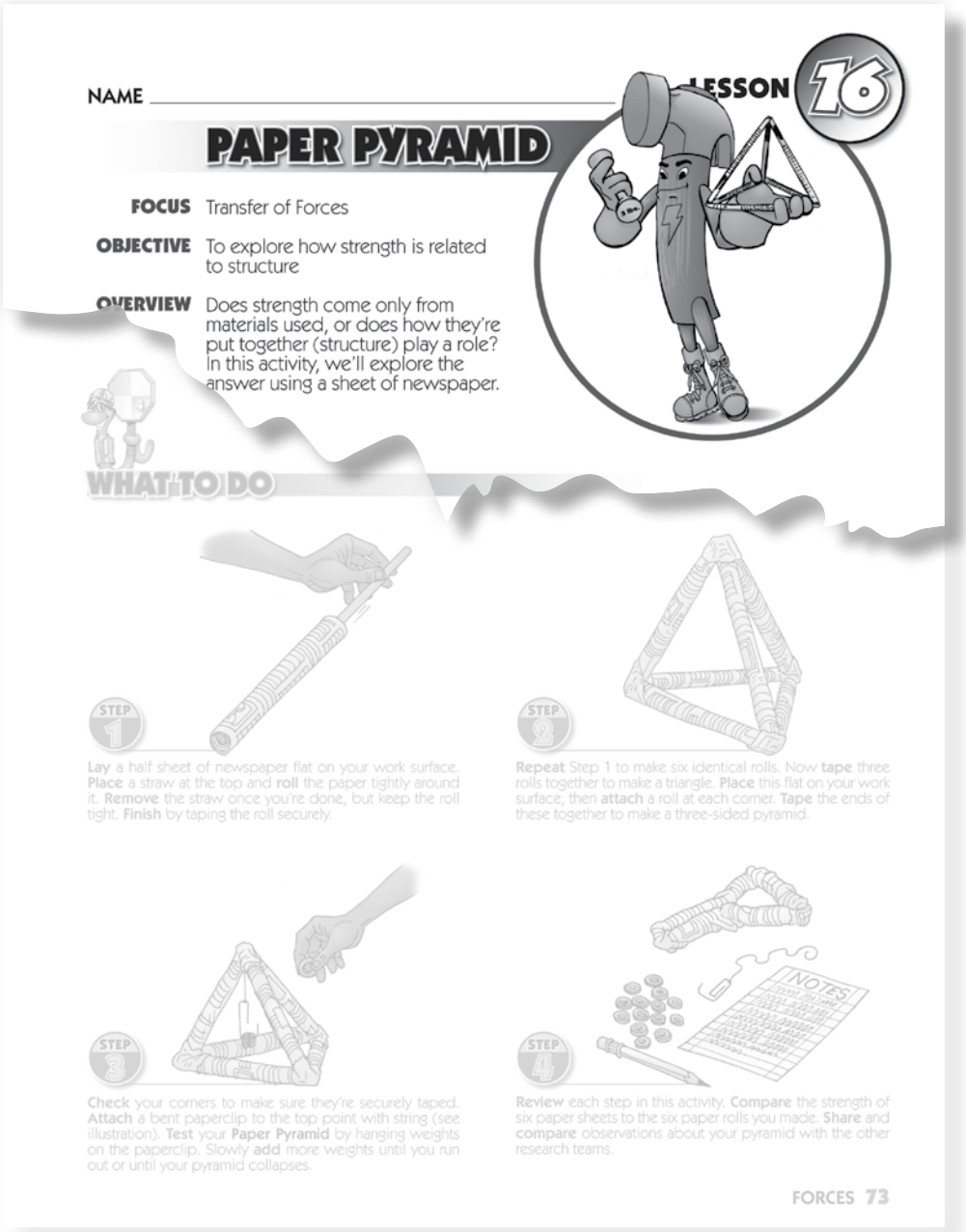

NAME _____ LESSON 16

PAPER PYRAMID

FOCUS Transfer of Forces

OBJECTIVE To explore how strength is related to structure

OVERVIEW Does strength come only from materials used, or does how they're put together (structure) play a role? In this activity, we'll explore the answer using a sheet of newspaper.

WHAT TO DO

STEP 1 **Lay** a half sheet of newspaper flat on your work surface. **Place** a straw at the top and **roll** the paper tightly around it. **Remove** the straw once you're done, but keep the roll tight. **Finish** by taping the roll securely.

STEP 2 **Repeat** Step 1 to make six identical rolls. Now **tape** three rolls together to make a triangle. **Place** this flat on your work surface, then **attach** a roll at each corner. **Tape** the ends of these together to make a three-sided pyramid.

STEP 3 **Check** your corners to make sure they're securely taped. **Attach** a bent paperclip to the top point with string (see illustration). **Test** your **Paper Pyramid** by hanging weights on the paperclip. Slowly **add** more weights until you run out or until your pyramid collapses.

STEP 4 **Review** each step in this activity. **Compare** the strength of six paper sheets to the six paper rolls you made. **Share** and **compare** observations about your pyramid with the other research teams.

FORCES 73

Category

Physical Science
Forces

Focus

Transfer of Forces

Objective

To explore how strength is related to structure

National Standards

A1, A2, B1, B2, B3, E1, E2, F5, G1, G2

Materials Needed

paperclip
string
straw
newspaper
tape
weights

Safety Concerns

4. Sharp Objects
Remind students to exercise caution when using scissors.

Additional Comments

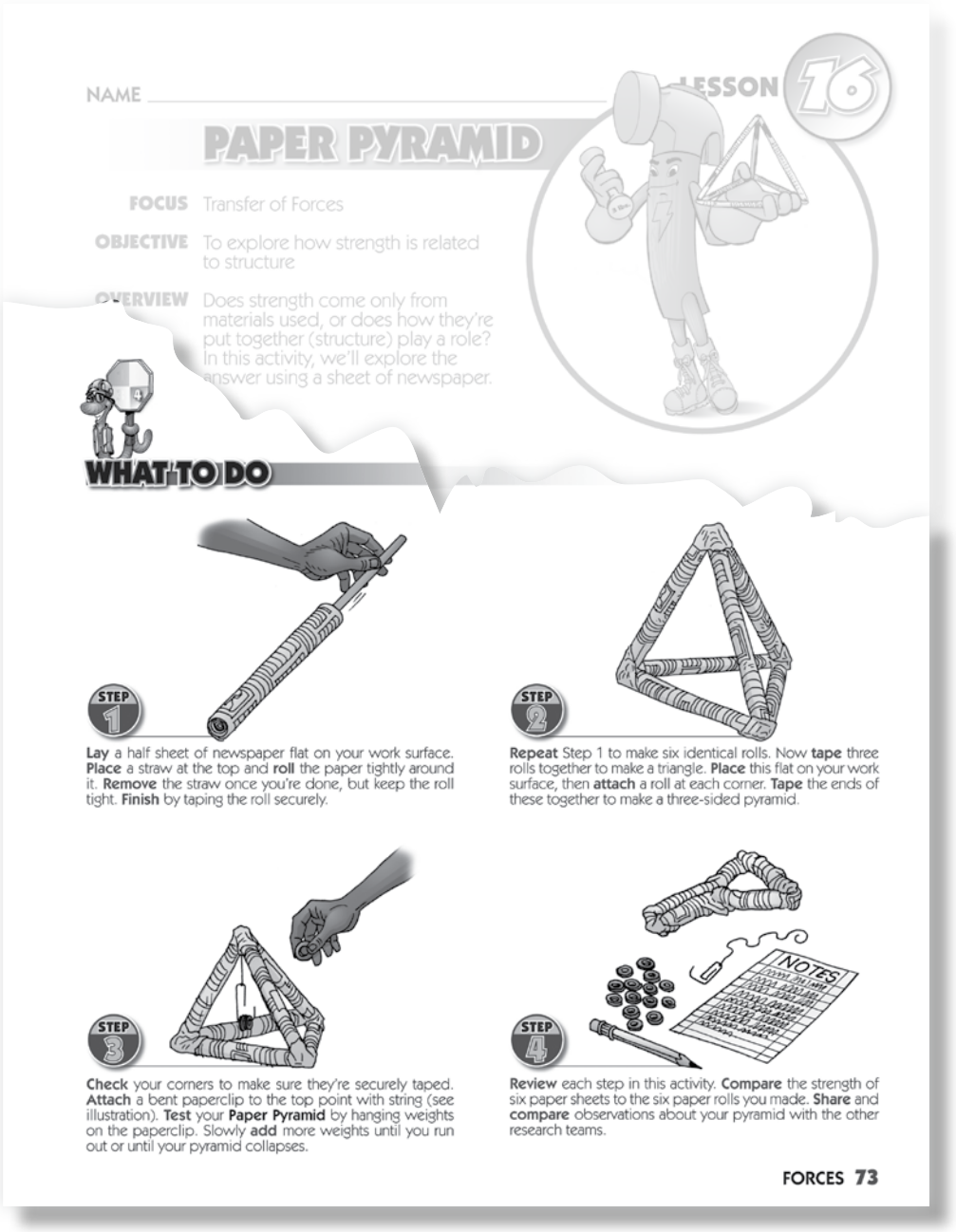
Cut a newspaper down the middle fold so each full sheet produces two equal half sheets. The sheets must be the same size and only a single sheet thick. Students should roll these single sheets from the narrow end to make their tubes. If they're having difficulty rolling, have them use the straw to start the rolling process.

Overview

Read the overview aloud to your students. The goal is to create an atmosphere of curiosity and inquiry.

WHAT TO DO

Monitor student research teams as they complete each step.



NAME _____ LESSON 16

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WHAT TO DO

STEP 1

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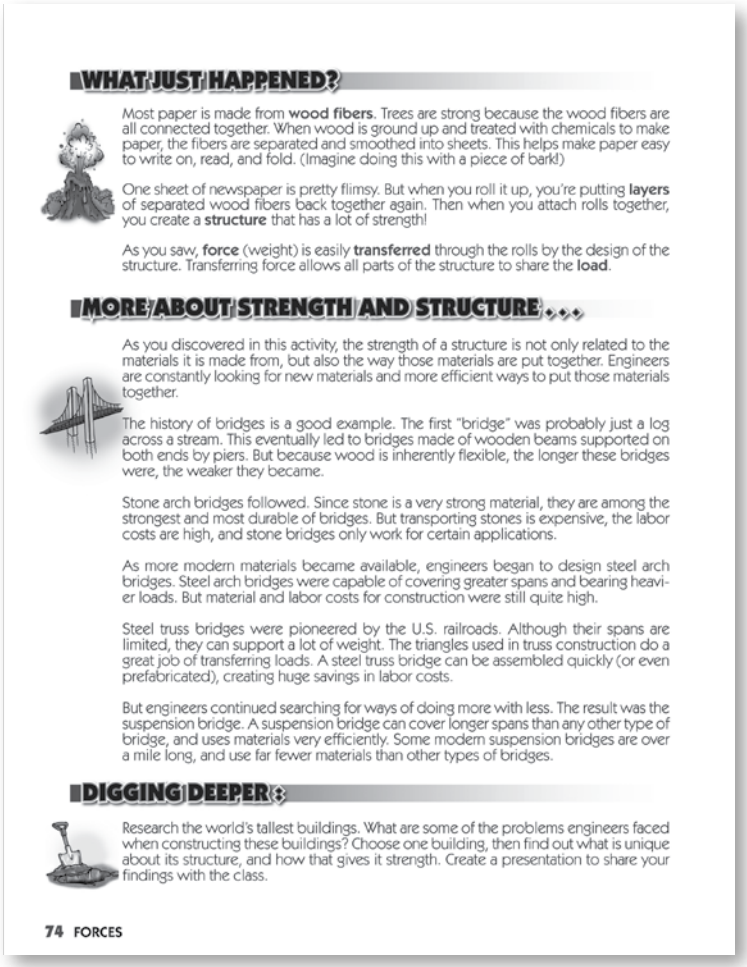
FORCES 73

Teacher to Teacher

A structure's shape is an essential part of its support. In a house, for instance, the weight of the roof is transferred by the shape of the rafters to the walls. The force is then transferred but the shape of the walls to the foundation, and from there into the Earth itself. If these shapes are not well designed, the house will collapse.



WHAT JUST HAPPENED?

Most paper is made from **wood fibers**. Trees are strong because the wood fibers are all connected together. When wood is ground up and treated with chemicals to make paper, the fibers are separated and smoothed into sheets. This helps make paper easy to write on, read, and fold. (Imagine doing this with a piece of bark!)

One sheet of newspaper is pretty flimsy. But when you roll it up, you're putting **layers** of separated wood fibers back together again. Then when you attach rolls together, you create a **structure** that has a lot of strength!

As you saw, **force** (weight) is easily **transferred** through the rolls by the design of the structure. Transferring force allows all parts of the structure to share the **load**.

MORE ABOUT STRENGTH AND STRUCTURE . . .

As you discovered in this activity, the strength of a structure is not only related to the materials it is made from, but also the way those materials are put together. Engineers are constantly looking for new materials and more efficient ways to put those materials together.

The history of bridges is a good example. The first "bridge" was probably just a log across a stream. This eventually led to bridges made of wooden beams supported on both ends by piers. But because wood is inherently flexible, the longer these bridges were, the weaker they became.

Stone arch bridges followed. Since stone is a very strong material, they are among the strongest and most durable of bridges. But transporting stones is expensive, the labor costs are high, and stone bridges only work for certain applications.

As more modern materials became available, engineers began to design steel arch bridges. Steel arch bridges were capable of covering greater spans and bearing heavier loads. But material and labor costs for construction were still quite high.

Steel truss bridges were pioneered by the U.S. railroads. Although their spans are limited, they can support a lot of weight. The triangles used in truss construction do a great job of transferring loads. A steel truss bridge can be assembled quickly (or even prefabricated), creating huge savings in labor costs.

But engineers continued searching for ways of doing more with less. The result was the suspension bridge. A suspension bridge can cover longer spans than any other type of bridge, and uses materials very efficiently. Some modern suspension bridges are over a mile long, and use far fewer materials than other types of bridges.

DIGGING DEEPER

Research the world's tallest buildings. What are some of the problems engineers faced when constructing these buildings? Choose one building, then find out what is unique about its structure, and how that gives it strength. Create a presentation to share your findings with the class.

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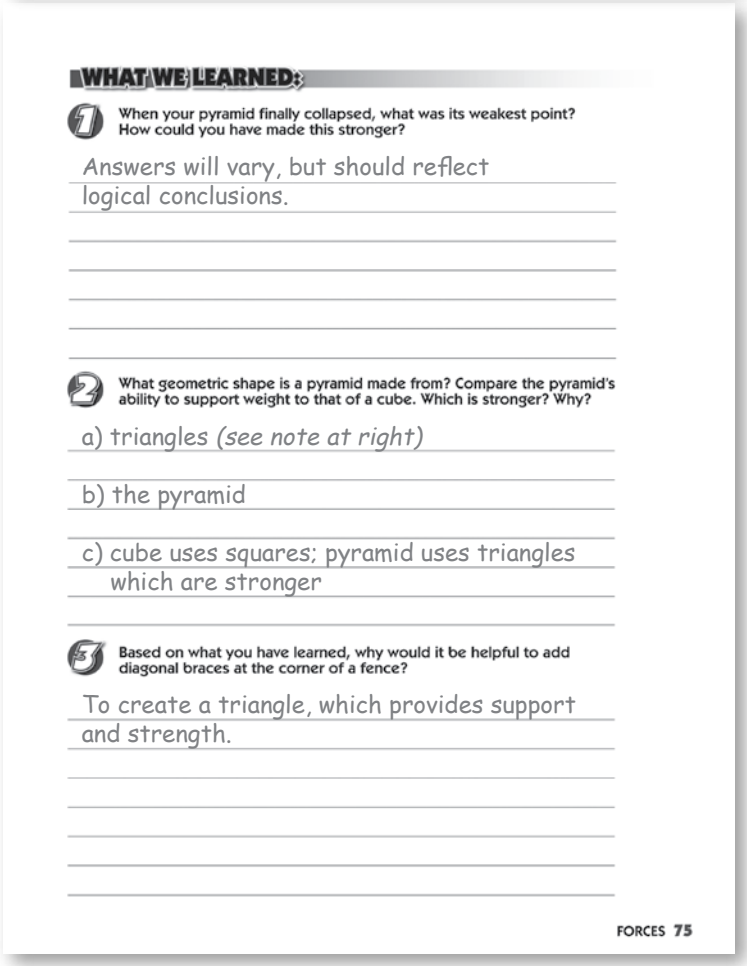

WHAT WE LEARNED:

1. When your pyramid finally collapsed, what was its weakest point? How could you have made this stronger?

Answers will vary, but should reflect logical conclusions.

2. What geometric shape is a pyramid made from? Compare the pyramid's ability to support weight to that of a cube. Which is stronger? Why?

a) triangles *(see note at right)*

b) the pyramid

c) cube uses squares; pyramid uses triangles which are stronger

3. Based on what you have learned, why would it be helpful to add diagonal braces at the corner of a fence?

To create a triangle, which provides support and strength.

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What Happened

Review the section with students. Emphasize bold-face words that identify key concepts and introduce new vocabulary.

*Most paper is made from **wood fibers**. Trees are strong because the wood fibers are all connected together. When wood is ground up and treated with chemicals to make paper, the fibers are separated and smoothed into sheets. This helps make paper easy to write on, read, and fold. (Imagine doing this with a piece of bark!)*

*One sheet of newspaper is pretty flimsy. But when you roll it up, you're putting **layers** of separated wood fibers back together again. Then when you attach rolls together, you create a **structure** that has a lot of strength!*

*As you saw, **force** (weight) is easily **transferred** through the rolls by the design of the structure. Transferring force allows all parts of the structure to share the **load**.*

More About . . .

Have students read this section as you would a traditional science text — or use cooperative learning techniques to allow students the opportunity to work on the material collaboratively.

Digging Deeper

(Optional) Challenge teams to reseach and discuss practical applications of the lesson concepts. Encourage them to share their findings with the rest of the class.

What We Learned

Answers will vary. Suggested responses are shown at left.

***AUTHOR'S NOTE**: (for answer 2a at left)*
If you have a student who is studying geometry, he or she may point out that a pyramid like the one in this activity is technically a tetrahedron (made from triangles). This provides a great opportunity to research geometric shapes and the work of architects like Buckminster Fuller.

Conclusion

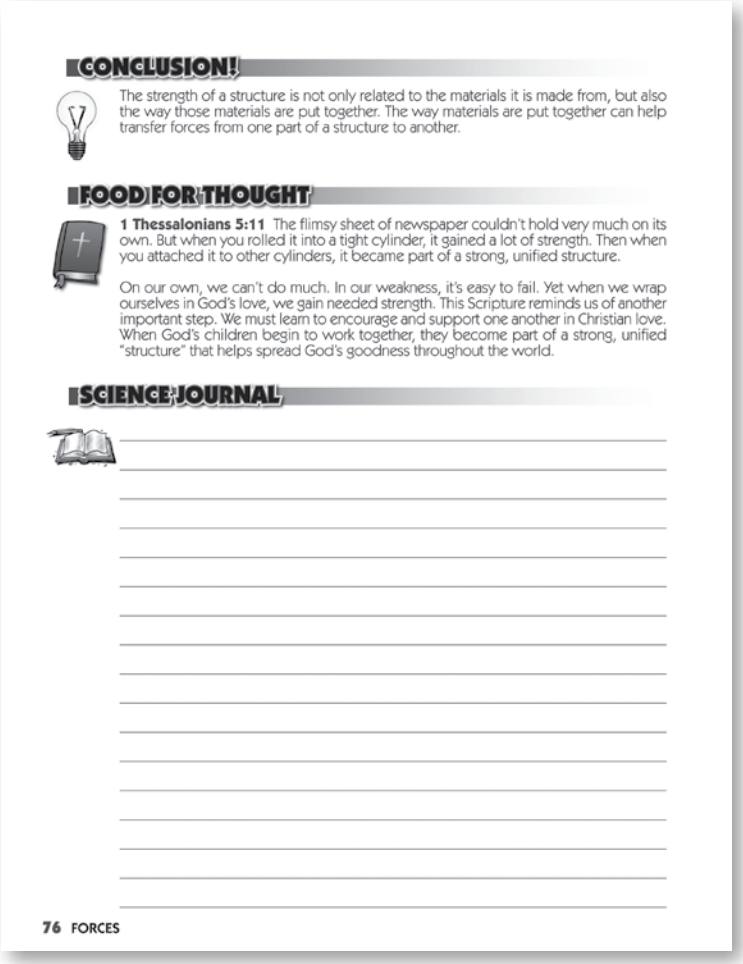
Read this section aloud to the class to summarize the concepts learned in this activity.

Food for Thought

Read the Scripture aloud to the class. Talk about what it means to "wrap yourself in God's love." Discuss how working together makes Christians stronger.

Science Journal

If time permits, have a general class discussion about notes and drawings various students added to their journal pages. Discuss correct and incorrect predictions, and remind students that this "trial and error" process is part of the scientific process.



CONCLUSION!

The strength of a structure is not only related to the materials it is made from, but also the way those materials are put together. The way materials are put together can help transfer forces from one part of a structure to another.

FOOD FOR THOUGHT

1 Thessalonians 5:11 The flimsy sheet of newspaper couldn't hold very much on its own. But when you rolled it into a tight cylinder, it gained a lot of strength. Then when you attached it to other cylinders, it became part of a strong, unified structure.

On our own, we can't do much. In our weakness, it's easy to fail. Yet when we wrap ourselves in God's love, we gain needed strength. This Scripture reminds us of another important step. We must learn to encourage and support one another in Christian love. When God's children begin to work together, they become part of a strong, unified "structure" that helps spread God's goodness throughout the world.

SCIENCE JOURNAL

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Extended Teaching

1. Extend this activity by building other structures from paper rolls (bridges, log cabins, scaffolds, etc). Test for strength and compare results with the original activity. How were they similar? How were they different?

2. Take a field trip to a construction site. Have students examine the framework of the structure being built. Challenge teams to identify how weight is transferred to the ground. Have them write a paragraph about one thing they learn.

3. Invite the manager of a home improvement center to visit your classroom. Discuss products made from wood scraps and other by-products. What gives them their strength? Have students write a paragraph about one thing they learn.

4. Using the Internet, have teams research how wood is turned into paper. Challenge each team to make a poster depicting at least one thing they learn.

5. Have teams research how archeologists think the Pyramids of Giza were made. What materials were used? Where did they come from? How were they moved into place? Discuss student findings.