Once Upon a Physical Science Book

12 Interdisciplinary Activities to Create Confident Readers

Jodi Wheeler-Toppen
Karen Kraus
Matthew Hackett

nsta Press
National Science Teaching Association

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Dedication

For Jon, Natalie, and Zachary
—Jodi Wheeler-Toppen

For Rick
—Karen Kraus

For Carrie
—Matthew Hackett

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About the Authors

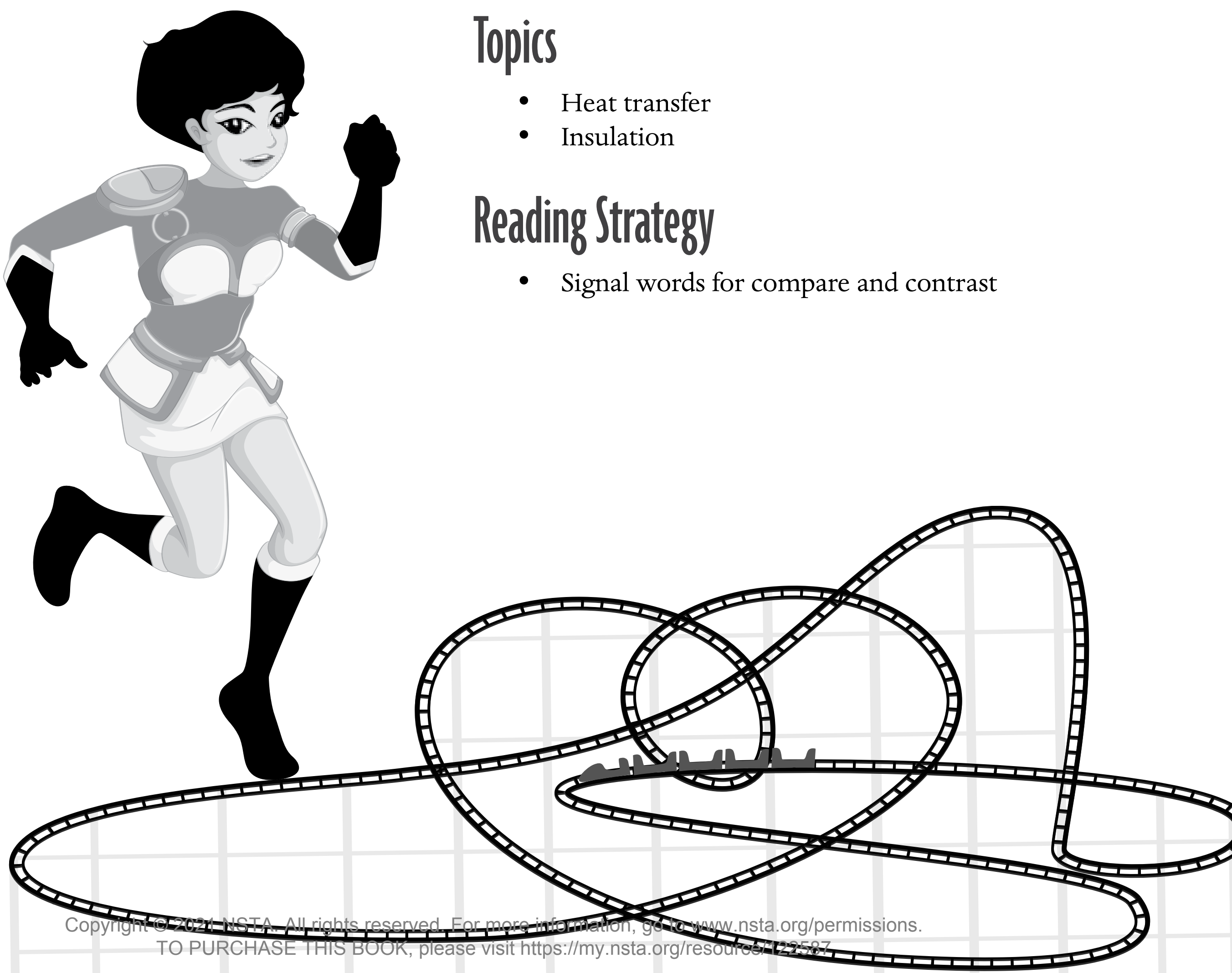
Jodi Wheeler-Toppen is the author of more than 10 science books for children and teachers, including the *Once Upon a Science Book* series with NSTA Press. She has been working in K–12 and teacher education for more than 15 years, with a focus on helping students read and write about science. She loves having adventures with kids—her own and any others who come her way.

Karen Kraus raised and supported a family before teaching middle school science for 13 years in Blue Springs, Missouri. Now in semi-retirement, she continues to work at helping new and experienced teachers improve their instruction. She enjoys traveling to see family, spoiling her grandchildren, and experiencing the wonders of nature.

Matthew Hackett has taught various disciplines for 19 years, including science, mathematics, and reading. He currently teaches sixth- and eighth-grade science in Blue Springs, Missouri. He and his wife coach and volunteer with their church youth group to fill the hours between school days. Matthew is a cat person, but his students remember him for his more exotic classroom pets, including tarantulas, geckos, and snakes.

Chapter 11

How to Not Die in Antarctica



Topics

- Heat transfer
- Insulation

Reading Strategy

- Signal words for compare and contrast

Connections to Standards

Next Generation Science Standards (*NGSS*) Correlations		
Standard **MS-PS3.** Energy (*www.nextgenscience.org/dci-arrangement/ms-ps3-energy*)		
Performance Expectation(s) The materials/lessons/activities outlined in this chapter are just one step toward reaching the performance expectation(s) listed below. **MS-PS3-3.** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.		
Dimension	**Element**	**Matching Student Task or Question From the Activity**
Science and Engineering Practice(s)	• Constructing Explanations and Designing Solutions	• Students use data from their initial coat design investigation and evidence from the reading to design a coat for optimal warmth.
Disciplinary Core Idea(s)	**PS3.B.** Conservation of Energy and Energy Transfer • Energy is spontaneously transferred out of hotter regions or objects and into colder ones.	• Students investigate different types of coat insulators to slow the transfer of heat into an icy environment. • Students read about energy transfer and how it relates to the design of extreme cold weather gear. • Students calculate and analyze data on building materials to recommend the best building material to slow heat transfer in the Thinking Mathematically section.
Crosscutting Concept(s)	• Energy and Matter	• Students investigate different types of insulators to slow the transfer of heat into an icy environment. • In the Thinking Mathematically section, students calculate the R-value (a measure of how well a material blocks heat transfer) and cost of three different building materials to identify the best home insulator option for the price.
Common Core State Standards (*CCSS*) Correlations		
Reading Standard(s)	• **CCSS.ELA-Literacy.RST.6-8.5.** Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic. • **CCSS.ELA-Literacy.RST.6-8.2.** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	• The reading skill asks students to look at how the author uses comparisons and contrasts to structure the article. • The big question asks students to summarize what the article says about the characteristics of good cold weather gear.
Writing Standard(s)	• **CCSS.ELA-Literacy.WHST.6-8.9.** Draw evidence from informational texts to support analysis, reflection, and research.	• Students use information from the text to reflect on their insulation experiments and decide what changes to make in their coats.

Background

This chapter should be used near the end of the study of heat. Before doing this lesson, students should understand that temperature is a measure of the energy of particle motion and have had hands-on experiences with each of the three types of heat transfer: radiation, conduction, and convection. Here, students will look at stopping the transfer of heat through insulation. They'll "suit up" a warm water bottle to see if they can slow the transfer of energy into an icy environment. They'll read about coat design for extreme environments and then improve their coat design.

SAFETY NOTES
The following safety recommendations apply to all activities in this chapter:
- Wear safety glasses with side shields or safety goggles during the setup, hands-on, and takedown segments of the activities.
- Use caution when working with glass or plasticware, which can cut skin.
- Appropriately dispose of lab materials at the end of the activities as directed by the teacher.
- Use caution when working with ice cubes or hot water, which can burn skin.
- Immediately wipe up any spilled water on the floor to avoid slipping or falling hazards.
- Immediately report any lab accident to the teacher.
- Wash your hands with soap and water after completing the activities.

Pre-Reading/Exploration

Materials for Activity (Per Group)

- Safety glasses with side shields or safety goggles
- 2 empty mini water bottles (8–10 oz.) with holes drilled in caps (¼ inch drill bit will create a hole that works for most classroom thermometers)
- 2 plastic sandwich bags for holding bottles and coat filling
- Choice of coat filling materials (whatever materials are available in your classroom setting, including aluminum foil, cotton batting or cotton balls, plastic beads, newspaper, shredded paper, packing peanuts, bubble wrap, corrugated cardboard, felt scraps)
- Tape for holding bag shoulders closed
- Warm tap water (roughly 40°C works well)
- Beaker or graduated cylinder of 250+ ml capacity
- 2 thermometers
- Stopwatch or clock
- Ice
- 4 quart-size plastic bags for holding ice
- 2 gallon-size plastic bags for keeping ice bags snug against the coat
- Freezer or cooler (optional)

Activity

Use With Student Page(s): Controlled Experiment: Bundle Up! (lab sheet)

Before class, prepare two "icy environments" for each group. For each icy environment, fill two quart-size bags with ice and place them inside a gallon bag. The "coats" will be wedged between the quart-size bags, as

Figure 11.1. Coat in Icy Environment

Figure 11.2. Coats Ready for Testing

shown in Figure 11.1. The ice can be reused through several classes if you store the bags in a freezer or cooler in between.

Introduce the lesson by showing photos or videos of researchers working in Antarctica. The Weddell Seal Science multimedia page (*http://weddellsealscience.com/multimedia.html*) has a variety of options. Point out that it is hard for researchers to stay warm while working outside in extreme cold conditions. Hold up one of the small water bottles. Tell students that Captain Water Bottle is going to do some research in Antarctica and will need a good coat. The students must figure out how to make an effective coat that will keep the captain safe. To begin, they will need to gather data on the effectiveness of a variety of coat fillings.

Have each group of students select two coat filling materials they would like to test. To make it easier to reuse materials between classes, each group should use only one type of material per coat (Figure 11.2). If you find your classes are short on time, the coats can be premade and reused. If no one chooses a highly conductive material like foil, measure one yourself to add to the class data. Your class should have usable results in 20 minutes. Have students share their results with the entire class so each group has more data on more types of coat filling to use for their claim.

Reading

Use With Student Page(s): "How to Not Die in Antarctica" (article)

Introduce the Reading. Tell students that they are going to read about the insulation that researchers use in Antarctica to stay warm.

Reading Strategy: Signal Words for Compare and Contrast

To introduce the strategy, begin by displaying the following sentence, with blanks as shown:

> *Given that air transfers heat through convection, you might expect it to be a terrible insulator. However, __________________________________ __________________.*

Ask students to predict what might go in the blank. Students usually guess something about air being good for insulation. Point out that they can make that guess even if they don't know what the word *insulator* means. Ask them which word gave them the biggest clue as to what should go in the blank. (Answer: *however.*) Put up the end of the sentence to confirm their prediction:

… it turns out that very small pockets of air are excellent insulators.

Signal words were first introduced with cause and effect in Chapter 10. If you haven't used Chapter 10 with your students, tell them that certain words and phrases are signals for what the text is about to tell you. The signal word *however* lets you know that two things are different, or that they contrast. When students see a signal word for contrasts, they should pause and ask themselves what two things are being contrasted and how they are different.

Ask students to list other words that might signal a contrast, and add these to the list as appropriate. Students may provide the following terms: *in contrast*, *on the other hand*, *conversely*, *whereas*, *alternatively*, and *instead*. The words *but*, *yet*, and *while* sometimes indicate a contrast.

Now add this sentence beneath the previous sentence, with blanks as shown:

In thick wool socks, the air is trapped between the cotton fibers. Similarly, a down coat _____________.

Ask students to predict what might go in the blank. They may not know how a down coat traps air. But with coaxing, they can probably predict that the rest of the sentence will have something to do with trapping air. *Similarly* is a signal word for comparisons, or explanations of how two things are the same. When students see a signal word for comparisons, they should ask what things are being compared and how they are alike. Have students list other possible signal words and phrases for comparisons, including *similarly, in the same way*, *just like*, *just as*, *likewise*, *too*, and *also.*

Journal Question

After students have completed the reading, give them the following prompt for their reading journals, which will help them internalize the strategy they practiced. Write a short paragraph comparing and/or contrasting this year's science class with your class from last year. Use at least two signal words and underline them.

Application/Post-Reading/Writing

Note: We strongly recommend asking students to revisit their coat filling materials and attempt to engineer a coat that will work better than those tested in the original experiment. However, engineering projects are beyond the scope of this book. If you choose this option, you may wish to edit the writing assignment to reflect their engineering experience.

- **Writing Prompt.** Pick the coat from the test with the best results and describe what changes you would make to it if you were using that material to make a coat for people. Why would you make those changes? Use information from the article "How to Not Die in Antarctica" (p. 159) to help you form your response.
  - **Pre-Writing Suggestions.** Ask students what information from the article helps explain the changes they would make. Have them think about what science words they want to include. Ask how they might integrate a sketch into their writing to help illustrate their ideas. (Students can use phrases such as *this picture shows* and *as you can see in the diagram*.)
  - **Key Evaluation Point.** Answers will vary, but students are likely to discuss at least one of the following topics based on the reading: air trapped in small spaces for insulation, water resistance and wicking, comfort of the coat, smell absorbency, or weight of the coat.
- **Thinking Mathematically.** Students will calculate the cost of insulation materials using the worksheet A Different Kind of Wolf (p. 162).

Controlled Experiment: Bundle Up!

You are a textile engineer trying to select a filling material for a new coat. You need to find the best choice for helping Captain Water Bottle stay toasty for 20 minutes in an icy environment. You will be testing two coats, each with a different filling material.

1. To begin, look at the filling materials available. Decide with your group which two you want to test.
   a. Which two have you selected?

   b. Why did you choose them?

2. Prep your coats. The basic design has already been selected by another team at your company.
   a. Place a mini water bottle inside each of the plastic sandwich bags provided for you.
   b. Surround the water bottles with your choice of coat filling. Use only **one** type of filling in each coat. What variables will you need to control to make sure that the only difference between the coats is the filling material? Sketch your two coats here and label what you will do to keep them the same.

   c. Tape the sides of each bag closed to ensure the contents of your coat filling stay in the coat. The bottle opening should still be visible and above the edges of the seal.
   d. Carefully pour 150 ml of very warm tap water into each bottle.
   e. Screw the caps onto the water bottles. Insert the thermometers into the holes in the caps.
   f. Quickly measure the water temperature in each bottle and record it in the Water Temperature Data Table under Initial Water Temperature.

3. Now it's time to test the effectiveness of each coat under cold conditions.
   a. Take your coats to the icy environment your teacher has prepared.
   b. Set a timer for 20 minutes. After 20 minutes, record the water temperature of each bottle.

Water Temperature Data Table

Coat Filling Material	Initial Water Temperature (°C)	Water Temperature After 20 minutes (°C)

4. Share the results with your class. Then use the class data to make a claim. Give the evidence and reasoning for your claim, as well.
   a. Claim: Based on our results, we recommend using ____________ as the filling for the coat.
   b. Evidence (What data supports this claim?)
   c. Reasoning (Explain how your controlled experiment gives you confidence in your data. If you do not feel confident about your data, explain why.)

How to Not Die in Antarctica

REMEMBER YOUR CODES
! This is important.
✓ I knew that.
X This is different from what I thought.
? I don't understand.

Weddell seals thrive in the ice and snow of Antarctica. Jay Rotella, a professor at Montana State University, heads the Weddell Seal Project that studies them. For two months each year, Rotella's research crew packs up and moves onto the ice to count, weigh, measure, and observe the seals (Figure S11.1).

Packing for this kind of camping trip is a big deal. Instead of tents, the researchers bring four small cabins made from metal shipping containers. They set the containers onto giant skis and drag them behind snowmobiles to a spot near one of the seal colonies they will study. For clothes, each researcher brings two duffle bags of ECW gear.

Figure S11.1. A Seal Pup Sighted by Rotella's Team

Source: Jay Rotella, Weddell Seal Project, photo of Weddell seal was obtained under NMFS Permit 21158.

E-C-What?

ECW (extreme cold weather) gear is special clothing issued to every U.S. researcher who travels to Antarctica. The clothes are designed to help the scientists survive in this harsh environment. What materials work well for ECW gear? As you've probably observed, materials vary in how well they stop heat from moving. Lay your hand on a metal cabinet, and it feels cold. Touch a book in the same room, and it doesn't feel as cold. The cabinet and book are the same temperature—room temperature. However, heat moves through the metal cabinet more easily than it moves through the book. If you want to survive in Antarctica, you'd better pack materials that limit the flow of heat, called insulators.

Getting Colder

The seal researchers lose some of their precious heat as radiation, or electromagnetic waves, carry heat away from the body. They can also lose heat by conduction. If a researcher grabs a metal drill with bare hands, for example, she will feel the heat moving into the drill. Although they lose small amounts of heat to radiation and conduction, the researchers lose the most heat through convection.

Figure S11.2. A Researcher Without a Hat Loses Heat Through Convection

To understand why convection is such a dangerous source of heat loss, imagine that a researcher heads into the Antarctic cold without a hat. His head is warm and heats the molecules of air nearby. Those molecules move faster, spread out, and float away, as shown in Figure S11.2.

Colder molecules rush in to fill the gap, and the process repeats. There is an endless supply of cold air to draw heat away, until the researcher puts on a hat—a puffy hat, with plenty of room for air.

Getting Warmer

Wait, a puffy hat with room for *air*? Given that air transfers heat through convection, you might expect it to be a terrible insulator. However, it turns out that very small pockets of air are excellent insulators. Air is not a good conductor. It also does not radiate heat very well. When air is trapped in small spaces, it cannot form efficient convection currents either. Insulating clothes are usually made from a material that radiates slowly and does not conduct heat well. That material is used to trap air.

For example, in thick wool socks, the air is trapped between the wool fibers. Similarly, a down coat traps air in goose or duck feathers (Figure S11.3) held between fabric layers. In foam, the pockets of air give the material a spongy feel.

When making ECW gear, another important factor to consider is water. Researchers' clothing can get wet from water in the environment. It can also get wet from perspiration. For instance, Weddell seal researchers can break into a sweat while slip-sliding after seal pups! Water leads to heat loss through both conduction and convection. Therefore, Antarctic researchers need fabrics that prevent water from the environment from soaking in and that draw sweat away from skin.

Figure S11.3. Feathers Trap Air Between Bits of "Fluff"

Cozy and Comfortable

The best ECW gear meets a few other requirements, as well. It should be comfortable, of course—who wants to deal with itchy or scratchy clothing? Furthermore, it should be lightweight. Every extra pound has to be hauled on long, tough walks across the ice. And, ideally, the cloth would not absorb odors. Researchers often need to wear the same clothes for days on end. Everyone on the expedition is happier if their clothes don't stink!

To achieve these goals, ECW clothes consist of at least three layers. The inner layer conducts as little heat as possible while wicking moisture away from the skin. It should also be soft and comfortable. By contrast, the outer layer is tough so that that it doesn't rip or wear away, and it has a coating to keep out rain and wind. The middle layer is usually the thickest and contains many pockets of air for insulation. (See Figure S11.4.)

Figure S11.4. Wearing ECW Gear in the Field

Source: Jay Rotella, Weddell Seal Project.

Rotella and his team may wear even more layers because the temperature can change dramatically while they are working. The morning may start with a windy snowmobile ride during which temperatures can hit −20°C. But by afternoon, the researchers may be lifting heavy seal pups in 20°C temperatures. On such a day, the team might start out wearing waterproof boots, long johns, insulated pants with a bib, a turtleneck, a fleece top, a thin down jacket, a work coat, a scarf-like neck warmer, sunglasses, a hat, and a hood. By afternoon, they may need to take off the jacket, the coat and hood, and even the neck warmer to avoid building up sweat that might turn icy later. Rotella and his team take the cold weather seriously and know the right clothes will keep everyone as warm and cozy as the seals they study.

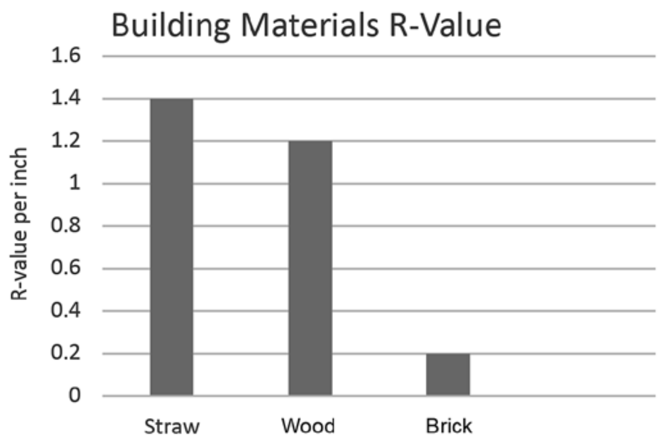
The Big Question

Based on this article, describe the characteristics of good cold weather gear. Use the word *insulator* as part of your answer.

Thinking Mathematically: A Different Kind of Wolf

The story of the *Three Little Pigs* was about building strong houses to keep the wolf out. But real-life builders have another "big bad wolf" to consider: heat. Buildings need to keep heat out on a summer day and heat in on a winter day. This has more to do with putting in lots of insulation than building with strong materials.

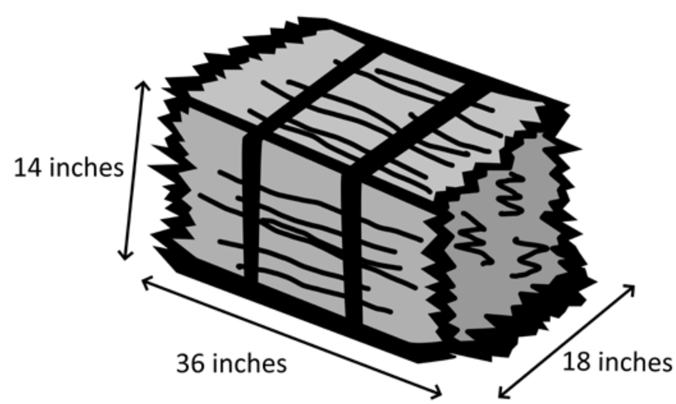
Builders rate insulation with an *R-value*: a measure of how well a material blocks heat transfer. A higher number means the material is a better insulator. Take a look at the Building Materials R-Value chart and answer the questions that follow:



1. Which little pig home building material slows heat transfer the best?
2. How many inches of brick would it take to equal the heat-stopping power of one inch of straw?

Now you will choose what material—straw, wood, or brick—gives the most insulation for the best value. Selecting building materials involves a combination of different decisions, including considerations about cost. To make calculations easier, all materials will be sold in similarly sized units. A bale of straw (Figure S11.5) will be used to set the dimensions for each unit of material. This bale of straw is 18 inches thick. It will take about 16 boards or about 135 bricks to make a pile the same size as the bale of straw.

Figure S11.5. Bale of Straw



Find the cost of each unit of material by multiplying the amount of material by the cost.

- 1 bale of straw × \$5 per bale = ___________ cost for a unit of straw
- 16 boards × \$4 per board = ___________ cost for a unit of wood
- 135 bricks × \$0.50 per brick = ___________ cost for a unit of brick

At 18 inches thick, what is the total R-value of each of the building materials?

- 18 inches of straw × ________ R-value per inch = ___________ total R-value
- 18 inches of wood × ________ R-value per inch = ___________ total R-value
- 18 inches of brick × ________ R-value per inch = ___________ total R-value
- Which material represents the best value? ___________
- What evidence would you use to justify this answer?

- A wall that is two straw bales deep would have an R-value of about 52. It would take three layers of wood to get the same result. How many units deep would a brick wall have to be to reach an R-value of 52?

- If you're trying to keep heat in or out of your house, which building material would you want to use?

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Once Upon a Physical Science Book

12 Interdisciplinary Activities to Create Confident Readers

I am excited about the release of this book. My school district has been using the *Once Upon a Science Book* series for our sixth and seventh graders to promote the integration of literacy into the science classroom. This resource makes that integration quite seamless. The lessons provide the support necessary to help teachers with literacy strategies, as well as content.

—**Rabieh J. Hafza, PhD,** grade 6–12 science coordinator, Atlanta Public Schools

The authors of this book have been in your shoes. These experienced science teachers know what it's like to work with students who struggle to understand their science texts. *Once Upon a Physical Science Book* came about because they couldn't find a resource that shows how to integrate reading, writing, and physical science—so they wrote one themselves.

Practical and easy to use, *Once Upon a Physical Science Book* provides everything you need to boost students' skills in science and reading at the same time. It starts with advice on teaching reading-comprehension strategies to middle school students. Then the 12 content chapters give you

- Hands-on physical science lessons with engaging titles such as "The Smash-Masters," "Energy's Wild Ride," and "How to Not Die in Antarctica."
- Readings that cover key physical science concepts, including physical and chemical properties, inertia, energy, magnets, and waves. The readings support the *Next Generation Science Standards* and the *Common Core State Standards*.
- Writing activities to connect what students did with what they read, plus "Thinking Mathematically" activities.
- Assessment exercises to give you feedback on what your students are learning.

A follow-up to NSTA Press's *Once Upon a Life Science Book* and *Once Upon an Earth Science Book*, this resource emphasizes the special ability of science teachers to improve students' literacy skills. As the authors note, "The good news is that there are many parallels between how people learn science and how they learn to become better readers. … As you and your students work through these lessons together, you will be able to watch their confidence as readers—and your confidence as a reading educator—grow."

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Grades 6–8

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