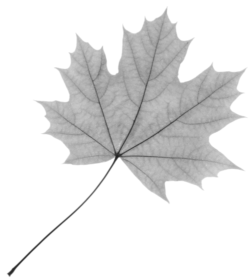
Sharing Books
TALKING SCIENCE



Valerie Bang-Jensen • Mark Lubkowitz

FOREWORD BY LESTER LAMINACK

Sharing Books TALKING SCIENCE

Exploring Scientific Concepts with Children's Literature

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Portsmouth, NH

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Portsmouth, NH 03801–3912
www.heinemann.com

Offices and agents throughout the world

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Library of Congress Cataloging-in-Publication Data
Names: Bang-Jensen, Valerie, author. | Lubkowitz, Mark, author.
Title: Sharing books, talking science : exploring scientific concepts with children's literature / Valerie Bang-Jensen and Mark Lubkowitz.
Description: Portsmouth, NH : Heinemann, [2017] | Includes bibliographical references.
Identifiers: LCCN 2016044776 | ISBN 9780325087740
Subjects: LCSH: Science—Study and teaching (Elementary). | Literature and science.
Classification: LCC LB1585 .B26 2017 | DDC 372.35/044—dc23

LC record available at https://lccn.loc.gov/2016044776

Editor: Katie Wood Ray
Production: Vicki Kasabian
Interior and cover designs: Suzanne Heiser
Cover image: books © Getty Images Prestige/Holloway
Typesetter: Kim Arney
Manufacturing: Steve Bernier

Printed in the United States of America on acid-free paper
21 20 19 18 17 PAH 1 2 3 4 5

This one's for our kids:

Bree and Nell, and Jax and Zander.

CONTENTS

FOREWORD

I marvel at folks who can take something complex and present it as if it were common sense. I stand back and study how they break it down and present it in a manner that leaves me thinking, *How come I didn't think of this?* That is exactly how I felt by the time I reached the end of the first chapter in this book. And on the last page I would have given Valerie and Mark a standing ovation had I been in their audience. This work is smart yet they make it so very accessible.

Perhaps it is the pairing of an education professor and a biology professor as coauthors that brings this particular focus and wisdom to the page. Clearly it works to merge the passion for literature and the passion for science into a passion for teaching. The current attention given to STEM/STEAM has many of us exploring new ways to make science more accessible, more practical, more inviting to our students, and less intimidating for ourselves. Mark and Valerie have given us a new tool to do just that. Together they provide us with a lens for noticing science everywhere, and most happily, in the pages of many of our favorite picture books. There are the expected titles with a science focus, and you'll be pleased to find many of the recommended authors' names printed on the spines in your nonfiction collection. But you'll be surprised when they gently lead you to notice how the principles of science and the seven crosscutting concepts can be found in the plots and structures of some of your favorite fiction. It is amazing what you see when you are wearing different glasses.

Valerie and Mark show us how to notice and name pattern, cause and effect, structure and function, scale, systems and system models, energy and matter, and stability and change in a variety of genres. Along the way they help us recognize how these seven crosscutting concepts overlap and weave a broader and deeper understanding of the world. As you proceed through the book you will find yourself developing what they refer to as a *scientific habit of mind*. Those of us who live our lives in the reading–writing world are familiar with the idea of "living a writerly life." We naturally approach a text with a reader lens or a writer lens. In this book Mark and Valerie nudge us to live a scientific life: to think like a scientist, talk like a scientist, and read like a scientist so that we question the texts we encounter and come to notice what has been there all along. They give us a new way to revisit texts for different purposes and, as with anything, this emerging awareness brings life into focus in new and interesting ways. We get a fresh look at science while we develop the schema necessary for organizing our learning and building the vocabulary that will enable us to communicate our insights, formulate our questions, and develop deeper conceptual understandings.

Read-aloud sessions have been given much more attention in recent years. We have come to recognize the power of bringing children into the flock of readers with brilliant models of literature delivered on the cadence of a well-practiced voice. We have seen the power of sharing books and visiting them again and again as we lift ideas, vocabulary, and craft to the surface for our students to notice and learn to employ on their own. I celebrate that attention to literature and to the seemingly magic power of read-aloud experiences. Now we have another powerful reason to read aloud to children across the grades and throughout the curriculum. Valerie and Mark have merged their worlds of literature and science into a practical, accessible, commonsense tool for the rest of us.

—Lester Laminack

To think like a scientist is to remember that a system is stable, changing, or both, depending upon scale.

4

STRUCTURE AND FUNCTION

Appreciating the Paper Clip

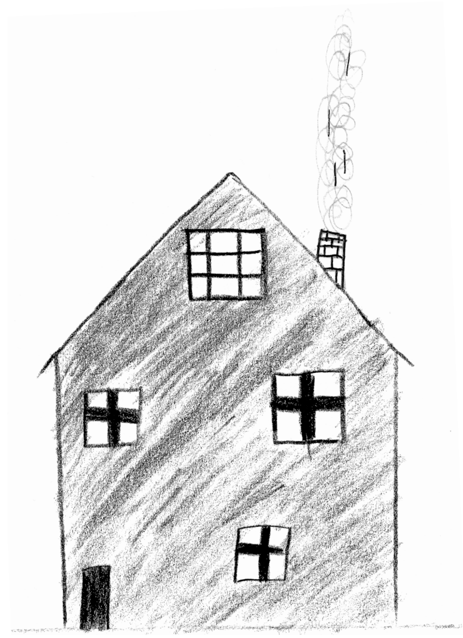

Figure 4.1
The structure of the chimney serves the function of drawing the smoke away from the house.

Learning and Teaching the Science

What You Need to Know: *Structure Dictates Function*

Mark often says that he is not a handy person even though he owns a Sawzall and has used it successfully. But in his pre-Sawzall days, he enjoyed wandering the tool aisles of the local hardware store trying to figure out the purpose and use of all of the oddly shaped tools and foreign objects. Like Mark, we all deduce that this is how structure and function works—the structure of an object tells us what it does. (See Figure 4.1.)

Helping your students see structure and function relationships is a key step in developing an understanding of how things work in the world. All of us have watched young children grab a tool and intuit how to use it, but how? What are the visual clues? Watch the children in your classroom as they pick up a pair of scissors. The handle provides a visual clue of how they should interact with it and even how to use it. The same is true of a handheld hole punch. A child will very quickly deduce how to use one because the shape provides clues. One of

Mark's favorite ways to teach this idea is to give students tools—the more unorthodox the better—and have them guess the functions. More times than not they get it right, and when they discuss how they deduced the purpose of each tool, they often reveal one of the central types of cause-and-effect relationships found in science—structure dictates function.

In addition to tools, you can use familiar items such as staplers, scissors, eating utensils, and clothes hangers to lead students to the understanding that *structure dictates function*. Ask a child which utensil he or she would use to eat soup: a spoon or a fork. Why? Why do scissors cut paper but staplers don't? If you straighten a clothes hanger, does it still work? Questions like these help children see that this is how structure and function works—the structure of an object tells you what it does.

Developing Your Lens: Three Key Ideas

Shape Matters

Shape matters and the perfect place to see this is in a simple paper clip. Show your class a paper clip and ask your students to describe what it does. It is almost always easier to start the discussion by having the class define the function of the object rather than the structure. Function is typically more apparent because most of us think about *what a thing does* before *how its shape enables it*. We approach and even group objects by their function; the hardware store does not organize tools by shape, rather, tools are arranged by what they do. After your students have explained the function of the paper clip, straighten it, and ask them if it can be used to hold paper (be prepared, someone will try to jab the straightened paper clip through a stack of papers). The straightened paper clip no longer functions as it did because the shape changed. Shape dictates function.

This is the pillar of structure and function: because the structure enables the function, it is a type of cause-and-effect relationship. Objects, molecules, and life-forms come in a myriad of shapes, and the physical shape and properties of each determine what it can do and its strength and govern what it can interact with. Butterfly wings work because of their shape—they have a large surface area and are thin—which allows this insect to stay aloft by fluttering. On the other hand, airplane wings are not light nor thin but their shape creates lift when they move through the air.

Even interactions are governed by shape. Imagine you are asked to pick up a handsaw. No doubt you will grab it by the handle and not the blade simply because the shape of the grip matches your hand and the blade does not. This principle of interactions based on shape is a foundational idea in biology. Grasping tails, extended giraffe necks, canine teeth, and cocklebursonly work because of their shape. We can even see how shape matters in species that interact. For example, the hummingbird's beak fits the cardinal flower's tubular shape. In many ways, this is analogous to a Phillips-head screwdriver and the matching screw—the two work together because their shapes fit and are complementary.

Physical Properties Matter

Returning to the paper clip, now use a piece of string to make the shape of a paper clip on a desktop and ask the class if this new paper clip can hold paper. This reveals the second key idea of structure and function: physical properties matter. The string may have the right shape but it is has the wrong physical properties because it is made of the wrong material.

The physical properties of a structure greatly contribute to how well it works. A paper kite can fly because it is light; one made of flattened tin cannot. Structures can be light or heavy, smooth or rough, rigid or flexible, or porous or solid, to name a few. Several years ago, Mark judged a science fair where third grader Ben tested the flying ability of paper planes made from different weights of card stock. Mark asked him what would happen if he made the same plane from a paper towel or sheet of rubber. Ben furrowed his eye brow, wrinkled his forehead, and answered with complete confidence, “Why would I do that? It wouldn’t work.” Clearly, the building materials help determine the success of a flying machine. The same is true of life-forms, objects, and molecules. For example, the skeleton is a supportive structure not only because of its shape but also because the minerals that serve as building blocks of the bones impart stiffness. A more dramatic example is skin. Thankfully, skin is quite elastic and it has to be, otherwise we would rip and tear every time we smiled, laughed, or even wiggled a finger. The elastic nature of skin comes from the gel-like molecules that are arranged in such a way as to allow plasticity. Understanding that shape and physical properties matter is the gateway to being able to see structure and function relationships in the biological and engineered worlds.

QUICK START FOR

Thinking About Structure and Function

To understand the relationship between structure and function, remember the two key ideas: shape matters and physical properties matter.

Ask: “What does it (object, plant or animal part) do?”

Ask: “What’s its shape?”

Ask: “What are its physical properties?”

Ask: “How do the shape and physical properties enable its function?”

(See Figure 4.2.)

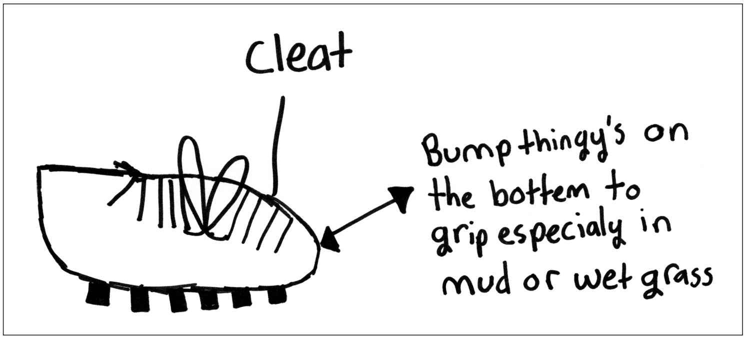

Figure 4.2
Eliza applies the quick start to her cleats.

Evolution and Intent Matter

As a scientific concept, structure and function are specific to biology (the result of evolution) and engineering (the result of intentional design). Two simple questions will help your students see structure and function at work in these two worlds. In the natural world, ask, "How does this structure help this animal or plant survive or reproduce?" In the engineered world, ask, "What problem (i.e., function) was solved by the builder of this structure?"

Recognizing that structure dictates function is a critical concept for students to understand both engineering and biology. The engineered world is a good starting place because it is all around us and children have many firsthand experiences with purposefully designed and built objects. People, whether they be engineers, carpenters, or children in the Lego bin, design and then build objects to fulfill a specific function. Take, for example, two swings on a playground. The first swing is a small, bucket-shaped structure with leg holes and a harness. With no other information, the structure suggests that this swing was designed for very young children. On the other hand, a swing consisting of a wooden plank dangling from chains twenty-five feet in length calls to an older and more daring age group. Both swings were designed with intent, and at its core this is what engineering entails: solving a problem by designing the proper structure for a given function. The bucket swing holds toddlers (and excludes even the most tenacious teenager) and the plank swing is only safe for the older group.

After your students have become more adept at seeing how structure dictates function in the engineered world, they are ready to wade into the murky waters of biology. Your students may notice that we are not the only animals that build structures for a specific function; birds build nests to rear young, bees build hives to store honey and hatch offspring, and beavers build dams to create a habitat, to name a few. These animals do not engineer solutions to problems but rather these building behaviors are innate. If you discuss animal structures, you may find it helpful to explain the difference between innate behavior (e.g., beavers build dams) and learned behavior (e.g., engineers build dams). Generally, when an animal builds, it is an innate behavior that evolved to help the creature survive or reproduce. You can help students distinguish between learned and innate behaviors by asking, "Did the animal learn to build the structure or was it born knowing how to build it? If they learned it, who taught them, when, and how?"

As we pointed out earlier, the biological world was not designed but rather evolved and is much more diverse, complex, and nuanced than the engineered world. The central tenet that structure dictates function still holds true, but what makes it interesting is that the function of structures in organisms is quite specific: it's to help them either survive or reproduce. Take the moose and the beaver, both of which spend a good portion of their life in water. Ask your students to describe the shape and physical properties of the beaver's tail and the moose's legs. They both facilitate movement in the water, but how? Each has a defined shape that performs a specific function. The beaver's tail allows it to navigate quickly through the water because it is long, flat, and flexible (like a diving fin), and the moose's stiff, stilt-like legs allow it to wade through the water and graze on aquatic plants. Remember, to help your students see that the function of the tail and legs is a product of evolution, ask them, "How does each structure help the animal survive or reproduce?"

As you explore this concept with your students, consider the fact that all structure and function relationships are cause-and-effect relationships, but the reverse is not true. You may notice that some of your students start to confuse cause-and-effect relationships with structure and function. A stone in a brook may cause a ripple to form because of its shape, but the stone's function is not to make the ripple; a stone in a brook does not have a function. Evolution and intent matter, and enabling a function is a key aspect of both.

Exploring Structure and Function in Children's Literature

Structure and function appear in some books in a physically unique way, and many young children are attracted to the physical elements of books that invite them to open flaps, unfold pages, reorient the book, and open pop-ups. Diligent librarians may experience these features as attractive nuisances, but these structures often do a brilliant job at expressing ideas that typical illustrations can't deliver. When Steve Jenkins wants to convey the actual size of a snake skeleton, two gatefold pages allow him to do so. The structure of the book—extra-long pages—enables the function. The reader really gets how long the snake is. Similarly, the structure of the pop-out moon in Eric Carle's *Papa, Please Get the Moon for Me*, serves the function of contrasting the size of the moon with the father and his ladder. Your students will probably love to reminisce about lifting the flaps in board books to reveal the answers to questions or fabric swatches for tactile experiences. They may even remember patting the bunny. Flaps, gatefolds, pop-up pages, and even the book's orientation (landscape or portrait) are physical structures that authors and illustrators use for specific functions.

We can even see structure and function playing out in many genres. In the folktale *Caps for Sale* (Slobodkina), when the peddler naps with an improbably tall tower of caps on his head, it is our innate sense of structure and function that makes this humorous. Dr. Seuss and Shel Silverstein's images appeal to us for similar reasons; we know that a sidewalk doesn't "end" in the middle of nowhere, and a fish can't balance a bowling ball that is balancing a tricycle. Illustrations like these make us all laugh because they turn our sense of structure and function on its head. Whether a book shouts or whispers, you can always call attention to the shape and physical properties of different objects or animals you're discussing. Would Red Riding Hood be able to carry her basket if it were made of concrete? Could the woodsman slay the wolf with a paper axe?

Books That Shout Structure and Function

Books written specifically about structure and function, many nonfiction, are a great way for you and your students to ease into this concept because the text and illustrations are explicitly about this relationship. For example, Steve Jenkins' book *How Many Ways Can You Catch a Fly?* examines the strategies that evolved for catching flies across the animal kingdom and how different animal structures enable this same function; spiders use webs, and geckos use tongues. His book *Creature Features: 25 Animals Explain Why They Look the Way They Do* takes the opposite approach by starting with animal structures and then detailing how each does its function. On one page, Jenkins asks a hamster why its cheeks are fat (structure) and the hamster replies that it stores seeds and nuts in its cheeks (function).

Structure and function are everywhere, of course, but some topics are more accessible to children than others, and they shout this concept on seemingly every page. For students in the elementary grades, we like biology topics such as seed dispersal, pollination, animal parts like teeth and tails, and plant parts such as leaves, roots, shoots, and flowers. If you are interested in engineering, bridges, boats, airplanes, and buildings (castles!) are equally good starting points. Like Steve Jenkins, another nonfiction superstar author, Gail Gibbons, has written several books about animal features that enable unique functions, and she has also written about objects in the engineered world including skyscrapers and cameras. In books like these, the structure–function relationship is explicit and highlighted.

Book Selection and Beginning Conversations

Remember, shape matters and all picture books present objects that have shapes whether they be tails, pedals, or petals, so layering in some talk about structure and function during read-aloud is easy. The most helpful illustrations will allow you to see the connection between the shape and what the object does, like a flyswatter connecting with a fly. Start by identifying the function of the objects or the animal/plant parts in the book; next ask whether the illustrations show how the structure accomplishes this function. When you see a paintbrush, ask your students which end goes in the paint and which end in the hand and how they know. If you get stuck, try to draw parallels to the examples we have given you—screwdriver, saw, paper clip, and butterfly wings. Next, consider how the text complements or enriches this information. The best books weave visual and textual information together to build understanding. A book like *Teeth* (Collard) may show the pointy teeth of a vampire bat accompanied by the word *slice*.

To understand that physical properties matter, consider whether a structure you're discussing needs to be small, large, stiff, plastic, dense, light, or flexible to do its thing. Illustrations are key in helping readers grasp that not just any material would work, and the text often adds details and vocabulary that enrich the understanding. For example, in an illustration from *Mr. Ferris and His Wheel* (Davis), we see an enormous structure; from the text we learn that it is made of a "strong new metal called steel." We can't resist advising here to avoid books that will go over like a lead balloon.

To help you pick books that are *about* structure and function, for students at all grade levels, try the guidelines that follow (keep in mind two key ideas: *shape matters and physical properties matter*).

BOOKS ABOUT BIOLOGY

- Pick a book about a specific animal or plant part, or a specific living function. You want a book that highlights either a structure (such as tails) or function (such as pollination). Remember the whole point of shout books is to teach the reader about the structure and function relationship; some authors start with structure (*What Do You Do with a Tail Like This?* [Jenkins]) and others with function (*Flowers Are Calling* [Gray]) but all end by illuminating this relationship.

- Consider the title. You will know immediately you are on the right track with a title like *A Fruit Is a Suitcase for Seeds* (Richards), but some titles are more subtle, for instance *Aviary Wonders Inc. Spring Catalog and Instruction Manual* (Samworth). If the title hints animal and plant parts, take a look to see if it's about structure and function.

- Finally, apply the litmus test: does the book show what something does (function), what it looks like (structure), and how it does it (structure and function relationship)? For example, a book about pollination would show flowers and insects, the process of pollination, and how their respective structures allow this to occur.

BOOKS ABOUT ENGINEERING

- Consider the title. Find a book whose title suggests problem-solving or design. For example, *Mr. Ferris and His Wheel* tells the story of creating a new ride for the 1893 World's Fair. Some titles *shout* that a book is about solving an engineering problem such as *The Boy Who Harnessed the Wind* (Kamkwamba and Mealer). Similarly, it's easy to predict that David MacCaulay's *Castle* and *Mosque* or any others in this series are about these marvels of design.
- Apply the litmus test: does the book convey the problem (function)? Is it clear how the shape and physical properties of the building materials solve the problem? For example, a girl might experiment with different materials and shapes to build a kite that will fly in a strong wind.

In the following table, we present three books about biology and one about engineering to illustrate how you might guide your students to the key ideas while exploring structure and function. The questions in this table follow a clear pattern for discussing structure and function relationships that apply to any book: students identify the shape of the thing, its physical properties, and how these enable it to function. (See Figure 4.3 for a beginning list of books that shout structure and function.)

TALK PROMPTS for exploring structure and function in books that shout

Use this book to:	Notice this:	Ask this:
Introduce the concept of structure and function in the animal world	*What Do You Do with a Tail Like This?* (Jenkins) challenges readers to guess which animal parts accomplish which functions. For example, one page features different noses, and readers have to guess which animal they belong to. Why does one nose have nostrils on top (an alligator needs to breathe while mostly underwater), while another has twenty-two pink appendages? (The starry-nosed mole uses these to find its way around.) Connections between structure and function are clear to young and older readers.	• What does this nose do (function)? • Describe the nose. What is its shape? • What are the physical properties that allow this nose to dig, breathe, or spray water? • Why are the shape and physical properties key to what each nose does?

continues

Use this book to:	Notice this:	Ask this:
Introduce concept of structure and function in the plant world	*Flowers Are Calling* (Gray) is about pollination and gets the point across by offering a structure–function matching game between flower and pollinator. We see a porcupine and a hummingbird next to a trumpet honeysuckle; it's an easy guess that only the hummingbird's beak will fit inside of the long, tubular-shaped flower. Flower shape, smell, and color all "call" to the pollinator with the best matching structure.	• Describe the shape of the flower. • Describe the shape of the pollinator. • What are the physical properties (weight, size, and flexibility) of both the pollinator and the flower? • How are the shape and physical properties of both the pollinator and flower key to pollination (function)? Remember how the Phillips-head screwdriver works.
Deepen students' understanding by applying what they learned	*Aviary Wonders Inc. Spring Catalog and Instruction Manual* (Samworth) humorously mimics a catalog featuring bird parts and invites older readers to "build their own bird" by mixing and matching feet, wings, beaks, and feathers by function. Are you designing a water bird? Buy some webbed feet. Will your bird eat fish? Buy a long pointed beak for stabbing.	These questions focus on beaks: • What do you want your bird to eat (function)? • Which of the beak shapes would enable this? • What are the physical properties of the beak that will enable it to function? Is it stiff? Hollow? Strong?
Introduce concept of structure and function in engineering	In *Mr. Ferris and His Wheel* (Davis), it's a delight to learn that the Ferris wheel came from a boy's observation of a water wheel at a mill. As an adult, Mr. Ferris used his engineering skills to design and build a huge "monster wheel" for the Chicago World's Fair in 1893.	In engineering, always start with the problem to be solved. • What is the problem or goal (the function is to build a Ferris wheel)? • What are the obstacles to building the wheel? • Describe the shape and how it carries people. • What physical properties will enable the Ferris wheel to carry people safely while rotating?

BIOLOGY

Birds: Nature's Magnificent Flying Machines (Arnold)

A Seed Is Sleepy (Aston)

The Tiny Seed (Carle)

Teeth (Collard)

Outside Your Window: A First Book of Nature (Davies)

Monarch and Milkweed (Frost)

Planting the Wild Garden (Galbraith)

Seeds, Bees, Butterflies, and More! (Gerber)

Tell Me, Tree (Gibbons)

Plant Secrets (Goodman)

Animals in Flight (Jenkins and Page)

Creature Features (Jenkins and Page)

How Many Ways Can You Catch a Fly? (Jenkins and Page)

Move! (Jenkins and Page)

Whose Teeth Are These? (Lynch)

Flip, Float, Fly: Seeds on the Move (Macken)

What If You Had Animal Teeth? (Markle)

Isabella's Garden (Millard)

Dandelions: Stars in the Grass (Posada)

A Fruit Is a Suitcase for Seeds (Richards)

Seeds (Robbins)

This Is the Sunflower (Schaefer)

Swirl by Swirl: Spirals in Nature (Sidman)

Feathers: Not Just for Flying (Stewart)

Mama Built a Little Nest (Ward)

You Nest Here with Me (Yolen and Stemple)

ENGINEERING

Building Our House (Bean)

Pop's Bridge (Bunting)

Workshop (Clements)

The Golden Gate Bridge (Doherty)

13 Bridges Children Should Know (Finger)

How a House Is Built (Gibbons)

Airplanes: Soaring! Diving! Turning! (Hubbell)

Boats: Speeding! Sailing! Cruising! (Hubbell)

The World's Most Amazing Bridges (Hurley)

Bridges: Amazing Structures to Design, Build, and Test (Johmann and Rieth)

The Boy Who Harnessed the Wind (Kamkwamba and Mealer)

Building a Bridge (Macken)

The Brooklyn Bridge: A Wonders of the World Book (Mann)

Twenty-One Elephants and Still Standing (Prince)

You Wouldn't Want to Work on the Brooklyn Bridge! An Enormous Project That Seemed Impossible (Ratliff)

Golden Gate Bridge (Riggs)

Let's Go to the Hardware Store (Rockwell)

Bridges Are to Cross (Sturges)

Queen Victoria's Bathing Machine (Whelan)

Figure 4.3

A beginning list of books that shout structure and function

Topic Spotlight: Seed Dispersal and Bridges

Seed Dispersal in a Nutshell. The role of fruit in seed dispersal is the ideal topic for introducing structure and function in the biological world because the two key ideas—shape matters and physical properties matter—are apparent and just about all students have firsthand experience with fruit. Flowering plants spread their seeds using fruit, and there are many titles that show this effectively. *Flip, Float, Fly: Seeds on the Move* (Macken) shouts the ways that the function of seed dispersal depends on the structure of the fruit. The illustrations in this book show how each type of plant uses a different type of dispersal: wind, water, animals, or flinging. Each of these methods depends on the structure of the fruit that encases the seed. For example, a bat eats the fleshy part of a fig, and then poops it out with seeds intact. The round coconut can float like a beach ball; the air inside makes it buoyant, just as floaties help children swim. Another illustration effectively shows how the spiky Velcro-like structure of seeds with burrs enables them to travel by hitchhiking on birds, animals, and human socks. Some seeds are dispersed by the wind, and the maple tree's helicopter-shaped samara is an efficient structure for this mechanism. One of the more surprising mechanisms may be how a seed pod, like lupine, dries and splits, which then flings the seeds.

Studying structure and function in any book on seed dispersal is as easy as asking:

- How does the seed travel? This is the function of the fruit.
- What's shape of the fruit? Is it round, parachute-like, long, spiky?
- What are the physical properties of the fruit? Is it heavy, flexible, light, stiff?
- How do the shape and physical properties enable the fruit to disperse its seeds? Look for responses that link the two. Burrs attach to animal fur or socks *because* they are spiky fruits.

We observed a first-grade teacher do exactly this with a book on monarchs that featured milkweed seeds drifting on the wind. When she asked how the shape and physical properties allow the seeds to travel, the students responded with ideas like, "Because the white stuff spreads like a fan or peacock. It catches the wind," and "It is like a hot air balloon. The heavy seed part is like the basket and the wind blows the white fluffy part like a balloon."

During an activity like this there is no set vocabulary; you really just want students to use words that accurately describe either the shape or the physical properties. Watch out for observations about the chemistry of fruit (smell, color, and taste), which are pattern and cause and effect (see Chapters 2 and 3), because although they attract animals to disperse the fruit, they do not affect the structure.

Remember that structure and function have a type of cause-and-effect relationship, and an effective way to help students understand this is by having them complete the sentence: "If ____________, then ____________." The first blank is completed with an observation about the structure followed by the effect this would have. See Figure 4.4.

Bridging to Engineering. You can't beat bridges as an engineering topic. These structures provide the opportunity to explore with your students one of the most fundamental questions of the designed world—how do we get to the other side? The possibilities are endless; the other side could be across a street, river, lake, canyon, or any other space that needs to be safely traversed. A bridge may not even be the answer—sometimes a zip line is what you really need—but that is what engineering is all about: solving a problem. If the function of a bridge is to span a space (e.g., the problem) then the engineer's job is to design the structure (e.g., the bridge) that will do this.

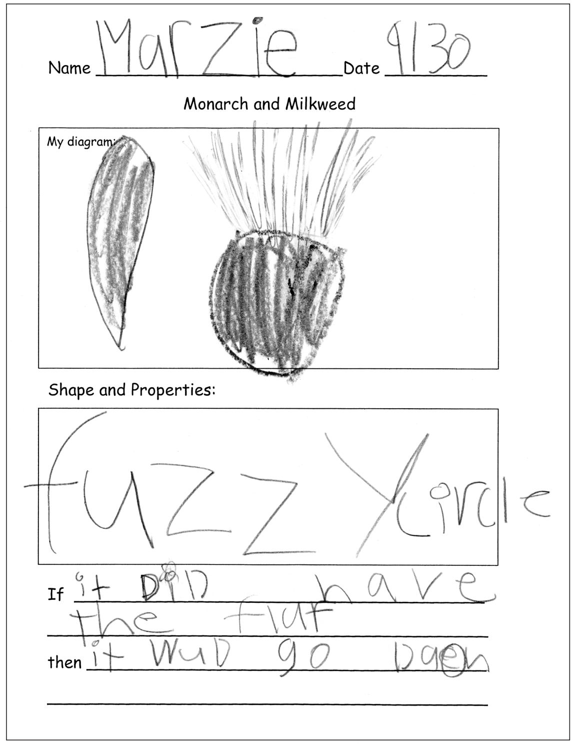

Figure 4.4

Marzie's pictures show that she understands structure and function

Fruit or Vegetable?

The term *fruit* is often confusing because the grocery store definition is different from the scientific one. Scientists define fruits as structures that develop from flowers and house seeds, which means that oranges, apples, squash, and peppers are all fruits—if it has a seed inside it, it is a fruit (yes, a green bean is also a fruit).

A trio of delightful picture books expertly depicts the challenges faced in completing the Golden Gate and the Brooklyn Bridges, two engineering landmarks. *Pop's Bridge* (Bunting) details the construction challenges of spanning the San Francisco Bay. Students will love the unique weight test described in the aptly titled *Twenty-One Elephants and Still Standing* (Prince). *Bridges Are to Cross* (Sturges) shouts about structure and function through impressive paper collage illustrations, captions, text, and sidebars. This engaging compendium of bridge structures will help any student see how each obstacle—river, mountain valley, busy highway—requires a carefully designed structure to cross. In one example, the island neighborhoods of Venice are connected by pedestrian bridges with steps; the structure of these bridges only has to support foot traffic. Architects of the Tower Bridge of London connected the two banks of the Thames River but also accommodated river traffic below with a drawbridge. You and your students can explore the many functions of bridges—to carry water (aqueducts), defense (castle moats), and transportation (pedestrian, car, train) with an eye to understanding the challenge that bridge builders face: what structure and materials will help them create the workable solution?

Studying structure and function in any book about bridges is as easy as asking:

- What problem does this bridge solve? This is the function.
- Who or what will cross this bridge? How do they cross—walk, drive, bike, or other method? This is part of the function; it will determine the shape and physical properties.
- What is the space like that has to be spanned by the bridge? Is it long? Deep? Windy? This will determine the shape of the bridge and what it is made of (physical properties).
- What is the shape of the bridge and what's it made of?

The age and experience of your students will determine how deep you go into various structures and why they work. Most students do not need to learn about load distribution, but they will benefit from understanding that some shapes and materials work better than others for different functions.

In addition to exploring structure and function, you might also find opportunities to talk about how bridges are universal symbols in the designed and literary worlds. They are cultural icons (London Bridge), historical turning points (General Burnside's Bridge in the Battle of Antietam), engineering marvels (Golden Gate Bridge), and literary devices (*Bridge to Terabithia* [Paterson]). Bridges span spaces both literally (the Mississippi) and metaphorically (*that's water* *under the bridge*). We even use the bridge metaphor to describe life decision making: *burning your bridges* and *crossing a bridge when you get to it.*

Books That Whisper Structure and Function

We typically find that books whisper about structure and function in one of two ways. Some books use the principles of this concept to resolve an aspect of the plot. For example, in the classic tale "The Three Little Pigs," each pig builds a house (same structure and function) but they change materials, which as we all know has real consequences for two of the three pigs. You could launch an interesting discussion by considering whether there would even be a story if all three pigs had chosen the same building material. In the powerful true story of *Henry's Freedom Box* (Levine), an enslaved man mails himself from Virginia to free Philadelphia. Although escaping slavery is the sobering theme of the book, Henry's successful escape hinged on constructing a box that would hold him, allow him to breathe, and protect him through his daring and arduous journey. Both of these books show how structure and function help to resolve a problem.

Other books whisper about structure and function through illustrations that reflect either evolution or intent. Playing I Spy with the illustrations in any picture book encourages students to notice incidental examples of structure and function in illustrations of everyday life. Students will begin to see these everywhere—a character carrying a basket full of picnic items for her grandmother, a stroller with a bucket seat and wheels to transport a baby brother, or a bird carrying an insect in its beak. One of our favorite activities is to choose random books and then have students, regardless of age, describe the structure and function relationships they see. We picked *Last Stop on Market Street* (Peña) off the shelf and found examples on every page: the curved handle and tentlike canopy of an umbrella, crochet hooks, eyeglasses with curved earpieces, windshield wipers on a bus. Even books that play with reality in their illustrations can spark a discussion about whether the structure and function relationship shown could really work. You can go deeper than I Spy if you find a book where an object plays a role in the plot. For example, in *Brave Irene* (Steig), the plucky Irene creates a sled out of a dress box to deliver a ball gown on time during a snowstorm; can you image what would have happened if she had been carrying a garment bag?

Older readers may find themselves beginning to visualize structure and function in novels; they all know that Katniss' bow is not made of papier-mâché but something much stronger that can rebound. To help your students read like scientists, invite them to describe the structures that enable characters to live in a boxcar, survive in a cave, or snare a rabbit.

Although plants and animals populate the pages of children's literature, identifying the relationship between structure and function can be a tad trickier because organisms' bodies have many functions and an illustration can only show one or two. For example, an illustration showing a bird flying in the distance tells you something about wings but not how the beak functions. Picture books are filled with images of animals and plants but the key is to ask yourself which structure and function relationship is illustrated. If we see a dog eating a bone, we may learn something about its teeth but not about how its legs help it run. On the other hand, if we see a greyhound running, we know something about its legs but not its teeth.

To get you started, we have generated for any whisper book a list of prompts that you can pose to students. To illustrate how these could play out, let's return to Steig's *Brave Irene* as an example. In this story, Irene's dressmaker mother takes ill, and Irene must deliver a beautiful gown in a raging snowstorm. To make up time, she slides down a hillside on the dress box. In this way the box (structure) is used for sledding down the hill (function).

TALK PROMPTS to help you notice structure and function in books that whisper

Prompt	How these would look in a discussion about *Brave Irene*
Choose an object in the illustrations—what is it? What is it being used for?	Irene carries the ball gown in a large protective box; it then becomes her sled.
Describe its shape. Is it big, flat, round? Is it thick or thin?	The rectangular, thin box is as tall as she is.
How does the shape enable it to do its job?	The box can become Irene's makeshift sled because it is flat, thin, and big enough to carry her.
What is it made of? Is it heavy, light? Flexible or rigid? Is the surface smooth or rough?	The box is cardboard, light, and smooth. It is rigid enough to hold its shape but flexible and smooth enough to ride the bumps in the snow.
How do these physical properties that you just described allow it to work (function)? One fun way to think about this is to ask, what if a rigid object were flexible, or a light object, heavy? Here's where the "lead balloon" joke starts to make sense.	Because the box is light, rigid, and smooth, it can slide on the snow while carrying Irene's weight, like a sled. These physical properties and shape also allow it to protect the dress throughout this wild adventure.
Was it built by humans? What problem does it solve? How do the shape and materials work together to solve the problem?	The rigid and solid sides and large shape protect the dress from the elements and keep it from wrinkling.
If it's alive (evolved), how does the shape (structure) allow the animal or plant to live (survive) or reproduce?	Because Irene's box is from the engineered world, this question doesn't apply.

Learning to read like a scientist is really about developing a lens. Once students add structure and function to their view, they see relationships in the world differently. Webbed feet and flippers say *swim fast*. Cat claws shout *tree climber* and *mouser*. Kayak says *maneuver me* and barge says *load me*. With this lens in place, structure and function appear even when you are not looking for them. This is where books that whisper are powerful, because students will now see structure and function every time they read a picture book or go to the hardware store to buy a new tool.