Further Reading

Books

Ball, Johnny. *Go Figure!: A Totally Cool Book about Numbers.* London: DK, 2005.

Ball, Philip. *Shapes: Nature's Patterns: A Tapestry in Three Parts.* Oxford: Oxford UP, 2009. (adults)

Kajander, Ann. *Big Ideas for Small Mathematicians: Kids Discovering the Beauty of Math with 22 Ready-to-Go Activities.* Tucson, AZ: Zephyr, 2003. (teachers)

Websites

Fractal Foundation: http://fractalfoundation.org/

Yale University Online Course: http://classes.yale.edu/fractals/

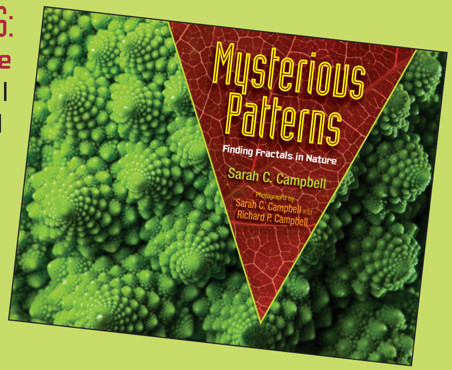
Videos

Fractals: Hunting the Hidden Dimension. PBS Nova, 2011.

MYSTERIOUS PATTERNS:
Finding Fractals in Nature
Written by Sarah C. Campbell
Photographs by Sarah C. Campbell and Richard P. Campbell

978-1-62091-627-8

Ages 7–10
Grades 2–5
$16.95



★ "The husband-and-wife team behind *Growing Patterns: Fibonacci Numbers in Nature* (2010) demystify the concept of fractals. . . . This fascinating exploration should awaken readers' powers of observation and appreciation for the intricacies of nature."
—*Publishers Weekly*, starred review

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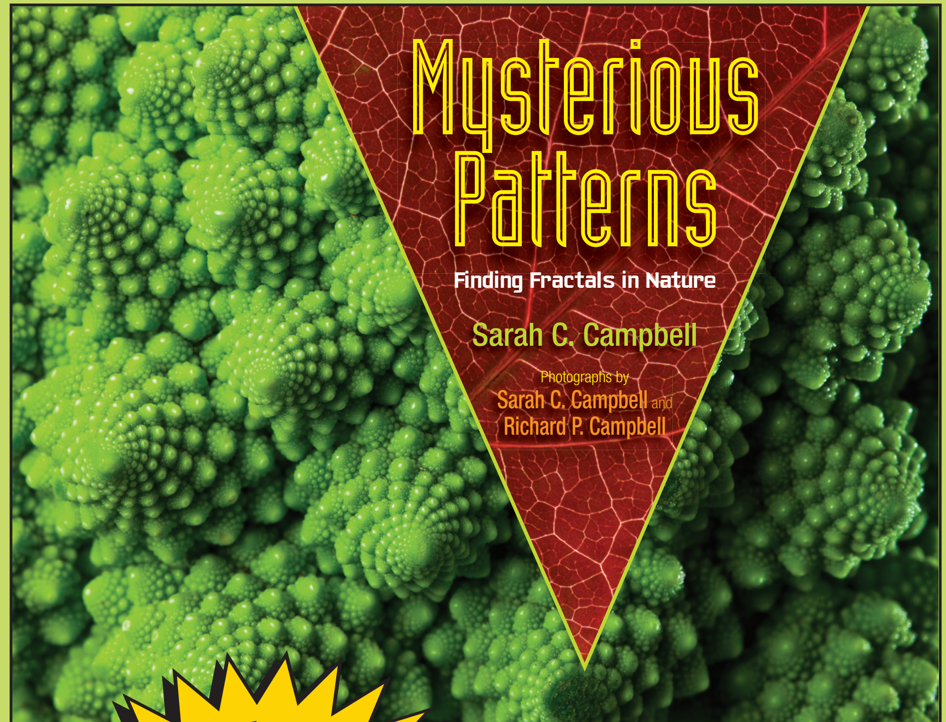
For marketing inquiries, contact marketing@boydsmillspress.com.

For the complete Common Core State Standards, visit corestandards.org/ELA-Literacy.

This guide was created by author and reading specialist Tracie Vaughn Zimmer.

Educator's Guide



With Common Core State Standards correlations

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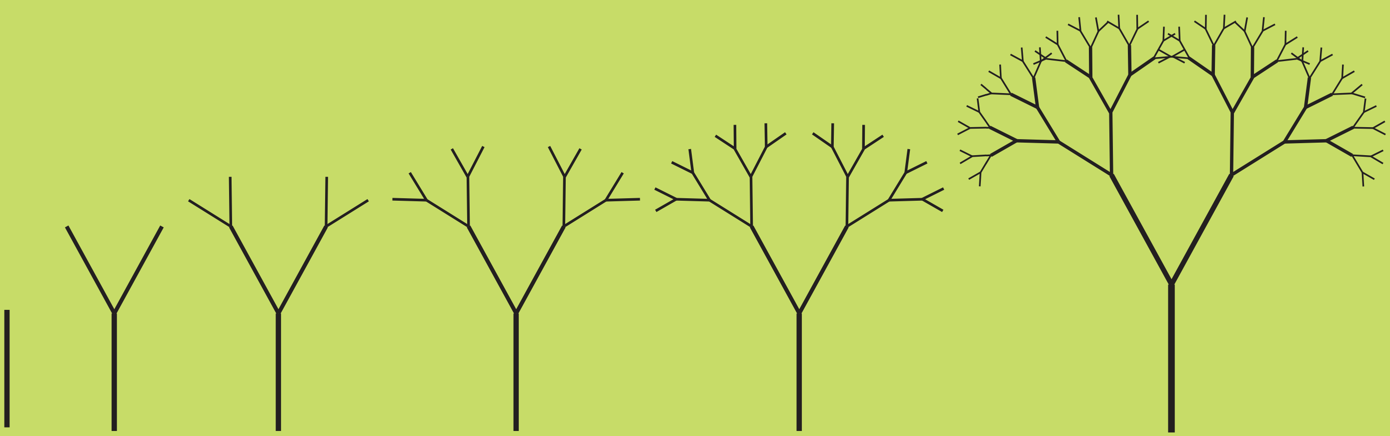
In MYSTERIOUS PATTERNS, Sarah and Richard Campbell offer readers a new way to look at the world around them. Detailed photographs and rich explanations help to foster an understanding of how so many seemingly random and complex forms found throughout nature actually have a commonality: fractals. Not only does the book clearly illustrate the concept of fractals for young readers, it also introduces them to the life of a brilliant mathematician named Benoit Mandelbrot, who dared to find connections between vastly disparate things. This compelling nonfiction picture book offers your class the opportunity to study the world around them with a new lens. This guide is designed to help you take full advantage of these curriculum possibilities. You'll find connections to the Common Core State Standards noted with each activity.

Pre-Reading Activity

Review the mathematical terms in the glossary at the beginning of the book. Walk students through your school or playground looking for examples of those shapes and recording them in the chart below.

Shape:	Examples we find:
Cone	
Cylinder	
Sphere	
Line	
Curve	

Once you return to the classroom, circle any shapes that appeared in nature. Graph the results of the shapes that appeared the most. **(SL 4.1; RI 4.4)**



Key Questions:

1. Do you think people built objects and buildings that reminded them of things in nature? **(RI 4.1)**
2. Why are things in nature similar but not exactly alike? **(RI 4.1, 4.3)**
3. How would you describe a piece of broccoli or a fern leaf? **(RI 4.1)**

Discussion Questions

What mathematician noticed a pattern across nature? How did he make the connection? **(RI 4.2)**

Explain how a fractal is created in nature. **(RI 4.2)**

What is the easiest way to recognize if something is made up of fractals or not? **(RI 4.3)**

List three specific examples of things in nature that are made up of fractals. What are two examples that have patterns but not fractal patterns? **(RI 4.1)**

Do all fractals form at the same speed? What are examples of fractals that take a long time to develop? Using only examples from the book, which fractals form in the shortest amount of time? **(RI 4.3)**

Fractals appear not just on the outside but on the inside, too. Give two examples of fractals appearing inside a structure. **(RI 4.1)**

Why was the discovery of fractals important? How does it help us (and scientists) to better understand our world? **(RI 4.3)**

Post-Reading Activity

Have students bring in five items from their own yards or a neighborhood park. Then, in pairs, have them share the items and decide whether they contain fractals or not. Students should tape each item that is determined to be a fractal to an index card. Then, using a complete sentence, they should write why they believe it to be a fractal.

If a pair decides that something is a fractal, they can place it on a table near the front of the room for other pairs to study. **(W 4.1; SL 4.1a, 4.1c)**

Research

Allow students the opportunity to research one of the following topics used as examples in the book: ferns, lightning, the Colorado River, the Grand Teton mountain range, lungs, broccoli, trees, and Queen Anne's lace. Using websites that are appropriate for their grade level and comprehension level, students should discover at least five key facts to share with their peers. **(W 4.7, 4.8)**

Alternately, students can research Benoit Mandelbrot, the creator of the word "fractal," and report their findings to the class. Prompt the kids to see if there are puzzles in their own experiences of the world that make them "wonder" the way Mandelbrot did. Why are things the way they are? What things are like other things we have experienced? What things are different? How are they different? What might be a reason? **(W 4.7, 4.8)**

Writing

Students should create a pamphlet, poster, or website sharing the information they learned from their research. Their writing should consist of several stages: researching, taking notes (including paraphrasing), pre-writing, drafting, revising, and editing. Each stage of writing should be discussed in mini-lessons, with students having an opportunity to work on independent projects following the example lessons. **(W 4.2, 4.2a, 4.2b)**

Close Reading

Nonfiction writers often organize the information in their texts into a variety of structures to help readers better understand the topic. Review the following structures with your students.

Common structures of nonfiction texts:	Definition:
Chronology	Information is listed in order of when it happened.
Comparison	Two or more items are compared by their most important parts.
Cause/Effect	A relationship is shown between an event or idea and what resulted from it.
Problem/Solution	A difficulty is explained, followed by how an answer was found.
Definition/Example	An important vocabulary term is discussed, often with examples.

Next, have students identify passages from the book that demonstrate each text structure. **(RI 4.5)**

Vocabulary

Good readers know that many words can be figured out by the context of the sentence in which they appear. Have students use context to try to define the words on the following pages. If they're not certain, have them look up the words in a dictionary. **(RI 4.4; L 4.4, 4.4a)**

Word in context:	What I think it means:	What the dictionary says:	A new sentence of my own:
"On a street, in a town, in a city, **familiar** shapes are everywhere." (page 4)			
"Some, like these tomatoes, are **similar** to but not exactly like those shapes." (page 8)			
"Instead of being straight, smooth, and flat, many natural shapes are rough, **bristly**, and bumpy." (page 10)			
"Instead of adding parts over and over and over again, the Queen Anne's lace produces a bud that opens over the course of days to **reveal** a fractal flower." (page 16)			
"Fractals have edges that are **jagged**, wriggly, or craggy." (page 18)			
"The Grand Teton mountain range formed at least nine million years ago when pressure below the earth's crust pushed one giant slice of rock against another so forcefully that it created **towering** peaks." (page 22)			

Illustration Study

Pictures, charts, diagrams, and illustrations can aid a reader a great deal when it comes to understanding a complex text, especially nonfiction. In pairs, have students discuss why the author chose the illustrations for this book. Assign two illustrations to each pair, and for each illustration, have students describe the visual information conveyed in the image and explain how it helps the reader understand the text. **(RI 4.7)**

Reasons & Evidence

Authors, especially of nonfiction, use reasons and evidence to support the claims they make in a text. This gives the reader proof that something is so and better helps them understand a concept by showing concrete examples. Using the text, students should find specific evidence the author uses to back up each of the following claims. **(RI 4.8)**

- Familiar shapes are everywhere.
- Natural shapes do not look like perfect shapes that people make.
- Fractal shapes have smaller parts that look like the whole shape.
- Fractals have parts that repeat.
- Fractals exist inside living things as well.

Main Idea/Key Detail

Main ideas are the gist or the most important information presented in a text. They are the ideas that most often end up on tests and quizzes, too. Key details back up what the author is trying to teach. Have students determine whether the following statements from the book are main ideas or key details. They should explain their reasoning for each response. **(RI 4.2; SL 4.1D)**

- "Tomatoes are like spheres." (page 9)
- "A mathematician named Benoit Mandelbrot noticed similar patterns in these natural shapes." (page 12)
- "A tree is a fractal." (page 12)
- "Every fractal shape has smaller parts that look like the whole shape." (page 12)
- "Human lungs hold fractal shapes, which can be seen in airways, veins, and arteries." (page 25)

Extra Credit

Make your own fractals!

Construct your own Sierpinski triangle following the instructions on page 30. Then, search the internet to find instructions on how to make a three-dimensional Sierpinski tetrahedron. What will you use to make this fractal?

Construct a Koch curve. To make one, follow these steps:

1. Using a pencil, draw a straight line.
2. Divide the line into three equal parts.
3. Using the middle part of the line as your base, draw a triangle pointing up. (The sides should be the same length as the base.)
4. Erase the base of the triangle. Now, you have a new shape with four straight line pieces.
5. For each of the straight pieces, repeat steps 2 through 4.

This Koch curve could go on forever. Can you imagine making a Koch curve with a line that is as long as a school hallway or a football field or the world's longest river?