

## FRACTALS

Have you ever noticed how some natural objects have shapes made of repeating patterns? You can see these shapes in mighty rivers and delicate seashells. These shapes are called **fractals**, which repeat at different scales, or sizes, and form never-ending patterns within patterns.



river delta



tree branches



lightning

Fractals were first identified and studied by mathematician Benoit Mandelbrot. He created a mathematical formula that measures different aspects of these fascinating structures, and he was one of the first individuals to use computers to create fractal images.

Fractals have **self-similarity**, which means you can zoom in on one, then zoom in again and it will always be the same pattern. Branches and spirals are some of the easiest fractal designs in nature to recognize.



Whirlpool galaxy

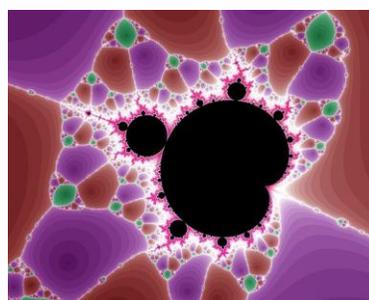
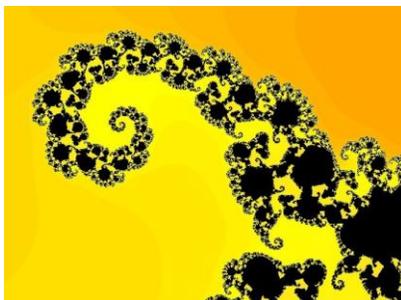


chambered nautilus shell



cacti

Mandelbrot is also known for his mathematical discovery of the **Mandelbrot set**, fractals that are created from a particular mathematical equation. These fractals have special properties which become visible as you zoom in on the complex images. Each Mandelbrot set is made up of pieces that contain another Mandelbrot set – and so on, and so on. You can zoom in forever, and you will always find more Mandelbrot sets! Here are a couple of examples of what Mandelbrot sets look like:



Now, let's take a close look at a head of broccoli or cauliflower. If you're lucky enough to have some **broccoflower** (also called **Romanesco broccoli**) in your kitchen, you can see beautiful fractal swirls right on the surface of the head. If you snap off a small piece (a **floret**) from the main bundle, you will notice that looks just like a miniature version of the entire head.



Broccoflower (or Romanesco)

Broccoli

Cauliflower

Now that you know what a fractal is, see if you can find a few natural examples of these repeating patterns online (especially fun when the weather isn't so great outdoors), around the house, in your yard or favorite park.

**FRACTALS EVERYWHERE! SCAVENGER HUNT** - *Fractals are all around us. You'll see lots of them if you take the time to look carefully. Get outdoors, or if the weather's not so nice, look online at the links we've provided and check off the fractals that you find. We've also left some extra space for you to check off and label any fractals that you discover on your own.*

**Fractals in space** [https://www.nasa.gov/mission\\_pages/hubble/multimedia/index.html](https://www.nasa.gov/mission_pages/hubble/multimedia/index.html)

- galaxy
- patterns on planet surface
- ???

**Fractals on Earth** <https://earthobservatory.nasa.gov/images>, <https://www.wired.com/2010/03/gallery-rivers/>

- rivers
- mountains
- ???

**Fractals in the ocean**

<https://oceanservice.noaa.gov/gallery/category.php?siteName=nosimages&cat=Ocean%20Life>

- coral
- sponge



???

**Fractals inside our bodies** <https://kids.britannica.com/students/article/human-anatomy/272852>

blood vessels

nervous system

???

**Fractals at the grocery store (or in our kitchens)**

cauliflower

pineapple

???

**Fractals in the garden**

flower

tree branches

???

**Fractals in the sky**

clouds

lightning

???

***How many fractals did you find?*** \_\_\_\_\_

### **ADDITIONAL RESOURCES:**

#### Websites

The University of Kansas, School of Education & Human Sciences, "Fractals for Fun: Teaching Kids Patterns in Nature" <https://educationonline.ku.edu/articles/teaching-kids-patterns-in-nature>

Hobart and William Smith Colleges, Department of Mathematics and Computer Science, "Mandelbrot Viewer" <http://math.hws.edu/eck/js/mandelbrot/MB.html>

#### Videos



BBC Ideas, "How fractals can help you understand the universe"

[https://www.youtube.com/watch?v=w\\_MNQBWQ5DI](https://www.youtube.com/watch?v=w_MNQBWQ5DI)

Massachusetts Institute of Technology (MIT), MIT+K12 Videos, "Fun with Fractals"

<https://www.youtube.com/watch?v=XwWyTts06tU&feature=youtu.be>

Books available from the Washoe County Library System:

*Flow, Spin, Grow : Looking for Patterns in Nature* by Patchen Barss

*Mysterious Patterns : Finding Fractals in Nature* by Sarah C. and Richard P. Campbell

*Swirl by Swirl : Spirals in Nature* by Joyce Sidman

*Wild Fibonacci : Nature's Secret Code Revealed* by Joy N. Hulme

