**Curriculum topics:**

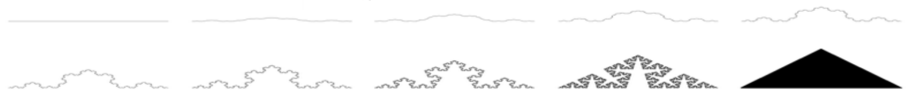
- Fractals
- Patterns
- Exponents
- Exponential Growth
- Decalcomania

**Subjects: Art, Math**

**Grade range: K – 12**

# FREAKY FRACTALS

## Explore fractals, as found in nature, by observing squished paint!



A fractal is an amazing geometric pattern which, when viewed closely, shows itself to be constructed of ever-smaller parts similar to the original. Fractal patterns are everywhere: trees, shells, leaves, ferns, flowers, vegetables, rivers, coastlines, mountains, geologic faults, planetary orbits, circulatory systems, music, clouds, weather, and even lightning bolts!

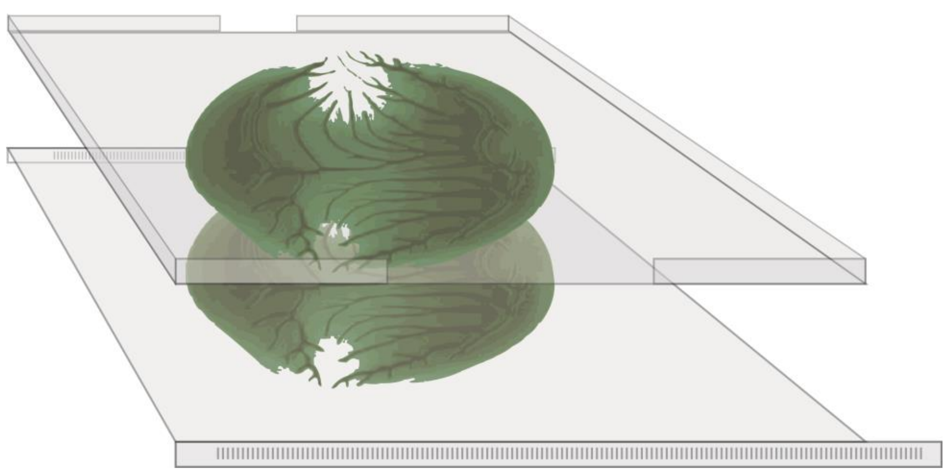


Figure 1 – Completed Fractals

# Materials required

- 1 CD jewel case, clear
- Thick paint, any color (acrylic or similar)
- 1 magnifier
- Paper towels
- 2 sheets paper or cardstock (optional)

# To do and notice

**Caution – CD cases can be sharp if cracked or broken. For children under 8 years old, use smooth plastic container lids instead of CD cases.**

**1** Unhinge a CD jewel case to separate the 2 covers. Lay both covers on paper towels with the flat outer sides facing upward.

**2** Add a dot of paint (about the size of a penny) to one cover.

**3** Pick up the other cover (the one without any paint) by the edges, turn it over, and lower it **straight down** onto the paint drop. Press the covers together to spread the paint. See figure 2.

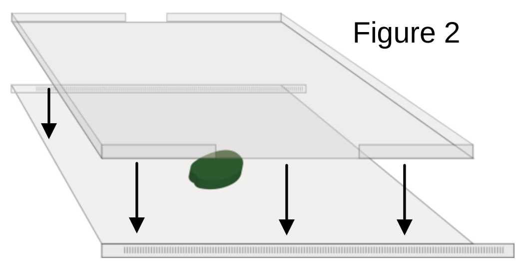


Figure 2

**4** Lift the top cover **straight up** (without sliding) and turn it over. Lay the cover, paint-side up, onto the paper towel. See figure 3.

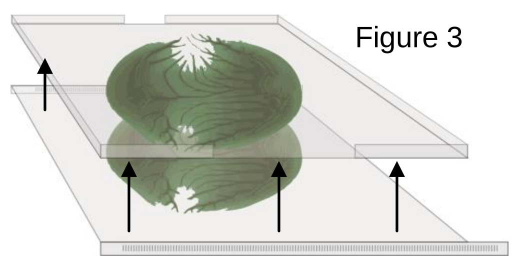


Figure 3

**5** Use the magnifier to examine the patterns in the paint on both covers. Note how the pattern seems to repeat in different places on the cover. What does this pattern remind you of? (Broccoli, tree branches, rivers, veins…)

**6** **Optional –** Place paper (or cardstock) onto the paper towel. Pick up either cover, turn over, and press the painted side straight down onto the paper. Slowly lift the cover straight up. Examine the pattern printed on the paper.

**7** **Optional –** Repeat step 6 with the other cover and another piece of paper or cardstock.

Note – After making a set of prints, students can add more paint to the CD case and repeat the process!

# The content behind the activity

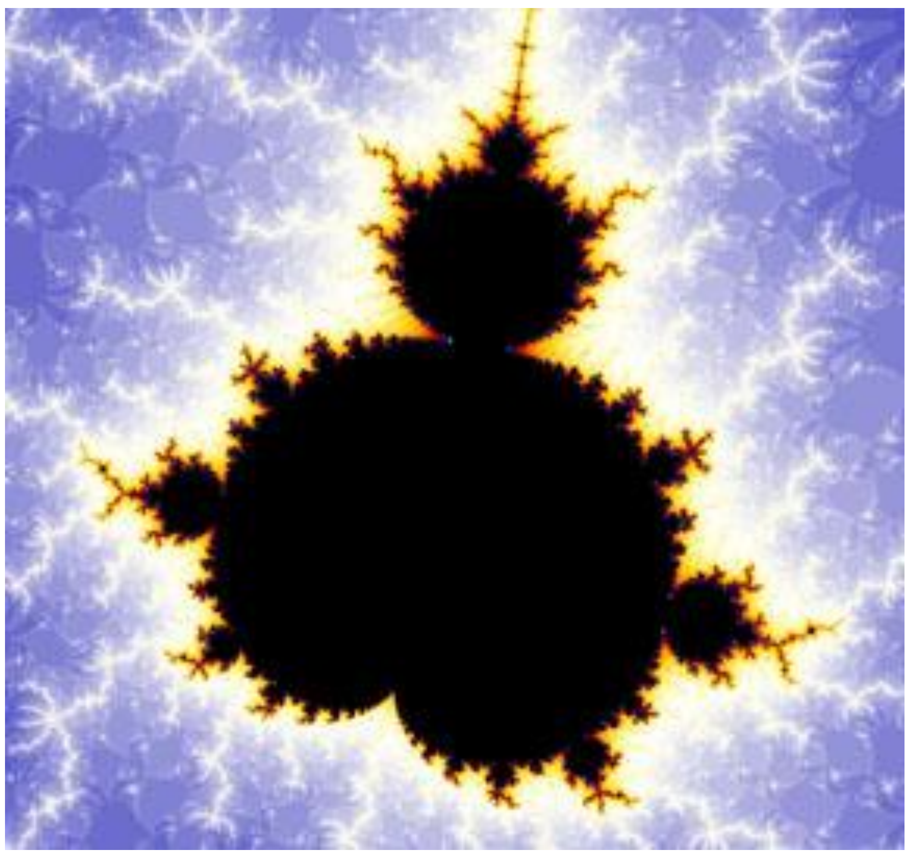
The ridges on the CD covers are formed when the areas of paint sticking to both the top and the bottom covers finally separate.  The ridges stretch and connect when the distance between the covers increases, forming a complex **dendritic** branching pattern called a **fractal** (**dendritic** meaning "branching like a tree").

**What is a fractal?**

Fractals are patterns that occur regularly in nature and were first described by Benoit Mandelbrot in 1961. He is commonly called "the father of fractals." Mandelbrot was fascinated by what he called "order in chaotic shapes and processes". He created the term **fractal** to describe curves, surfaces and objects that have some very peculiar properties. A fractal is a geometric shape which is both **self-similar** and has **fractal dimension.**  To be self-similar means that when an object is magnified, each of its smaller parts still looks much the same as the larger whole.

Fractal dimensions are different from the dimensions we use to describe lines, flat objects, and geometric solids.  Simple curves, such as lines, have one dimension.  Squares, rectangles, circles and other polygons have two dimensions, while solid objects such as cubes and polyhedra have three dimensions.  In all these cases, dimension, based on ancient Euclidean Geometry, is described as an integer: 1, 2, 3, 4… But a fractal curve could have a dimensionality of 1.4332, for example, rather than 1!  A fractal's dimension indicates its degree of detail, or "crinkliness," and how much space it occupies between the Euclidean Geometric dimensions.

Most objects in nature aren't formed from squares or triangles.  They are formed from fractals!



Fractal geometry usually follows an exponential function.  For example, the nautilus shell pattern is a self-repeating fractal that reduces in size exponentially. (See page 5 for a picture of a nautilus shell as well as other fractal images.) Dendritic fractals are called self-similar because at high magnifications, different parts appear to repeat but are not exactly the same.

By understanding the "fractal dimension," mathematicians can now measure forms that were once thought to be immeasurable.

Curriculum Standards:

Patterns (Common Core Math Standards: Operations & Algebraic Thinking, Grade 4, 5; Grade 5, 3)

Creativity and innovative thinking, (National Visual Arts Standards: Creating – Generate and conceptualize artistic ideas and work, Grades K-12)

Additional standards at: http://www.raft.net/raft-idea?isid=558

# Learn more

- Use various paper types, paint thicknesses, and/or paint applicators.
- Find the average number of small branches stemming from each branch.
- Do a hands-on activity with real broccoli. Cut off a small piece. How it is similar to the whole broccoli? Take an even smaller sample and look at it with a magnifier. Note how the similarity repeats, even at a smaller scale.
- Find a computer generated fractal that looks like an object in nature. Find a natural object that is also a fractal. See examples on page 5.
- Illustrate self-similarity by making a Pythagoras fractal tree with construction paper using instructions located at the following web site: http://mathforum.org/te/exchange/hosted/lee/second_lesson/part_3.htm
- Draw the Sierpinski Triangle. See http://www.ccs3.lanl.gov/mega-math/new/sierpins/sierpins.html for a graphic of the Sierpinski Triangle and more information about it. Also see the RAFT Idea Sheet ***Sierpinski Gasket***.
- Draw Pascal's Triangle. See http://www.mathsisfun.com/pascals-triangle.html for a graphic and more information about Pascal's Triangle.

**Related activities:** See the fractal-related RAFT Idea Sheets:

***Sierpinski Gasket -***
http://www.raft.net/ideas/Sierpinski Gasket.pdf

***Tetrix -***
http://www.raft.net/ideas/Tetrix.pdf

# Resources

Visit www.raft.net/raft-idea?isid=558 for "how-to" video demos & more ideas!

See these websites for more information on the following topics:

- **A variety of amazing fractal images**
  http://paulbourke.net/fractals/
- **Fractal geometry in art, science, and humanities** -
  http://classes.yale.edu/fractals/
- **Unit on fractals for elementary and middle school students that adults are free to enjoy** –
  http://math.rice.edu/~lanius/frac/
- **Multiple sites on teaching about fractals**
  http://mathforum.org/alejandre/workshops/fractal/fractal3.html
- **Teacher designed math courses from the New Jersey Center for Teaching & Learning –** https://njctl.org/courses/math

## Acknowledgements:

Inspired by "Fractal Patterns" in *Square Wheels, an Exploratorium Snackbook*.

# Sample Fractal Images

### Fern

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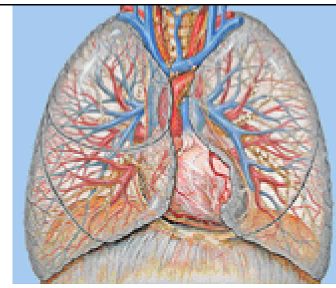
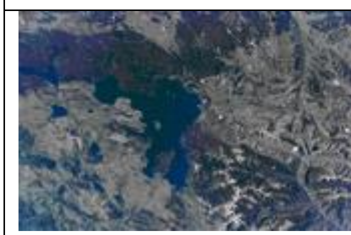
### Bubbles

By Mila Zinkova (Own work) [GFDL (www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0-2.5-2.0-1.0 (www.creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons http://commons.wikimedia.org/wiki/File:Bubbles_at_tide_pools_2.jpg



### Lungs

Patrick J. Lynch; illustrator; C. Carl Jaffe; MD; cardiologist Yale University Center for Advanced Instructional Media. Medical Illustrations by Patrick Lynch, generated for multimedia teaching projects by the Yale University School of Medicine, Center for Advanced Instructional Media, 1987-2000. Patrick J. Lynch, http://patricklynch.net Creative Commons Attribution 2.5 License 2006 http://commons.wikimedia.org/wiki/File:Thoracic_anatomy.jpg



### Geography

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### Nautilus Shell

This Wikipedia and Wikimedia Commons image is from the user Chris 73 and is freely available at http://commons.wikimedia.org/wiki/File:NautilusCutawayLogarithmicSpiral.jpg under the creative commons cc-by-sa 3.0 license.

### Clouds

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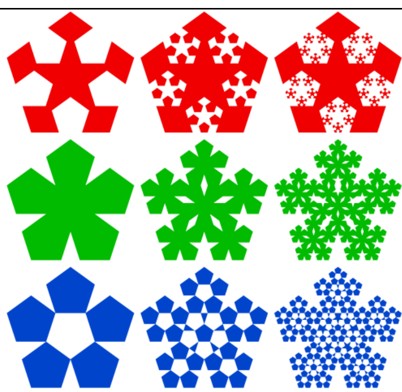

### Pentagonal Fractals

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### Broccoflower

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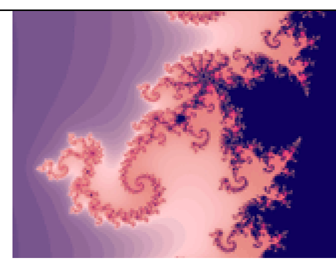

### Computer-Generated Fractal

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