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Find That Shape

By Nancy J. Thompson

- *Ever wonder what scientists and mathematicians call the shape of a coastline or snowflake?*

What do a mountain and a snowflake have in common? Here's a hint: It has to do with geometry. When you think of geometry, you probably think of squares, triangles, and circles. Those smooth-sided figures are called plane geometry shapes. Egyptians used them thousands of years ago to help them build **pyramids** and tombs.

Later, around 300 BC, a Greek mathematician named Euclid developed plane geometry's rules, which we've used ever since.

Some of the most exciting work in **math** today, though, is not being done with plane geometry. It's being done with fractals.

Like squares, circles, and triangles, fractals are figures. They have been used in art and crafts for hundreds of years, but didn't have a name until 1975. That's when mathematician Benoit (pronounced Ben-wa) Mandelbrot named them fractals.

The word "fractal" comes from the Latin word "fractus," which means "broken." Unlike plane geometry shapes, that's how fractals look: crinkly and irregular, with lots of nooks and crannies. Each is different.

What Makes a Fractal a Fractal?

Fractals have three special features. The first is that each little part of the figure has a shape that looks like the rest of the figure. This is called self-similarity.

To imagine this, draw a square. Now, draw a line across the middle of the square from left to right, and down the middle of the square from top to bottom. You should see four squares within the original square.

By drawing a tree, you can also see how a fractal has self-similar parts. Start with the two big curved lines for the trunk, then smaller curved lines for the main branches, and then smaller lines for the smaller branches. Each is similar to the others; they are just different sizes.

Another trait of fractals is their dimension. A line has just one dimension: length. A plane figure, such as a square or rectangle, has two dimensions: length and height. A cube figure, such as a box, has three dimensions: length, height, and depth.

A fractal, though, has a dimension that's a fraction. That's because fractals are in between dimensions. The dimension of a fractal is always smaller than the dimension where it is located.

For example, a piece of paper is a rectangle with two dimensions, but if you draw a fractal such as Koch's Snowflake on the paper, the fractal will have fewer than two dimensions (the dimension of Koch's snowflake is 1.26).

Finally, fractals are formed by a method called iteration. Iteration means that a rule is applied to a figure again and again to change it. As the figure changes, it becomes more complex.

Here's a simple **math** example of iteration: Start with the number 20. Divide it by 2. Add 2. Repeat the last two steps. The first five numbers will be 20, 10, 12, 6, 8. What will the next three numbers be?

Fractals Are All Around Us

Nature is full of fractals. Like snowflakes and mountain ridges, the shape of a fern is a fractal, and so is the shape of a head of broccoli. Look around your house and yard to see if you can spot anything that might be a fractal.

[\(See picture, "Fractal-Shaped Fern."\)](#)



Fractal-Shaped Coastline in South Africa

JAGGED EDGE: Aerial view of the fractal-shaped coastline of Cape Town, South Africa, including Table Mountain and Devil's Peak. (Photo by Melanie Stetson Freeman--Staff)

One area of nature in which fractal geometry is proving to be very important is measuring coastlines.

Look at the coastline of any continent on a map, and you'll see how irregular it is. Imagine measuring the coastline with a ruler that's 100 miles long. You could measure big straight lines, but not all the small inlets, coves, and projections.

[\(See picture, "Fractal-Shaped Coastline in South Africa."\)](#)

Now imagine measuring the coastline with a ruler that is only an inch long. Your tiny ruler would fit into more of the spaces along the coastline and the measurement would be more accurate. It would also be much longer. The coastline is a fractal, and fractal geometry helps to measure all of its length, including all its ins and outs.



Fractal-Shaped Fern

PART NATURE, PART MATH: It looks like these fern plants are reaching out their arms to each other in a morning greeting. The elegant plants are nearly completely unfolded from the tight spiral bud they start out from. The shape of a fern is a fractal. (Photo by John Nordell--The Christian Science Monitor)

Much of our world is made up of fractals, and scientists and engineers are learning more about them to solve many problems. Fractals help us understand crystals, the ocean floor, physics, and space. Recently, researchers have begun using fractals to help study the stock market. It's even possible to create fractal music!

Drawing Koch's Snowflake

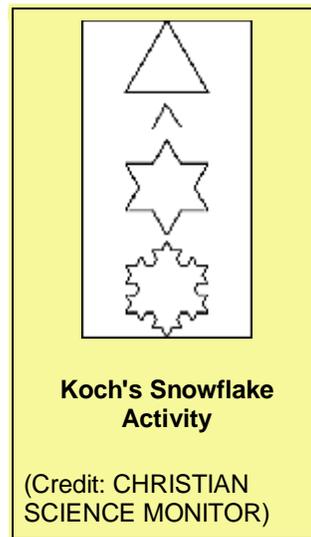
1. Let the four drawings at right be your guide. Use a pencil to draw a triangle with three equal sides, like the top drawing.

[\(See picture, "Koch's Snowflake Activity."\)](#)

2. In the middle of each of the three straight lines of your triangle, draw shape No. 2. Erase the lines beneath them. Your shape should look like the third drawing.

3. In the middle of each of the 12 straight lines, insert the pointed shape again, as you did in the second step and erase the lines beneath. Your shape should look like the fourth drawing.

4. You've just performed two iterations, and the snowflake shape is emerging. Try repeating the step one more time to see how complex the fractal snowflake becomes.



Where to Learn More

- At www.coolmath4kids.com, you can make your own fractal pictures on the computer.

- You can also visit Cynthia Lanus's "Fractals" page on the Internet, where you can make a Jurassic Park fractal and a Sierpinski triangle, and practice writing computer code for fractals. (<http://math.rice.edu/%7Elanus/frac/>)

- The book "Fractals, Googols, and Other Mathematical Tales" by Theoni Pappas (Wide World Publishing) explains fractals, magic squares, decimals, and other **math** ideas in fun and interesting stories.