

Fractals

understanding the geometry of nature

What is a fractal?

A fractal is a never ending pattern that repeats itself as you zoom in or zoom out of that shape. Mathematicians call this property "Self-Similarity." The word fractal was made by Benoît Mandelbrot in 1975 from the Latin word fractus, which means "broken" or "fractured". Amazingly, fractals are extremely simple to make. A fractal is made by repeating a simple process again and again. Fractals are not only beautiful, but also have many practical applications.

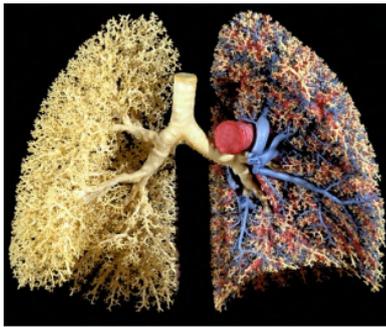
Natural fractals

Branching fractals

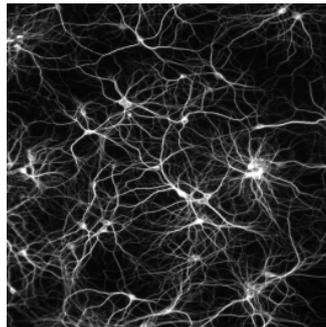
You can find fractals all over nature, from very small to very large sizes. We uncover the same patterns again and again, from the tiny branching of our blood vessels to the branching of trees, lightning bolts, and river networks. Regardless of the size, these patterns are all formed by repeating a simple branching process. A fractal is a picture that tells the story of the process that created it.



Branches of trees grow out from the trunk, and then each of the branches branching again and so on



Our lungs are branching fractals. The look very similar to trees because both lungs and trees both use their large surface areas to exchange oxygen and carbon dioxide



The branching of our brain cells creates the incredibly complex network that is responsible for all we perceive, imagine, remember.



Spiral fractals

The spiral is another common fractal in nature that spans from very small to very large sizes. Biological spirals are found in the plant and animal, and non-living spirals are found in the turbulent swirling of fluids and in the pattern of star formation in galaxies. Spiral fractals are formed by simple repetition, and combining stretching and rotation is enough to generate the common spiral.



A hurricane is a self-organizing spiral in the atmosphere, driven by the evaporation and condensation of sea water.



A spiral galaxy is the largest natural spiral comprising hundreds of billions of stars.



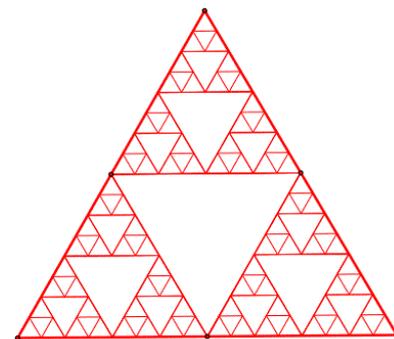
The turbulent motion of fluids creates spirals in systems ranging from a soap film to the oceans, atmosphere and the surface of Jupiter.



Jeff Duncan

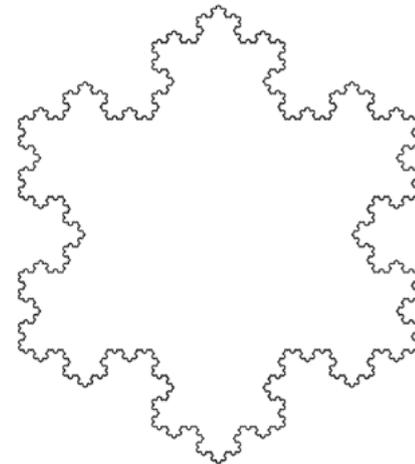
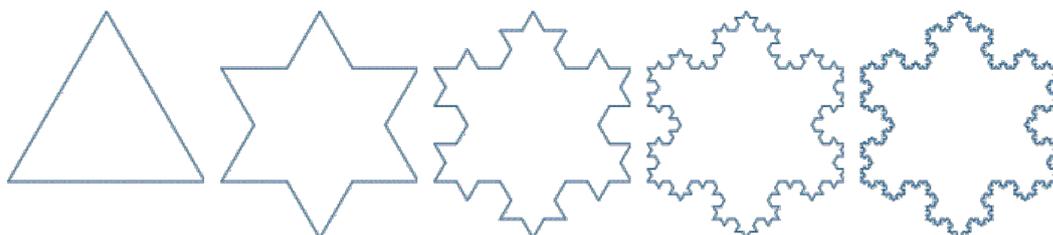
Geometric fractals

Purely geometric fractals can be made by repeating a simple process. The Sierpinski Triangle is made by repeatedly removing the middle triangle from the prior generation. The number of colored triangles increases by a factor of 3 each step, 1,3,9,27,81,243,729, etc.



Sierpinski Triangle

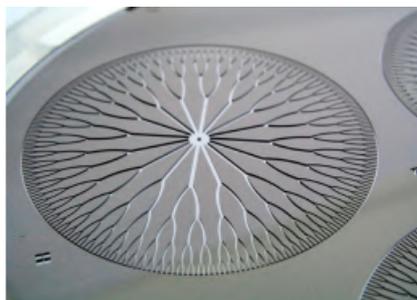
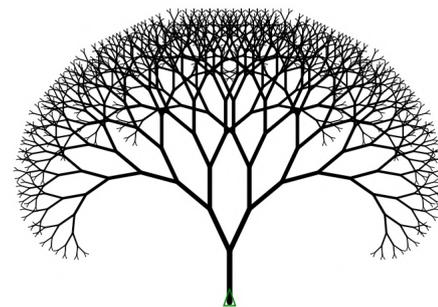
Swedish mathematician Niels von Koch published the fractal that bears his name in 1906. It begins with an equilateral triangle; three new equilateral triangles are constructed on each of its sides using the middle thirds as the bases, which are then removed to form a six-pointed star. The Koch snowflake is made by repeatedly replacing each segment of a generator shape with a smaller copy of the generator.



Koch snowflake

Where are fractals used?

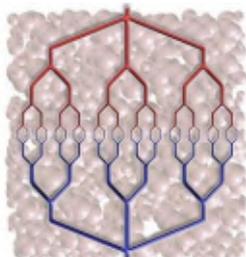
Nature has used fractal designs for at least hundreds of millions of years. Only recently have human engineers begun copying natural fractals for inspiration to build successful devices. Below are just a few examples of fractals being used in engineering and medicine.



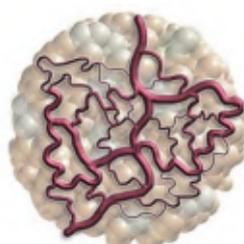
A computer chip cooling circuit etched in a fractal branching pattern. Developed by researchers at Oregon State University, the device channels liquid nitrogen across the surface to keep the chip cool.



Fractal antennas developed by Fractenna in the US and Fractus in Europe are making their way into cellphones and other devices. Because of their fractal shapes, these antennas can be very compact while receiving radio signals across a range of frequencies.



A. Normal



B. Abnormal

Researchers at Harvard Medical School and elsewhere are using fractal analysis to assess the health of blood vessels in cancerous tumors. Fractal analysis of CT scans can also quantify the health of lungs suffering from emphysema or other pulmonary illnesses.



Fractals can be used to produce images that bear a stunning resemblance to real landscapes. Such images are called fractal forgeries. Fractal techniques are routinely used to generate artificial landscapes and scenery for movies and video games.

