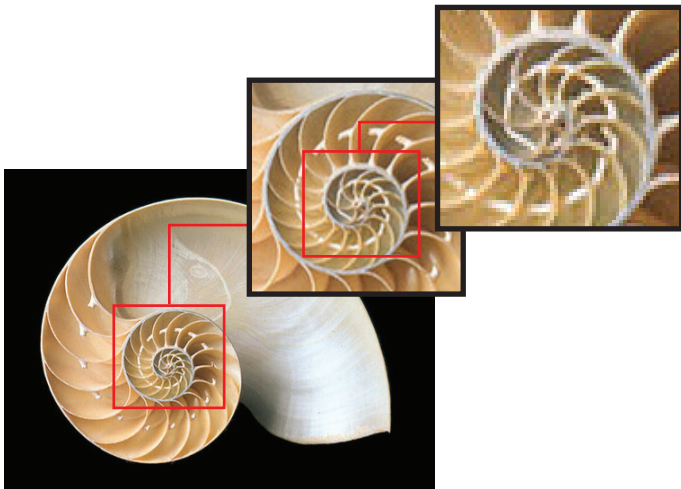


## 1.2 Fractals

Fractals are structures or designs made out of geometric shapes that repeat indefinitely at different scales. Any fractal exhibits self-similarity, which means that any component of the fractal's details is a replica of the whole.

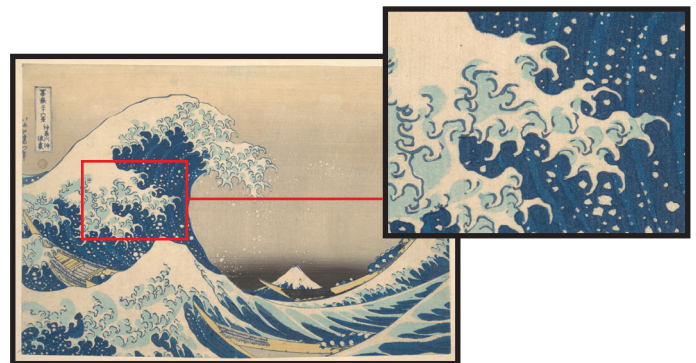
### In Nature

Fractals can be observed in nature, such as seashells, which have spiral patterns that recur. Seashell spirals feature limited fractals and are not mathematically perfect, yet they are nevertheless considered as fractals. Trees also resemble fractals due to their recurrent branching, as each branch is similar to the entire plant, just on a smaller scale.



### Art Forms

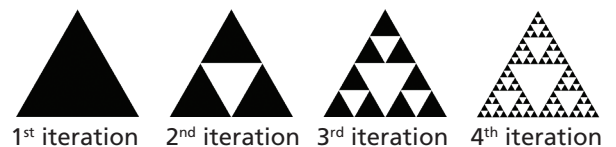
While fractals appear to be complex shapes, the process of creating one is simple – repeating a rule over and over. To make a fractal, start with a shape and apply a single rule to it; then keep repeating the rule. Fractals have been used in a variety of art forms throughout history. Katsushika Hokusai, a Japanese artist, created one of the most famous masterpieces, *The Great Wave off Kanagawa*. It is composed of a large ocean wave where the top splits into smaller and similar waves.



In mathematics, fractals can be produced when a basic rule or equation is repeated indefinitely. A few examples of mathematical fractals and the patterns they produce are shown below.

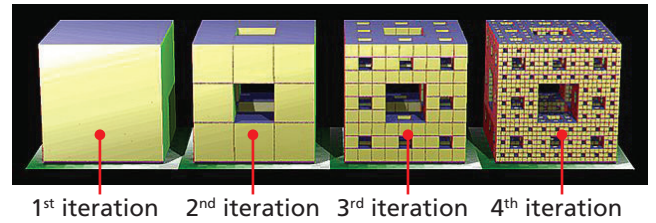
### Sierpiński Triangle

The Sierpiński triangle, also known as the Sierpiński gasket or Sierpiński sieve, is a fractal with the overall shape of an equilateral triangle. It is famous for being one of the most fundamental examples of a self-similar set. The Sierpiński triangle is named after the Polish mathematician Wacław Sierpiński. Different techniques can be used to create the Sierpiński triangle. One method is to start with an equilateral triangle. Divide it into four smaller equilateral triangles and remove the triangle in the centre. Divide each smaller triangle the same way and repeat the process with each of the subsequent similar triangles infinitely.



### Menger Sponge

The Menger sponge is a three-dimensional fractal which was first described by the Austrian mathematician Karl Menger. There are various ways to construct the Menger sponge. One is to begin with a cube. Divide each face of the cube into nine squares. Remove the cube in the centre of each face and the cube in the centre of the larger cube. Repeat the previous step infinitely and the Menger sponge will be produced.



In conclusion, fractal is a concept that makes use of recurring rules and similar shapes. Try creating a fractal of your own!