A **fractal** is "a rough or fragmented [geometric shape](http://en.wikipedia.org/wiki/Shape) that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole,"[[1]](http://en.wikipedia.org/wiki/Fractal#cite_note-0) a property called [self-similarity](http://en.wikipedia.org/wiki/Self-similarity). While fractals are a mathematical construct, they are found in nature, which has led to their inclusion in [artwork](http://en.wikipedia.org/wiki/Work_of_art). Objects in nature which have self-similar structure can be approximated by fractels.

Generation

**Four common techniques for generating fractals are:**

* **Escape-time fractals** – (also known as "orbits" fractals) These are defined by a [formula](http://en.wikipedia.org/wiki/Formula) or [recurrence relation](http://en.wikipedia.org/wiki/Recurrence_relation) at each point in a space (such as the [complex plane](http://en.wikipedia.org/wiki/Complex_plane)). Examples of this type are the [Mandelbrot set](http://en.wikipedia.org/wiki/Mandelbrot_set), [Julia set](http://en.wikipedia.org/wiki/Julia_set), the [Burning Ship fractal](http://en.wikipedia.org/wiki/Burning_Ship_fractal), the [Nova fractal](http://en.wikipedia.org/wiki/Nova_fractal) and the [Lyapunov fractal](http://en.wikipedia.org/wiki/Lyapunov_fractal" \o "Lyapunov fractal). The 2d vector fields that are generated by one or two iterations of escape-time formulae also give rise to a fractal form when points (or pixel data) are passed through this field repeatedly.
* [**Iterated function systems**](http://en.wikipedia.org/wiki/Iterated_function_system) – These have a fixed geometric replacement rule. [Cantor set](http://en.wikipedia.org/wiki/Cantor_set), **[Sierpinski](http://en.wikipedia.org/wiki/Sierpinski_carpet" \o "Sierpinski carpet)** [carpet](http://en.wikipedia.org/wiki/Sierpinski_carpet" \o "Sierpinski carpet), [Sierpinski gasket](http://en.wikipedia.org/wiki/Sierpinski_gasket" \o "Sierpinski gasket),[Peano curve](http://en.wikipedia.org/wiki/Peano_curve), [Koch snowflake](http://en.wikipedia.org/wiki/Koch_snowflake), [Harter-Heighway dragon curve](http://en.wikipedia.org/wiki/Dragon_curve), [T-Square](http://en.wikipedia.org/wiki/T-Square_(fractal)), [Menger sponge](http://en.wikipedia.org/wiki/Menger_sponge" \o "Menger sponge), are some examples of such fractals.
* **Random fractals** – Generated by stochastic rather than deterministic processes, for example, trajectories of the [Brownian motion](http://en.wikipedia.org/wiki/Brownian_motion), [Lévy flight](http://en.wikipedia.org/wiki/L%C3%A9vy_flight" \o "Lévy flight), [fractal landscapes](http://en.wikipedia.org/wiki/Fractal_landscapes) and the [Brownian tree](http://en.wikipedia.org/wiki/Brownian_tree). The latter yields so-called mass- or dendritic fractals, for example,[diffusion-limited aggregation](http://en.wikipedia.org/wiki/Diffusion-limited_aggregation" \o "Diffusion-limited aggregation) or [reaction-limited aggregation](http://en.wikipedia.org/w/index.php?title=Reaction-limited_aggregation&action=edit&redlink=1) clusters.
* **Strange attractors** – Generated by iteration of a map or the solution of a system of initial-value differential equations that exhibit chaos.

Classification

Fractals can also be classified according to their self-similarity. There are three types of self-similarity found in fractals:

* **Exact self-similarity** – This is the strongest type of self-similarity; the fractal appears identical at different scales. Fractals defined by [iterated function](http://en.wikipedia.org/wiki/Iterated_function) systems often display exact self-similarity. For example, the [Sierpinski triangle](http://en.wikipedia.org/wiki/Sierpinski_triangle" \o "Sierpinski triangle) and [Koch snowflake](http://en.wikipedia.org/wiki/Koch_snowflake) exhibit exact self-similarity.
* **Quasi-self-similarity** – This is a looser form of self-similarity; the fractal appears approximately (but not exactly) identical at different scales. Quasi-self-similar fractals contain small copies of the entire fractal in distorted and degenerate forms. Fractals defined by [recurrence relations](http://en.wikipedia.org/wiki/Recurrence_relation) are usually quasi-self-similar. The [Mandelbrot set](http://en.wikipedia.org/wiki/Mandelbrot_set) is quasi-self-similar, as the satellites are approximations of the entire set, but not exact copies.
* **Statistical self-similarity** – This is the weakest type of self-similarity; the fractal has numerical or statistical measures which are preserved across scales. Most reasonable definitions of "fractal" trivially imply some form of statistical self-similarity. ([Fractal dimension](http://en.wikipedia.org/wiki/Fractal_dimension) itself is a numerical measure which is preserved across scales.) Random fractals are examples of fractals which are statistically self-similar. The coastline of Britain is another example; one cannot expect to find microscopic Britains (even distorted ones) by looking at a small section of the coast with a magnifying glass.

Possessing self-similarity is not the sole criterion for an object to be termed a fractal. Examples of self-similar objects that are not fractals include the logarithmic spiral and straight lines, which do contain copies of themselves at increasingly small scales. These do not qualify, since they have the same [Hausdorff dimension](http://en.wikipedia.org/wiki/Hausdorff_dimension" \o "Hausdorff dimension) as [topological dimension](http://en.wikipedia.org/wiki/Topological_dimension).

The property of self-similarity or scaling is closely related to the notion of dimension. In fact, the name "fractal" comes from property that fractal objects have fractional dimension.

<http://www.stsci.edu/~lbradley/seminar/fractals.html> - fractal dimention

<http://www.stsci.edu/~lbradley/seminar/ifs.html> - leaf

<http://en.wikipedia.org/wiki/Affine_transformation>

<http://en.wikipedia.org/wiki/Linear_transformation>

Sierpenski triangle

Koch

What is a fractal? In the most generalized terms, a fractal demostrates a limit. Fractals model complex physical processes and dynamical systems. The underlying principle of fractals is that a simple process that goes through infinitely many iterations becomes a very complex process. Fractals attempt to model the complex process by searching for the simple process underneath.

<http://pages.cs.wisc.edu/~ergreen/honors_thesis/fractal.html>

<http://www.fractal.org/Bewustzijns-Besturings-Model/Fractals-Useful-Beauty.htm>

<http://www.skytopia.com/project/fractal/2mandelbulb.html> - 3d

NEW

 the Mandelbrot set is the set of values of *c* in the [complex plane](http://en.wikipedia.org/wiki/Complex_plane) for which the [orbit](http://en.wikipedia.org/wiki/Orbit_(dynamics)) of 0 under [iteration](http://en.wikipedia.org/wiki/Iterated_function) of the [complex quadratic polynomial](http://en.wikipedia.org/wiki/Complex_quadratic_polynomial) *zn*+1 = *zn*2 + *c* remains [bounded](http://en.wikipedia.org/wiki/Bounded_sequence)

he **Newton fractal** is a [boundary set](http://en.wikipedia.org/wiki/Boundary_set) in the [complex plane](http://en.wikipedia.org/wiki/Complex_plane) which is characterized by [Newton's method](http://en.wikipedia.org/wiki/Newton%27s_method) applied to a fixed[polynomial](http://en.wikipedia.org/wiki/Polynomial) p(Z)\in\mathbb{C}[Z]. It is the [Julia set](http://en.wikipedia.org/wiki/Julia_set) of the [meromorphic function](http://en.wikipedia.org/wiki/Meromorphic_function" \o "Meromorphic function) z\mapsto z-\tfrac{p(z)}{p'(z)} which is given by Newton's method.

Many points of the complex plane are associated with one of the \operatorname{deg}(p) roots of the polynomial in the following way: the point is used as starting value *z*0 for Newton's iteration z_{n+1}:=z_n-\frac{p(z_n)}{p'(z_n)}, yielding a sequence of points *z*1, *z*2, .... If the sequence converges to the root ζ*k*, then *z*0 was an element of the region *Gk*. However, for every polynomial of degree at least 2 there are points for which the Newton iteration does not converge to any root: examples are the boundaries of the basins of attraction of the various roots. There are even polynomials for which open sets of starting points fail to converge to any root: a simple example is *z*3 − 2*z* + 2, where some points are attracted by the cycle 0, 1, 0, 1 ... rather than by a root.