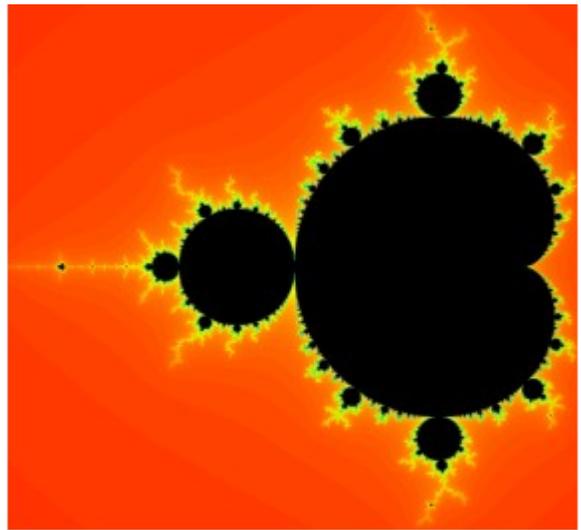


# Beautiful Images of Chaos

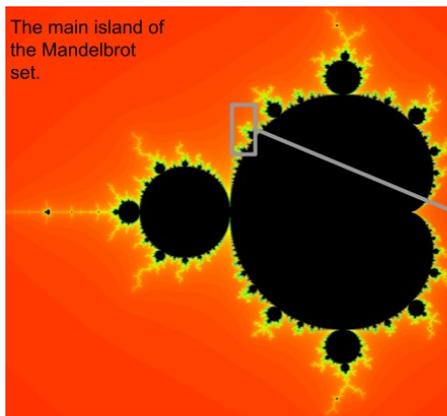
By [REDACTED]

## Mandelbrot set

In 1980, a pioneer in Chaos theory (an interdisciplinary subject in science) named Benoit Mandelbrot, working with some programmers from IBM (one of the biggest tech companies of the time) plotted the now-famous fractal Mandelbrot set. It looks like many circle-like blobs just touching each other at their edges. If you zoom into the boundary of the Mandelbrot set, you will see spirals, valleys, and satellites that almost keep repeating themselves without actually being alike. They are all unique, home to more spirals and satellites – smaller and smaller, forever. But the most fascinating feature of the beautiful Mandelbrot set is that its formula is very short and simple looking.<sup>5</sup>

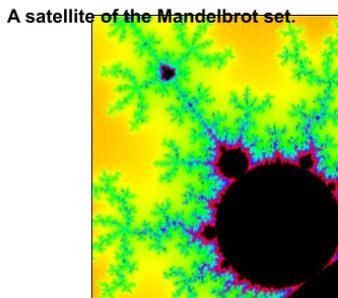


(Fig. 1) The Mandelbrot set in color.  
(I rendered this with p5js)

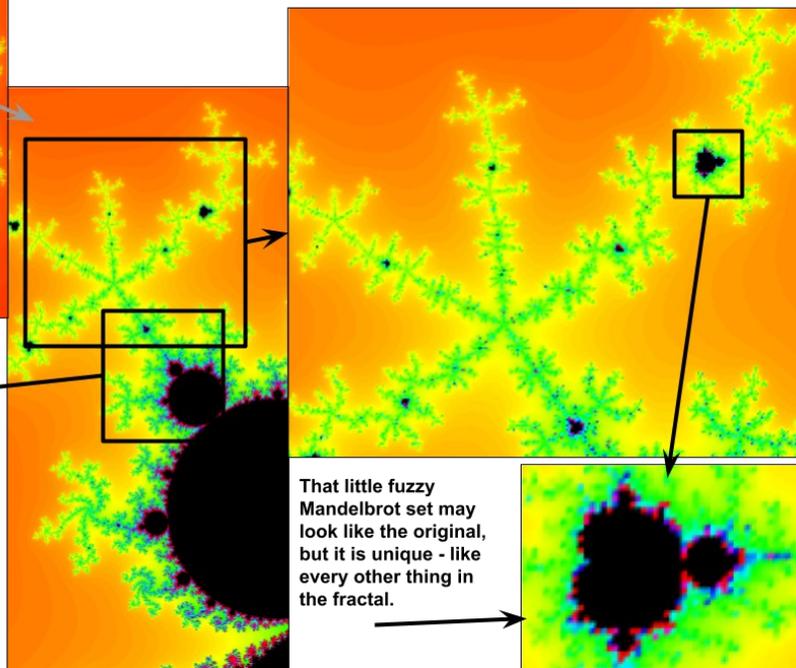


The main island of the Mandelbrot set.

(Fig. 2) A zoom into the boundary of the Mandelbrot set.



A satellite of the Mandelbrot set.



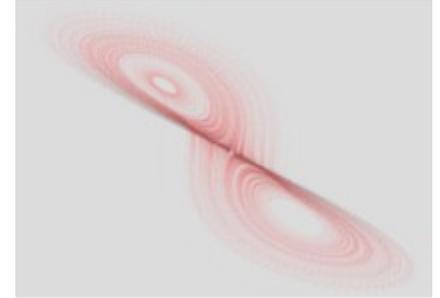
That little fuzzy Mandelbrot set may look like the original, but it is unique - like every other thing in the fractal.

You can see some nice images of the [Mandelbrot here](#).

<sup>5</sup>  $z = z^2 + c$ , where  $z$  and  $c$  are a kind of 2D number, called a complex number. To plot this you pick  $c$  to be a number from somewhere on your screen and then after setting  $z$  to  $c$  you do the formula on it at least 100 times. If  $z$  goes to  $\infty$ , color that pixel based on how long it took that point to go to  $\infty$ . If  $z$  goes to 0 color it black. Note that the more you zoom the more times you should do the formula. Link to my program: [Mandelbrot set plotter](#).

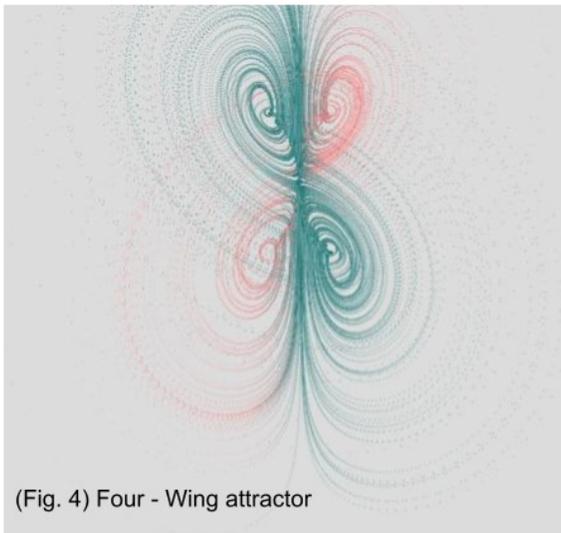
# Strange attractors

When you stir a cup of hot chocolate, you create swirls that look alike but are still somewhat different. In 1963, a meteorologist and mathematician named Edward Lorenz was thinking about something similar. He had just found out that with certain types of equations (including some that model the behavior of fluids) if you change the inputs by one in a thousand, the outputs can be very different. He then simplified them and decided to run them on his computer. After a while, the most incredible thing was waiting for him, a figure that we now know as the Lorenz attractor.

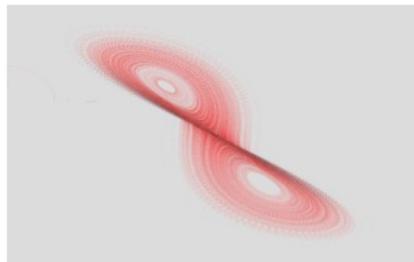


(Fig. 3) A rendering of the Lorenz attractor. I made this with p5js.

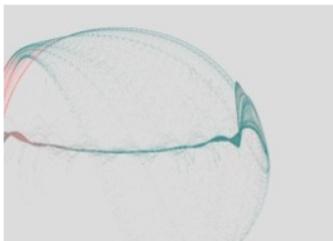
Soon after, people all over the world were discovering the beauty and complexity of strange attractors. Some others include the Thomas, the Aizawa, the Halvorsen, and dozens more. The equations that come from them describe things that range from the properties of components in electric circuits to the orbits of objects in the solar system. I have plotted pictures of these strange attractors with a javascript liberty called p5js. A link to my collection is here: [my strange attractors](#).



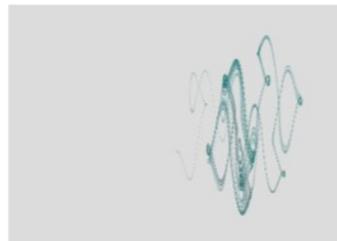
(Fig. 4) Four - Wing attractor



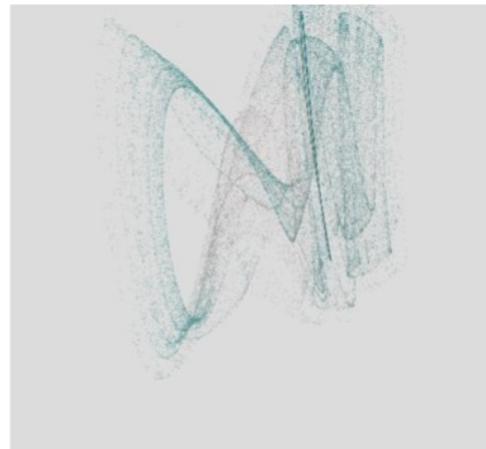
(Fig. 5) Lorenz attractor



(Fig. 6) Sprot attractor



(Fig. 7) Thomas attractor



(Fig. 8) Lorenz-84 attractor - a modification of the Lorenz attractor.