[MUSIC PLAYING]

[SINGING] Science out loud.

What do snowflakes and cellphones have in common?

The answer is never ending patterns called fractals.

Let me draw a snowflake.

I'll start with an equilateral triangle.

Then I'll draw another equilateral triangle on the middle of each side.

Pull out the middle and repeat the process, this time with 1, 2, 3, 4 times 3, which is 12 sides.

If I do this over and over, the shape will look something like this.

This is called a Koch snowflake, and it has a special property.

No matter where I look or how much I zoom in, I will see the same pattern over and over.

Never ending patterns like this that on any scale, on any level of zoom look roughly the same are called fractals.

We can actually draw a Koch snowflake on the computer by having it repeatedly graph a mathematical equation.

Each time we add a triangle, one side of the Koch snowflake will turn into four.

After the first repetition, we'll get three times four to the first, or 12 sides.

After the second repetition, we'll get three times four to the second, or 48 sides.

After repetition number n, we'll have three times four to the n sides.

If we do this an infinite number of times, we'll get infinitely many sides.

So the perimeter of the Koch snowflake will be infinite.

But the area of the Koch snowflake wouldn't be infinite.

If I draw a circle with a finite area around the snowflake, it will fit completely inside no matter how many times we increase the number of sides.

So the Koch fractal has an infinite perimeter, but a finite area.

In the 1990s, a radio astronomer named Nathan Cohen used the fractal antenna to rethink wireless communications.

At the time, Cohen's landlord wouldn't let him put a radio antenna on his roof, so Cohen decided to make a more compact, fractal like radio antenna instead.

But it didn't just hide the antenna from the landlord.

It also seemed to work better than the regular ones.

Regular antennas have to be cut for one type of signal, and they usually work best when their lengths are certain multiples of their signals' wavelengths.

So FM radio antennas can only pick up FM radio stations, TV antennas can only pick up TV channels, and so on.

But fractal antennas are different.

As the fractal repeats itself more and more, the fractal antenna can pick up more and more signals, not just one.

And because the perimeter of the Koch snowflake grows way faster than its area, the fractal antenna only takes up a quarter of the usual space.

But Cohen didn't stop there.

He designed a new antenna, this time using a fractal called the Menger sponge.

The Menger sponge is kind of like a 3D version of the Koch snowflake and has infinite surface area but finite volume.

The Menger sponge is sometimes used in cellphone antennas.

It can receive all kinds of signals while taking up even less area than a Koch snowflake.

Now, these antennas aren't perfect.

They're smaller, but they're also very intricate, so they're harder and more expensive to make.

And though low fractal antennas can receive many different types of signals, they can't always receive each signal as well as an antenna that was cut for it.

Cohen's invention was not the first application of fractals.

Nature has been doing it forever, and not just with snowflakes.

You can see fractals in river systems, lightning bolts, seashells, and even whole galaxies.

So many natural systems previously thought off limits to mathematicians can now be explained in terms of fractals, and by applying nature's best practices, we can then solve real world problems.

Fractal research is changing fields such as biology.

For example, MIT scientists discovered that chromatin is a fractal, and that keeps DNA from getting tangled.

Look around you.

What beautiful patterns do you see?

Hi.

I'm Yulia.

Thanks for watching "Science Out Loud." Check out these other awesome videos, and visit our website.

Good.

Now wait for it.

OK.

That's it.