[MUSIC PLAYING]

PROFESSOR: Hi. What do snowflakes and cell phones have in common? Well, let me start by drawing a snowflake first. I draw an equilateral triangle, divide each side into three parts, and draw another equilateral triangle on top of each one. Then take out the middle and repeat the process, this time with one, two, three, four, times three, which is 12 sides. Eventually, this shape will start looking something like this.

In mathematics, this is called a Koch snowflake. If I repeated my process again and again, I would see this same pattern anywhere I looked. This is a Koch snowflake, this time drawn on a computer. Such never ending patterns, that on any scale on any level of zoom look roughly the same, are called fractals.

Computer scientists can program these patterns by repeating an often simple mathematical process over and over. In the 1990s, a radio astronomer by the name of Nathan Cohen used fractals to revolutionize wireless communications. At the time, Cohen was having troubles with his landlord-- the man wouldn't let him put an antenna on his roof. So Cohen designed a more compact fractal radio antenna instead.

The landlord didn't notice it, and it worked better than the ones before. Working further, Cohen designed a new antenna, this time using a fractal called the Menger sponge. The Menger sponge is not really the sponge you'd be scrubbing your back with, but you can still think of it like that. Imagine both water and soap getting through your sponges holes, except the water is Wi-Fi and the soap is, say, Bluetooth.

The fractal's infinite sponginess allows it to receive many different frequencies simultaneously. Before Cohen's invention, antennas had to be cut for one frequency, and that was the only frequency they could operate at. Without Cohen's sponge, your cell phone would have to look something like a hedgehog to receive multiple signals, including the one your friends use when they call.

Cohen later proved that only fractal shapes could work with such a wide range of frequencies. Today, millions of wireless devices, such as laptops and bar code scanners, use Cohen's fractal antenna. Cohen's genius invention, however, was not the first application of fractals in the world.

Nature has been doing it the whole time, and not just with snowflakes. Natural selection favors the most efficient systems in organisms, often of a fractal form. The spiral fractal, for example, is present in sea shells, broccoli, and hurricanes. The fractal tree is relatively easy to program, and can be used to study river systems, blood vessels, and lightning bolts. So many natural systems previously thought off-limits to mathematicians can now be explained in terms of fractals.

Mathematics allows us to learn nature's best practices and then apply them to solve real world problems. Much like Cohen's antenna revolutionized the field of telecommunications, other fractal research is changing medicine, weather prediction, and building design here at MIT and everywhere in the world. Look around you. What beautiful patterns do you see?