FRACTAL GEOMETRY IN MEDICAL DIAGNOSIS

By Dr. Derek Conte

A fascinating NOVA program ran last week on Fractal Geometry which involves the idea that many structural patterns in Nature could be expressed mathematically. Fractal Geometry began in the mind of Dr. Benoit Mandelbrot while working for IBM in the 1950's when he brought mathematics to Nature instead of only applying it to Man-made things. He noticed that by taking a straight or smooth shape and breaking it into smaller and smaller contiguous pieces, the shape's finite length would be made infinite. For instance, taking an equilateral triangle and adding smaller triangles on each side yielded a six-pointed star shape. With the aid of those IBM computers he added more and more triangles resulting in an infinitely complex snowflake shape. The repeating patterns were called, "self-similar" in that, as you focused down on smaller and smaller areas of the overall picture, it looked just like the larger picture, only many orders of magnitude smaller.

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In Nature, this "self-similar" patterning is everywhere: in the branchings the vascular and pulmonary systems, in the veining of leaves or splitting of rivers into deltas at the ocean, or even in forests. Three scientists even showed that the branching of a single tree was perfectly reflected in all the trees of the forest in which it stood. The distribution and sizes of the trees in the forest exactly matched relative sizes of the branches of the single tree. These patterns are even echoed in the distribution of the galaxies of our universe.

Current applications fractals in technology include radio and cell phone antennae, which benefit greatly from the "self-similar" fractal patterns, allowing them to receive a broad band of frequencies due to the principles of resonance. Look inside your cell phone and notice the tiny golden grid inside. That's your antenna!

Now, how could this powerful insight assist in the diagnosis of disease, you ask? Well, one cardiologist noted that when normal fluctuations in heart rates are examined over long periods of time, the familiar "self-similar" fractal pattern emerges, and holds up, whether viewed over a month, a day or even an hour. If 'normal' macro-patterns can be established, then it may be possible to detect heart ailments much earlier. And in the field of cancer research there is also promise. Current imaging techniques have limitations in the size of tumors they can detect in the kidneys, say, but ultrasound does a very good job of seeing the overall movement of blood through the fractal branchings of the vessels in the kidneys. It has been discovered that the blood flow around even small tumors is very different from the flow in a healthy kidney. Perhaps the presence of very small tumors can one day be reliably inferred with this kind of observation.

Watching this NOVA special made me extremely excited as I thought of how beautifully organized our world is; how there is a mathematical coherence to its design, even with all those lovely curved lines around us.

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