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Fractal Vision

By JAMES GLEICK

HERE IS A mathematician's nightmare I heard in the 1980s when that irritating, unconforming, self-regarding provocateur Benoît Mandelbrot was suddenly famous — fractals, fractals everywhere. The mathematician dreamed that Mandelbrot died, and God spoke: "You know, there really was something to that Mandelbrot."

Sure enough.

Mandelbrot created nothing less than a new geometry, to stand side by side with Euclid's — a geometry to mirror not the ideal forms of thought but the real complexity of nature. He was a mathematician who was never welcomed into the fraternity ("Fortress Mathematics," he said, where "the highest ambition is to wall off the windows and preserve only one door"), and he pretended that was fine with him. When Yale first hired him to teach, it was in engineering and applied science; for most of his career he was supported at I.B.M.'s Westchester research lab. He called himself a "nomad by choice." He considered himself an experienced refugee: born to a Jewish family in Warsaw in 1924, he immigrated to Paris ahead of the Nazis, then fled farther and farther into the French countryside.

In various incarnations he taught physiology and economics. He was a nonphysicist who won the Wolf Prize in physics. The labels didn't matter. He turns out to have belonged to the select handful of 20th-century scientists who upended, as if by flipping a switch, the way we see the world we live in.

He was the one who let us appreciate chaos in all its glory, the noisy, the wayward and the freakish, from the very small to the very large. He gave the new field of study he invented a fittingly recondite name: "fractal geometry." But he wanted me to understand it as ordinary.

"The questions the field attacks are questions people ask themselves," he told me. "They are questions children ask: What shape is a mountain? Why is a cloud the way it is?" Only his answers were not ordinary.

Clouds are not spheres — the most famous sentence he ever wrote — *mountains are not cones, coastlines are not circles and bark is not smooth, nor does lightning travel in a straight line.*

If you closely examine the florets of a cauliflower (or the bronchioles of a lung; or the fractures in oil-bearing shale), zooming in with your magnifying glass or microscope, you see the same fundamental patterns, repeating. It is no accident. They are all fractal. Clouds, mountains, coastlines, bark and lightning are all jagged and discontinuous, but self-similar when viewed at different scales, thus concealing order within their irregularity. They are shapes that branch or fold in upon themselves recursively.

I was following him from place to place, reporting a book on chaos, while he evangelized his newly popular ideas to scientists of all sorts. Wisps of white hair atop his outsize brow, he lectured at Woods Hole to a crowd of oceanographers, who had heard that fractals were relevant to cyclone tracks and eddy cascades. Mandelbrot told them he had seen the same channels, flows and back flows in dry statistics of rising and falling cotton prices. At Lamont-Doherty Geological Observatory, as it was then known, the geologists already spoke fractally about earthquakes. Mandelbrot laid out a mathematical framework for such phenomena: they exist in fractional dimensions, lying in between the familiar one-dimensional lines, two-dimensional planes and three-dimensional spaces. He revived some old and freakish ideas — “monsters,” as he said, “mathematical pathologies” that had been relegated to the fringes.

“I started looking in the trash cans of science for such phenomena,” he said, and he meant this literally: one scrap he grabbed from a Paris mathematician’s wastebasket inspired an important 1965 paper combining two more fields to which he did not belong, “Information Theory and Psycholinguistics.” Information theory connected to fractals when he focused on the problem of noise — static, errors — in phone lines. It was always there; on average it seemed manageable, but analysis revealed that normal bell-curve averages didn’t apply. There were too many surprises — outliers. Clusters and quirks always defied expectations.

It’s the same with brainwaves, fluid turbulence, seismic tremors and — oh, yes — finance.

From his first paper studying fluctuations in the rise and fall of cotton prices in 1962 until the end of his life, he maintained a simple and constant message about extraordinary economic events. The professionals plan for “mild randomness” and misunderstand “wild randomness.” They learn from the averages and overlook the outliers. Thus they consistently, predictably, underestimate catastrophic risk. “The financiers and investors of the world are, at the moment, like mariners who heed no weather warnings,” he wrote near the peak of the bubble, in 2004, in “The (Mis)behavior of Markets,” his last book.

Fractals have made their way into the economics mainstream, as into so many fields, though Mandelbrot was not really an economist; nor a physiologist, physicist, engineer. . . .

“Very often when I listen to the list of my previous jobs, I wonder if I exist,” he said once. “The intersection of such sets is surely empty.”