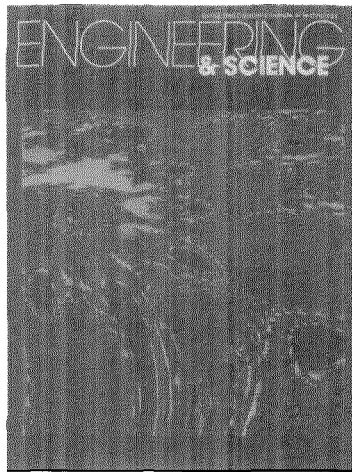


In This Issue



© B.B. Mandelbrot, 1987.

Art or Mathematics?

On the cover—a plane section through a four-dimensional generalized Mandelbrot set, often better known as a fractal. Benoit B. Mandelbrot, MS '48, Eng '49 in aeronautics, who recently received a Distinguished Alumni Award, generously contributed this cover illustration because, he said, "Since this award gave me surprise and pleasure, I would like to provide surprise and pleasure to my fellow alumni."

Mandelbrot, the inventor of fractals, also coined the word for this "geometry of nature" from a Latin root meaning fractured or fragmented, hence irregular. Through fractals Mandelbrot demonstrates the beauty inherent in "some of the most austere formal chapters of mathematics"—a complex beauty that can be enjoyed purely as art.

But is it complex? In "Simplicity and Complexity in the Description of Nature," Nobel laureate Murray Gell-Mann uses a more familiar version of the Mandelbrot set as a starting point for defining these terms and discussing how scientific theory seeks to organize, or reduce, the often random richness of natural detail into a hierarchy of basic laws. (Fractals, he notes, although they can be generated by a simple rule, are also connected in interesting ways to chaos.)

When Gell-Mann won the Nobel Prize in Physics in 1969,

he was described as having "contributed probably more than anyone toward bringing order out of chaos" with his "eightfold way" of classifying the ever-increasing number of elementary



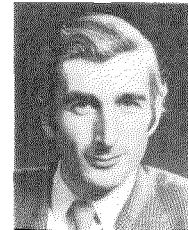
particles. He also came up with the theory, and name, of quarks, the building blocks of elementary particles and, with others, constructed the theory of quantum chromodynamics. Gell-Mann is the Robert Andrews Millikan Professor of Theoretical Physics at Caltech, where he has been a member of the faculty since 1955. He earned his BS from Yale in 1948 and PhD from MIT in 1950. His article, which begins on page 2, was adapted from an address to The Caltech Associates at their black-tie dinner last October 1.

Cosmic Clumps

In "Why Do Galaxies Exist?," beginning on page 10, astrophysicist Martin Rees summarizes recent research in cosmology and discusses how, if matter was indeed originally distributed

evenly throughout the cosmos, the aggregations of stars that we know as galaxies might have condensed out of the Big Bang.

Rees is the Plumian Professor of Astronomy and Experimental Philosophy (since 1973) and director of the Institute of Astronomy (since 1977) at Cambridge University,



where he also received his BA, MA, and PhD degrees. He had previously come to Caltech as a research fellow in 1968 and as visiting associate professor of astrophysics in 1971.

The purpose of his most recent visit, in January, was to deliver the 11th Charles and Thomas Lauritsen Memorial Lecture, from which this article is adapted. The Lauritsen Memorial Lecture commemorates two former professors of physics, father and son, who served Caltech for a total of more than 68 years. It's particularly appropriate that many of the advances in astrophysics that Rees considered in his lecture came out of Kellogg Laboratory, founded by Charles Lauritsen in 1931.

David Harper — *President of the Alumni Association*
Theodore P. Hurwitz — *Vice President for Institute Relations*
Robert L. O'Rourke — *Director of Public Relations*

STAFF: *Editor* — Jane Dietrich
Writer — Douglas Smith
Production Artist — Barbara Wirick
Circulation Manager — Susan Lee
Photographer — Robert Paz

PICTURE CREDITS: Cover, back cover—Benoit B. Mandelbrot; 2, 5, 7, 8—H.-O. Peitgen, P. H. Richter; 10, back cover—Palomar Observatory; 32, 38—Floyd Clark; 34—Terry Young; 35, 38—Robert Paz; 35—Richard Kee; 38—Kent McCaulley

Engineering & Science (ISSN 0013-7812) is published quarterly, Fall, Winter, Spring, and Summer, at the California Institute of Technology, 1201 East California Boulevard, Pasadena, California 91125. Annual Subscription \$8.00 domestic, \$20.00 foreign air mail, single copies, \$2.00. Third class postage paid at Pasadena, California. All rights reserved. Reproduction of material contained herein forbidden without authorization. © 1988 Alumni Association California Institute of Technology. Published by the California Institute of Technology and the Alumni Association. Telephone: 818-356-3630. Postmaster: Send change of address to Caltech, 1-71, Pasadena, CA 91125.