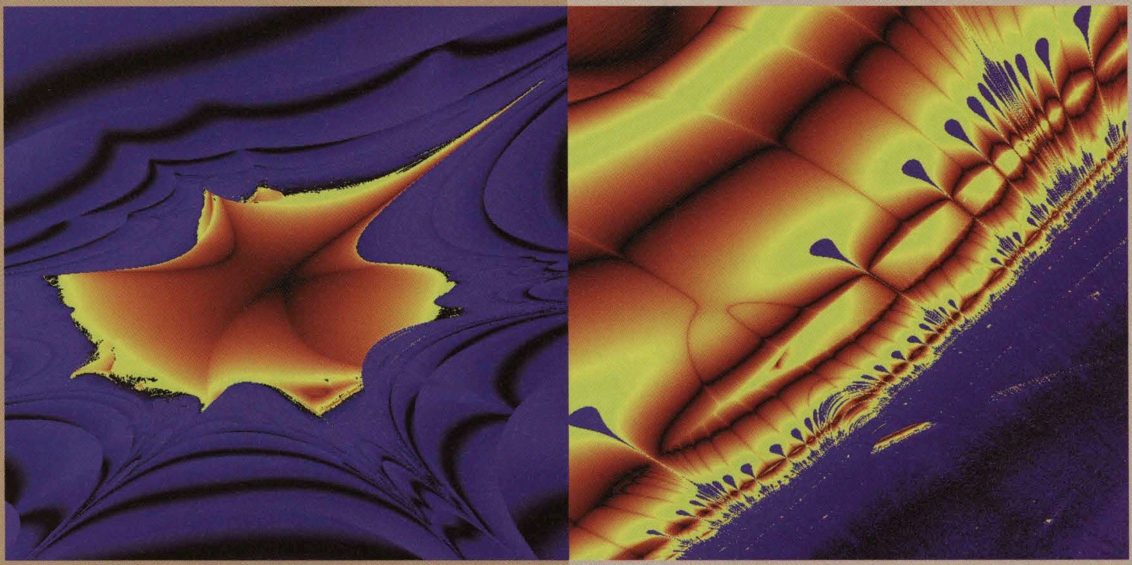
View from the Hill



howard blair

Computer science professor Howard Blair created the fractal, at left, as a byproduct of his research. The image, at right, represents a magnification of the fractal's lower-right portion where the gold and blue areas meet.

Creating Fractals from Computing Processes

At first glance, the image may look like a work by abstract expressionist Jackson Pollock. Closer examination, however, reveals that this is the art of mathematicians and scientists, of computer graphics and computations. The object is called a fractal, a word coined by mathematician Benoit Mandelbrot in 1975 to represent the shapes, dimensions, and geometry he began studying in the sixties and ushered to scientific prominence by the eighties. Beneath the art of this fractional geometry there is often a mathematical rule that dictates the outcome. Plug in a formula, adjust parameters here and there, and put the computer to work in a computational frenzy. Add colors and the fractal becomes a visual aid, revealing relationships not otherwise apparent.

In his office in the Center for Science and Technology, computer science professor Howard Blair '74, G'76, G'80 opens his web site and shares several examples of fractals. Some, he says, are classical ones like the Mandelbrot set, while others are byproducts of Blair's research. "They give me a sense of the lay of the land and phenomena I want to look at," he says.

Feedback, according to Blair, is the source of fractals. Many individual fractals, such as the Mandelbrot set, exhibit a universal quality in which a regular geometric structure is repeated within the pattern on infinitely finer and finer scales. In other kinds of fractals, quantifying the chaos in the feedback produces intriguing geometric structures that show up bizarrely balanced between regular patterns and chaotic froth.

Blair teaches a course on fractals and uses them in his research. In his course Computing Fractals and Chaos, he sees creating fractals as a direct way to motivate students to understand the role calculus plays in computations. "If they haven't taken a lot of science and math courses, it's not easy to find good numerical problems for them to apply their calculus to," he says. "But in this area it is particularly easy."

In research, Blair employs fractals to explore ways to continuously tune computer programs. "Even non-numerical algorithms can often be reformulated to depend in part on continuous numerical parameters," Blair says. "The reformulation sometimes reveals connections between solutions of similar problems." There are also times when a computation is seen as chaotically sensitive to its input. "These sensitivities are often fractal," Blair says. "Within these fractals there are apparently unpredictable islands of stability where we see the sudden emergence of self-organizing behavior." This self-organization, however, may not become apparent until a computer has spun through hundreds of generations of mathematical feedback. Recently, Blair began developing cryptographic methods based on these unpredictable stabilities.

Blair says methods from continuous mathematics can provide an approach to highly complex computing problems, giving computer scientists insights by tuning parameters on easier versions of these problems. "There's no easy general solution that will cover every case," he says. "But the more we can chip away at these kinds of problems, the closer we are to making them feasible to compute." —JAY COX