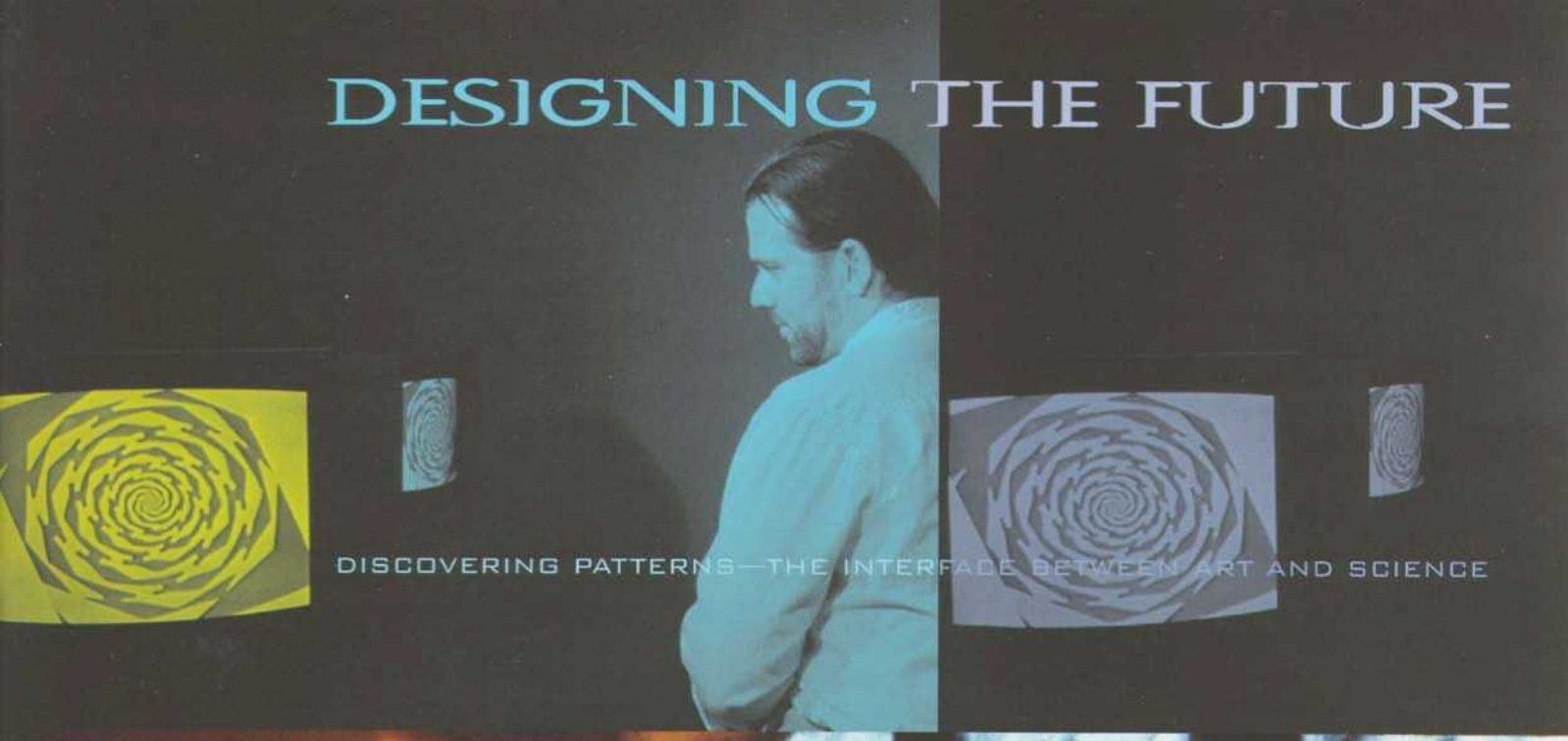
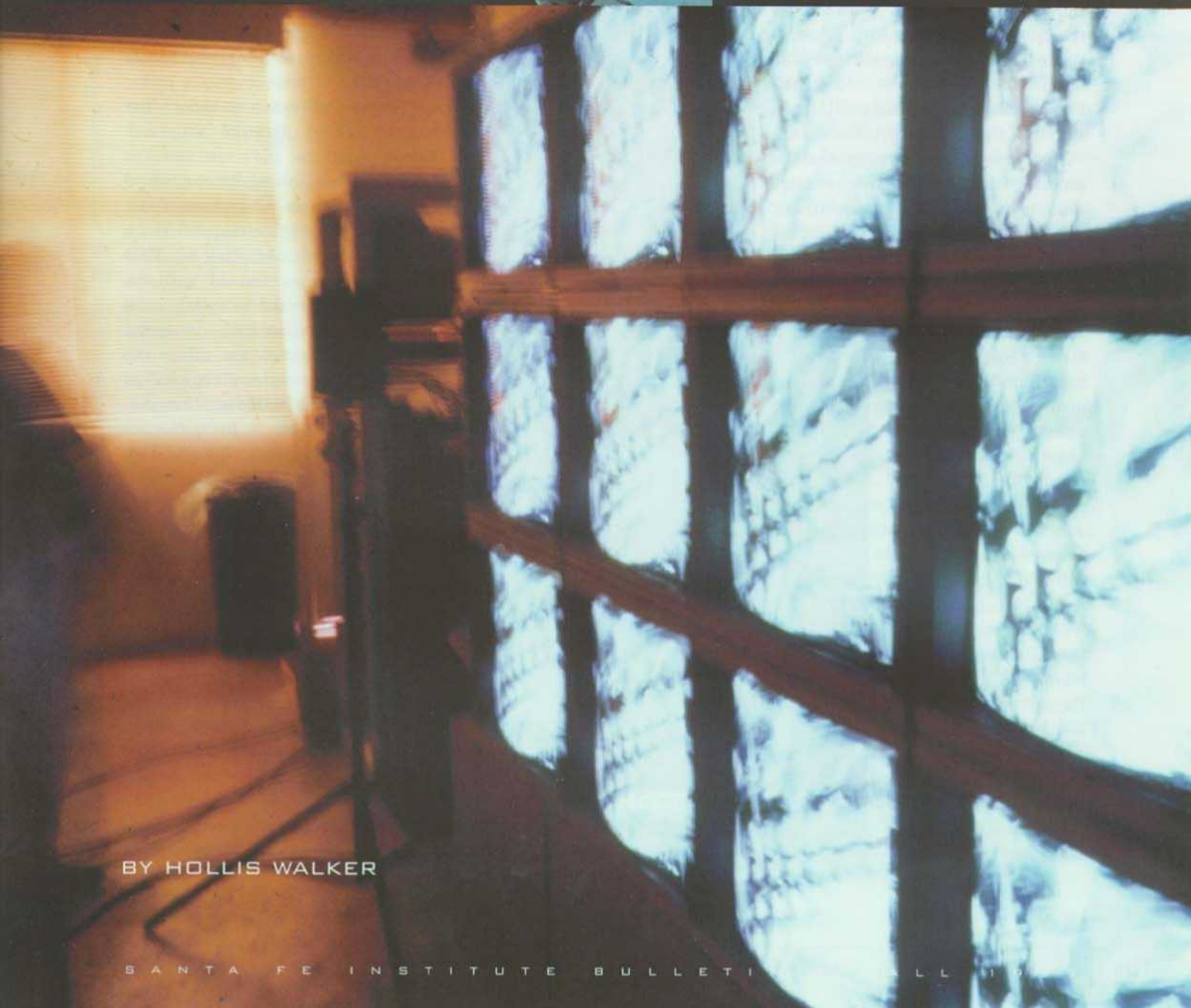
DESIGNING THE FUTURE



DISCOVERING PATTERNS—THE INTERFACE BETWEEN ART AND SCIENCE

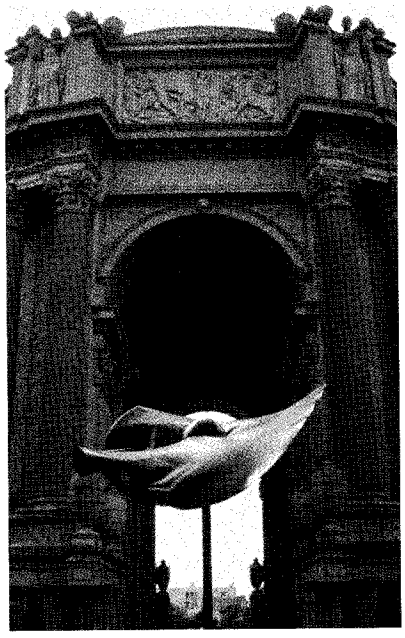


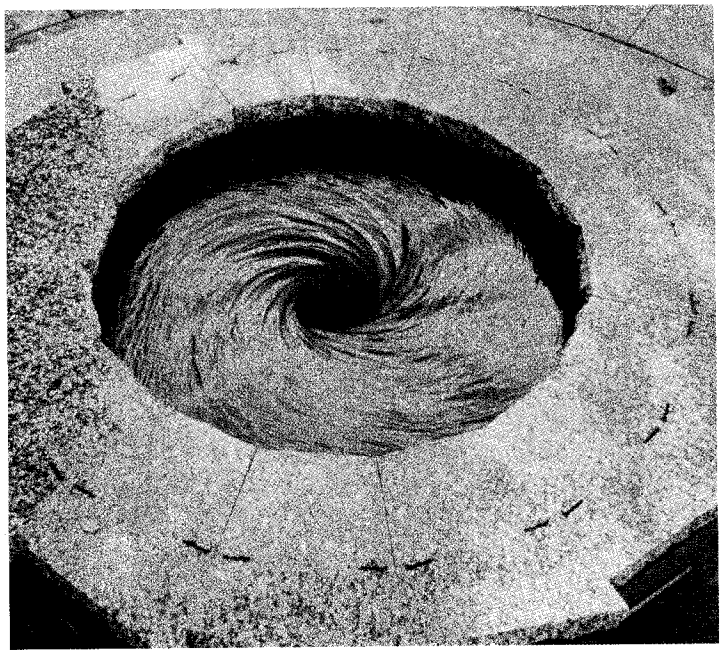
BY HOLLIS WALKER

These days, Jim Crutchfield is thinking about vocabularies—about how humans continuously extend our vocabularies to describe new realms of experience. His concerns run counter to those espoused by philosopher Ludwig Wittgenstein early in this century, who said that if you don't know about something, you can't talk about it. Crutchfield is more worried about how our perception of the world is limited by our vocabularies and how we transcend those limitations. "How do you extend your vocabulary in a dynamic way? How do you teach yourself to see new patterns you haven't seen before?" he asks.

This fascination with what he calls "pattern discovery" is one of the reasons Crutchfield spends more time hanging out with artists than other scientists. Like mathematics, art can be an iconic substitute for language—and at the same time a vocabulary unto itself. "In a way, art is a theory about the way the world looks to human beings," Mitchell Feigenbaum told James Gleick, author of *Chaos: Making A New Science*. "What artists have accomplished is realizing that there's only a small amount of stuff that's important, and then seeing what it was. So they can do some of my research for me."

Crutchfield says his long-standing friendships with many artists, including Ned Kahn, Sara Roberts, and Gail Wight, have inspired some of his more rigorous scientific inquiries. Kahn, with whom Crutchfield worked on the 1996-97 San Francisco Exploratorium exhibit, Turbulent Landscapes: The Natural Forces That Shape Our World (http://www.exploratorium.edu/complexity), creates art installations inspired by atmospheric physics, geology, astronomy, and fluid motion: flapping flags, dust devils, swirling streams.





top: "Circling Wave" by Ned Kahn, Exploratorium, San Francisco.
bottom: "Encircled Stream" by Ned Kahn, Seattle, Washington

During the years Crutchfield was at UC Berkeley, Kahn would call him for help on the scientific end of his constructions: "Hey, Jim, I've been squirting water into a satellite dish, and the vortex detaches from the drain. What do you think is happening?" Often Kahn's queries would send Crutchfield into his Berkeley physics lab, his own curiosity piqued. The artist, meanwhile, was looking for a way to put a frame around an active, natural system, then create a way for observers to alter it—in effect, manufacturing curiosity to engage ordinary people with nature, science, and art.

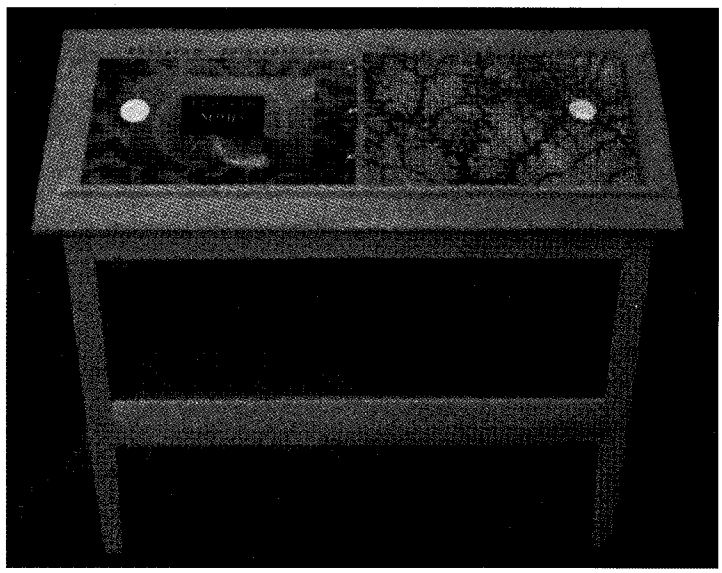
While Kahn formalizes opportunities to perceive and effect natural phenomena, Sara Roberts borrows the mathematics used to describe those phenomena and employs it in the design of her anthropomorphic computer programs. Roberts teaches at the California Institute of the Arts in Valencia, where she also founded and now directs the Integrated Media Program.

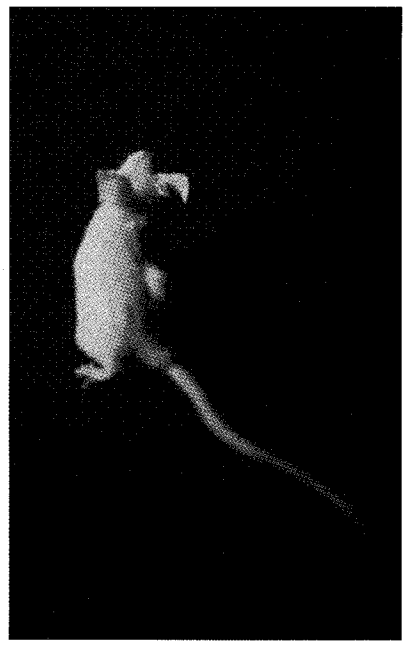
"Dynamical systems theory has lots of useful material for me," Roberts explains. "It's not that I'm interested in looking at the world through a dynamical systems filter. It's useful to me as technique." Much of Roberts' work, including her 1994 *Elective Affinities* (based on the Goethe novella), used dynamical systems models to drive the "emotional engines" of multimedia installations. In *Elective Affinities*, the installation became a metaphor for the dynamics of complex human relationships.

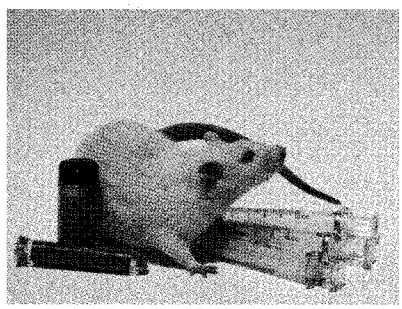
A married couple and two close friends are riding in a car together and, as a result of sexual innuendoes bandied about at a picnic from which they're returning, they are thinking about betraying each other. The characters are projected video images in front

PHOTOS COURTESY OF THE EXPLORATORIUM, SAN FRANCISCO

and back seats represented by video busts on a pedestal; the scenery outside the car rushes away from them on a screen mounted on the wall behind. Each character runs on its own computer and owns its own emotional program and database of thoughts; all four are networked. Occasionally, one character glances at another. That glance alters the state of the emotional engine in the other character according to a set of rules. "The spectator looking at them doesn't see the system in action, but when you walk close to each character's pedestal, you can hear their thoughts," Roberts says.







PHOTOS COURTESY OF GAIL WIGHT/INSTALLATION PHOTO: BEN BLACKWELL.

Another artist who has worked with Crutchfield is Gail Wight of San Francisco, who is developing a new electronic arts program at Mills College. Wight met Crutchfield while creating a piece for Turbulent Landscapes on biological self-organization in dictostelium slime mold. Biologists are fascinated with this species of slime mold because when a dictostelium cell is in danger of dying of starvation or thirst, it sends out chemical signals to surrounding cells—and they aggregate by moving in synchronized waves into a slug-like creature that forms a budding stalk, which explodes, sending spores flying to distant, and perhaps more hospitable, environments.

Wight was supposed to grow dictostelium as part of her Exploratorium installation, but the spores she was given were a different species (physarum) that only grows in tree-like structures and does not shift from individual cells to a multicellular organism—something she did not discover until after months of waiting for her slime cells to organize into traveling waves. The experience caused her to look at science differently, to question her implicit trust, and led to the way she now uses science in her work—by questioning it. "I started being very suspicious of my own infatuation with science," she said. "I began to wonder, how did we get to this place, this thing we now call science?"

Her question is apparent in a later installation in which she put 50 mice in individual cages; their environments illustrated moments in the history of genetics. One was a portrayal of Mendel's pea garden. Inside the cage was a miniature pea garden, which, eventually, the mouse ate. Another cage illustrated the studies from which scientists concluded twins had little in common genetically—only to later realize that their own biases prevented them from recognizing the twins' shared attributes. One mouse in the twin pair had a tiny baby grand piano in his cage; he decided to sleep inside it. The other had a shabby upright piano; he ate the instrument.

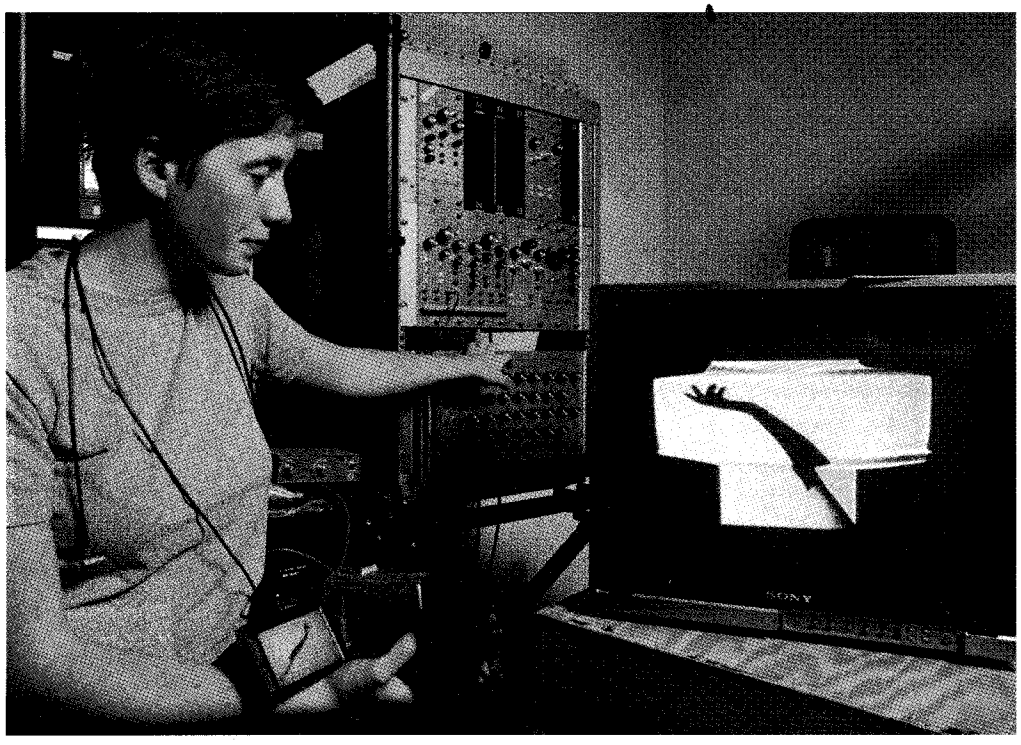
Recently, Wight designed a similar installation; this one includes five tiny tableaux from history representing "how we came to conceive of ourselves as electrochemical entities." Of this exhibit, Wight said, "These tiny tableaux are sitting inside a square Plexiglas maze, and there's a rat that lives inside of it. The rat will hopefully eat away the tableaux. The rat is sort of the artist."

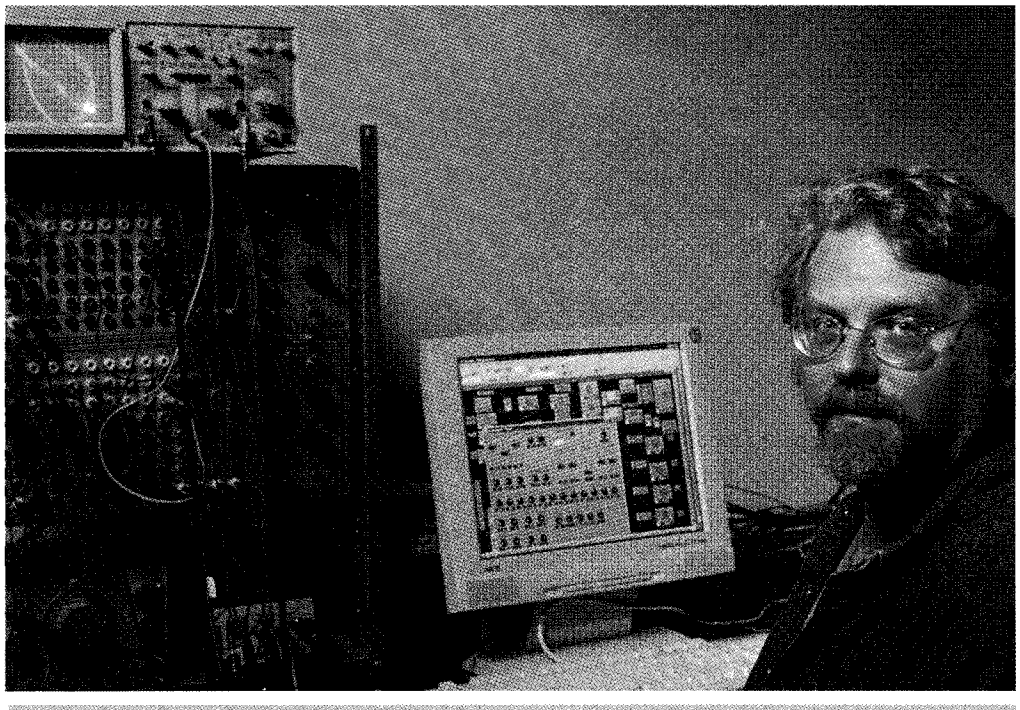
In the winter of 1998-99, Crutchfield organized a public lecture series in Santa Fe titled "Arts of the Artificial." Motivated by an interest in how art and science will determine the structure of "virtual spaces" created by networked computers, the series included talks by Gail Wight, Roberts, art critic Dave Hickey, and Rodney Brooks, director of MIT's Artificial Intelligence Lab.

The idea of the series was that public exposure to the

thinking of those on the forefront of pattern discovery in art and science might inspire others toward similar inquiries. Putting artists and scientists together often causes each to recognize old things in new ways—that mysterious process of pattern discovery at which humans are so good.

Kahn was recently working on a geological installation that represents a slice through a volcanic landscape. Air is pumped up through two sheets of glass, fluidizing a powdery mixture, erupting to the surface and creating a caldera. "When I got this working I called this geophysicist, Raymond Jean-Luz, at (UC) Berkeley," Kahn recalled. "He was so into this thing he spent three hours just staring at it. He came back the next day with a graduate student and they spent all day staring at it. They were looking at something real. It reminded them of why they got interested in geology in the first place."





PHOTOS: DAN BARSOTTI

"Techne and Eros: Human Space and the Machine" drew participants from around the world. Above, student participant. Below, David Dunn.

Kahn says looking at real phenomena prompts a different kind of thinking. "Your mind is working on a lot of levels. You're processing this visual information, and you're recognizing patterns, some so subtle you probably can't describe what you're seeing, but on some level aesthetically . . . there's an indication that there is an order in there."

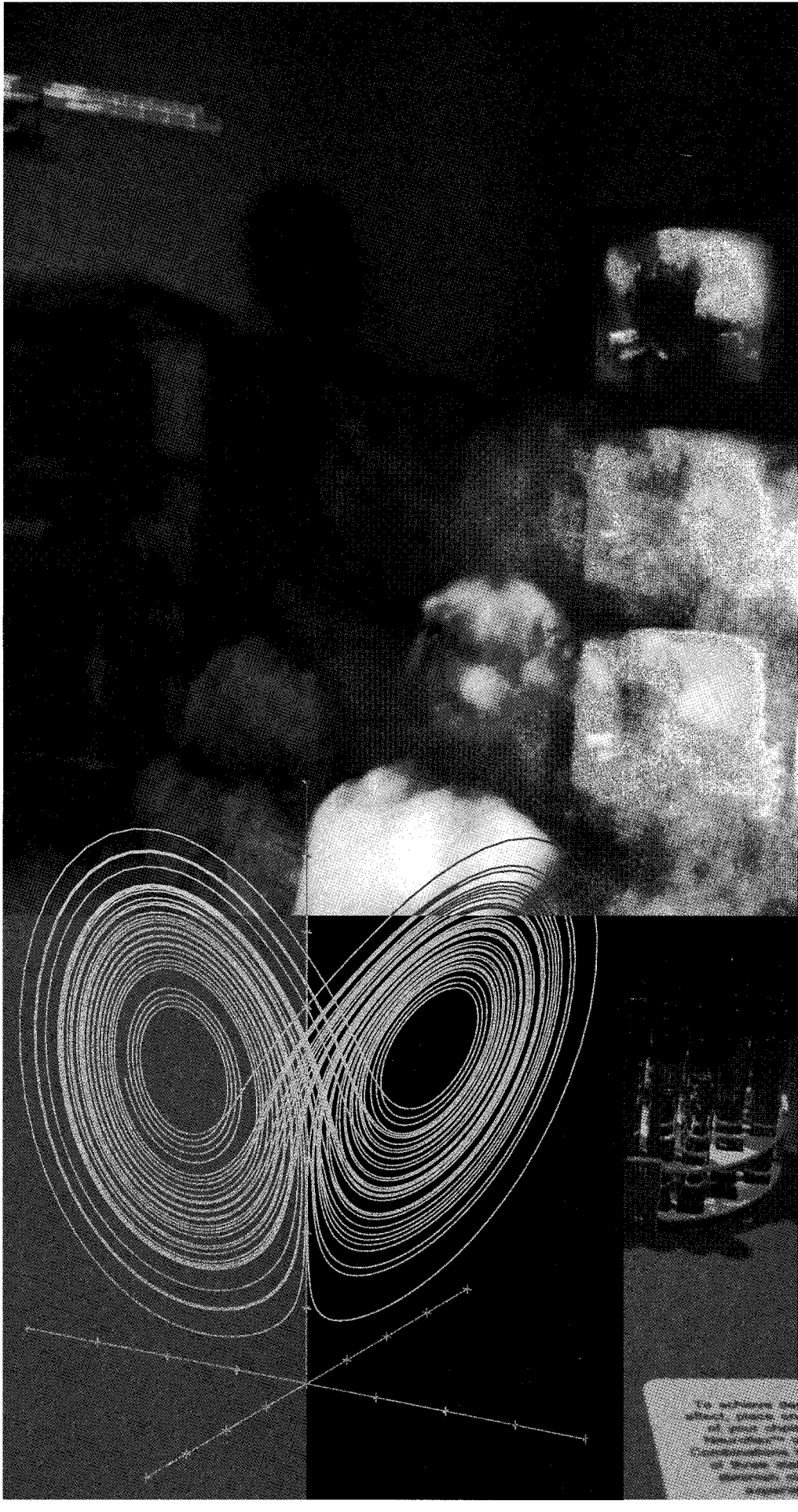
That's similar to what Crutchfield experienced in the laboratory during his experiments on video feedback. These were not focused so much on the rich patterns generated by that system, but on the process of his own perception of those patterns. Eventually, this led him to develop a mathematical framework to describe

the process of pattern discovery. He would be looking at the video monitor, thinking, "This pattern looks familiar...similar to something else I saw a few days ago," he recalls. "The empirical facts that I concentrated on were not images that appeared on the screen but the first intuitive impressions of regularity that occurred as I began to see new patterns."

One of the projects Crutchfield began recently involves magnetoencephalography (MEG), a new imaging technique that measures neural activity via magnetic signals generated by the functioning brain—a potentially more sensitive method than the more familiar electroencephalography (EEG). A clinician typically analyzes such data by visual inspection, that is, studying temporal information recorded on strips of paper or on a screen, and recognizing certain patterns within the data.

The problem is that the more sophisticated MEG machines, such as the 122-channel one at the Veterans Administration Hospital in Albuquerque, produce gigabytes of data in just a few minutes of recording from a subject, more data than a clinician could ever analyze by eye. What's needed is the ability to analyze such quantities of data for hundreds of people, over time, to identify norms and anomalies associated with illness. "Can we teach a machine to automatically discover patterns in such huge quantities of data?" Crutchfield asks.

In the past, human beings have been constrained by the limits of our physical world and our evolutionary heritage. Although it may not be possible for the human mind to perceive patterns in more than four or five



SPIRAL DESIGN GENERATED BY JIM CRUTCHFIELD. PHOTOS: PATRICK MCFARLIN, GAIL WIGHT

dimensions, once trained, machines may be able to do it for us, Crutchfield says. Such pattern-discovery machines could become our proxies in worlds we cannot visualize. A more intelligent MEG machine would not only produce massive quantities of data, but also be able to recognize patterns in that data—and then point them out to us. Can Crutchfield and his colleagues teach machines to see patterns and regularities in high-dimensional spaces, for example, to analyze those mountains of MEG data? That's their goal.

Some of these ideas will no doubt be on the agenda of a new research facility just formed in Santa Fe. What's tentatively being called The Art and Science Laboratory will involve Crutchfield and pioneer electronic composers and artists including David Dunn and Steina and Woody Vasulka (founders in the 1960s of The Kitchen, an electronic art performance space in New York City). This core group—plus composer/electronic artist Morton Subotnik and composer/vocalist Joan La Barbara—presented a six-week series of workshops, "Techne and Eros: Human Space and the Machine," at the Santa Fe Art Institute this summer that drew students from around the world. A permanent exploratory science-arts facility in Santa Fe will offer them and others working in these loosely defined arenas a way to easily interact with the researchers at SFI and other institutions.

New machines that can think better than we can, communicate in languages we do not speak, in realms of which we cannot perceive—it sounds like science fiction. In fact, these are the characteristics of cyberspace, only the first of the novel non-physical/non-biological realms humans are creating. The inventors of these new, very social spaces should include artists as well as scientists and technologists, Crutchfield says. Why? Consider the innovation in magnetic materials that led to the small, powerful motors which drive Sony Walkmans. Now people the world over are running, riding the subway, racing through their ordinary lives while wearing the ubiquitous headphones attached to miniature music boxes. Science affects technology which drives culture, and culture indirectly determines the directions in which society chooses to invest scientifically.

"Shift that feedback loop into the new virtual spaces," Crutchfield suggests. Imagine that artists, as well as scientists, have primary input into the structure of such new realms. He adds, "It will be an entirely different world, one in which physical and biological constraints are markedly less dominant, and aesthetic choice and design are primary."

Hollis Walker is arts and entertainment editor at The Santa Fe New Mexican. *She was a Pew Charitable Trusts' National Arts Journalism Fellow in 1996-97.*

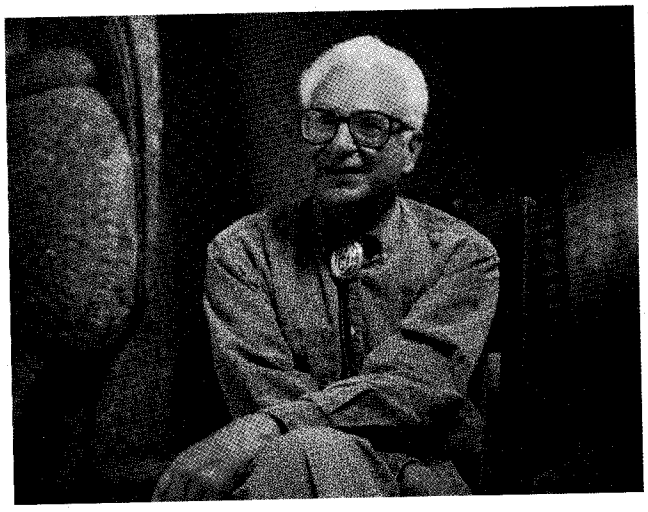


PHOTO: MURRAE HAYNES

MURRAY GELL-MANN AND THE CREATIVE PROCESS

SFI Distinguished Professor Murray Gell-Mann uses neckties as an easy way to talk about simplicity and complexity. "If you're looking at a pattern of a necktie and it's just regimental stripes, it's simple," he said. "But you've seen neckties with much more complex patterns." His point is that those complex patterns have regularities that it would take a long time to describe.

Gell-Mann's interest in questions of simplicity and complexity and their intersections with art led last fall to a forum co-sponsored with SITE Santa Fe called "Simplicity and Complexity in the Arts and the Creative Process." The forum brought together a number of scientists and artists in discussions at the Santa Fe Institute that culminated in a public presentation at SITE Santa Fe. Gell-Mann and his wife poet Marcia Southwick (whose latest book is *A Saturday Night at The Flying Dog and Other Poems*, Oberlin College Press, 1999) together organized the forum. Among the scientists attending were Chuck Stevens and Jim Crutchfield of SFI. Arts panelists included novelist Cormac McCarthy, architect Moshe Safdie, poet David St. John, and visual artist Joseph Kosuth.

Gell-Mann and Southwick also have attended recent meetings (along with others on the faculty at SFI) on connections between complexity and the arts in Abisko, Sweden and Catalina Island, California. Some of the topics explored at the meetings have included: regularities in the visual and musical arts that have counterparts in human brain function; the universal appeal of poetry; and measures of effective complexity in art.

Currently, Gell-Mann, with his assistant Marla Karmesin, is trying to compile a Digital Video Disk of material from the Santa Fe forum, including videotaped lectures, photographs of the art objects shown, recordings and supplementary materials. The DVD will provide a jumping-off point for future discussions.

Hollis Walker