Complexity

Although the term is becoming weakened by overuse, complexity is a truly new paradigm. The study of complexity creates bridges across many branches of science and offers a revolutionary intellectual vector that has ramifications for other disciplines, such as art and philosophy.

What is complexity? Even among scientists there is some disagreement regarding the necessary and sufficient conditions for a system to be deemed "complex." Generally, complex systems include large numbers of components interacting in nonlinear ways, often leading to surprisingly self-organized behavior. One is reminded of the saying in common language that "the whole is greater than the sum of its parts." For many, complexity is something found in varying quantities. For some, a measure of complexity is the effort needed to describe a system's "effective regularities." Often, complex systems exhibit emergent behavior that is both deterministic and dynamic in ways that can be dramatic, fecund, catastrophic or so unpredictable as to seem random.

As artists working in this realm, we organized *Complexity,* a fine-art museum exhibition featuring artists' explorations of complex systems and emergence. The exhibition is an inclusive, cross-disciplinary artistic attempt to explore commonalities among complex systems across all scales and levels of hierarchy.

Complexity originated at the Samuel Dorsky Museum of Art at State University of New York New Paltz during the fall of 2002. Included were prescient works by Hans Haacke and by Steina and Woody Vasulka plus contemporary works by Mauro Annunziato, Manuel A. Báez, Jonathan Callan, Nancy Chunn, Janet Cohen, Philip Galanter, Frank Gillette, David Goldes, Paul Hertz, Ellen K. Levy, Brian Lytle, Daro Montag, Jack Ox, Daniel Reynolds, Marianne Selsjord, John F. Simon, Jr., Karl Sims, Nell Tenhaaf and Leo Villareal, and a collaborative work by Remo Campopiano, Guy Marsden and Jonathan Schull. (See the exhibition catalog in Leonardo Electronic Almanac's Gallery at <http://mitpress.mit.edu/LEA>.)

This Gallery section features seven of the artists who participated in our original exhibition. We selected artists for diversity of media and aesthetic expression, while selecting work suited to black-and-white reproduction.

Manuel Báez explores tensegrity-like principles [1] and the emergence of form. His sculptures form complex systems determined by the local interactions of flexible joints made of bamboo dowels, rubber bands under tension, and gravity.

Jonathan Callan establishes conditions of unpredictable accommodations to displaced matter in his work. Callan relates his concerns to those of the philosopher John L. Austin, who likened language to a net with which we capture parts of experience. Callan seeks to capture the parts that fall through the net. He intuitively addresses generative, time-based dynamic activities that portray complexity.

A collaboration among Remo Campopiano, Guy Marsden and Jonathan Schull produced *Eight-Bit Ant Farm.* The work is driven by the emergent swarm behavior of two kinds of living organisms, the ants living in the sculpture and the people visiting the gallery. The interaction of the two results in a dynamic display as organic activity is mapped onto electronic and kinetic mechanisms.

The photography of David Goldes often portrays seemingly straightforward scientific experiments. In his evocative and understated 1998 silver gelatin print *Jar,* Goldes created and cap-

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tured the image of a miniature vortex in a glass jar by using a magnetic stirrer. In effect, he creates conditions for turbulence, forming a portrait of complex behavior.

Brian Lytle uses a patent-pending process involving the coarse manual placement of finely ground pigments supported by surface tension in large water baths. This sets the initial conditions of a complex system where the pigments then interact locally, generating fractal patterns that extend across microscopic and visible scales.

In his critiques of both physical and social systems, Hans Haacke has long anticipated the attempt in complexity science to address both from a unified standpoint. Haacke created *Condensation Cube* at about the same time meteorologist Edward Lorenz discovered that strange attractors ensure that weather systems are always chaotic and ultimately unpredictable.

Steina and Woody Vasulka count among their many accomplishments some of the most innovative uses of video feedback as a generative system. Video feedback is now cited in scientific textbooks as a canonical example of deterministic chaos, and the early explorations by the Vasulkas anticipated contemporary complexity science by many years.

During the 20th century, science proceeded by way of ever-narrowing specialization. Parallel to this approach, the scientific method encouraged the practice of reductionism, the breaking down of phenomena into (literal or figurative) atomic parts. The field of complexity has reversed both practices.

We find it encouraging that many contemporary artists have followed a similar track, attempting to take on more rather than less, and looking outward at the universe rather than inward at an insular vortex of art-world semiotics. However, we do not view complexity as the basis for an art movement or style. The artistic response to complexity is varied and wide-ranging, embracing all manner of old and new media. Complexity art is a matter of content, not complicated technique.

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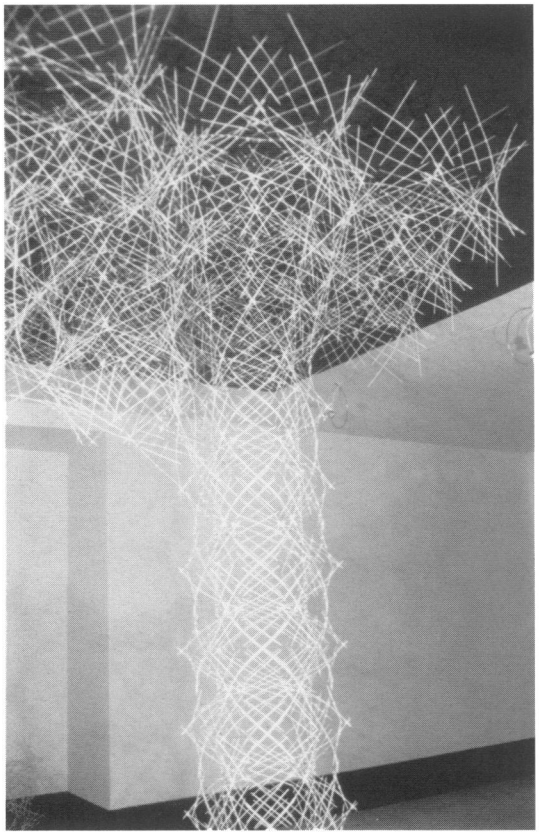
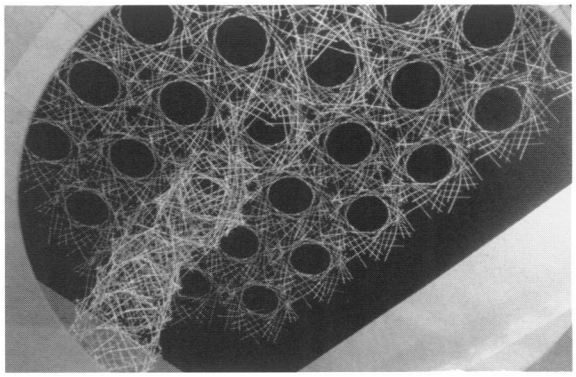
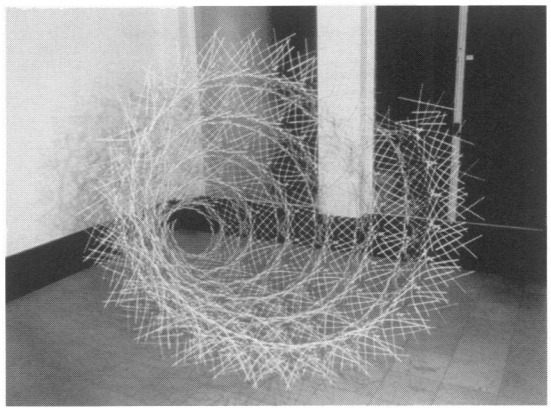
Note

1. The term *tensegrity* refers to structures that achieve stability by continuously transmitting and distributing tension and compression forces across all their parts. Examples include the geodesic domes of Buckminster Fuller and the sculptures of Kenneth Snelson. In the realm of complexity science, researchers such as Donald E. Ingber are investigating how tensegrity determines the form of organic structures across multiple scales including chemical compounds, cells and tissues.







MANUEL A. BÁEZ

Phenomenological Garden, installation for the Metaphoric Interweavings interdisciplinary symposium, 12-in and 6-in bamboo dowels and rubber bands, 16-×-30-×-9-ft overall installation space dimensions, 1998. (left) Installation view. (top right) Reflected ceiling view of the installation from the central mirrored table. Various random and highly organized patterns are revealed as one walks around the installation. (bottom right) *Coiled Serpent,* structure from the *Suspended Animation* series, 12-in and 6-in bamboo dowels and rubber bands, 4½-in diameter, 6-ft depth, 30-ft uncoiled length. (© Manuel A. Báez. Installation was conceived and organized by the artist at Cranbrook Academy of Art for the Sybaris Gallery in Royal Oak, Michigan.)

Nature's fundamental processes generate regulatory systems that correlate with the rich realm of natural phenomena. These dynamic processes are inherently composed of interweaving elemental relationships that evolve into integrative systems with startling form- and structure-generating capabilities. Intrinsically, these processes-in-formation are highly coordinated cellular relationships that are simultaneously stable, highly dynamic and fluently encoded with information. The analysis of this generative potential can yield more comprehensive insights into the emergence of complex morphology and the interrelationships between form, structure and generative process. Through analysis of the dynamics of these basic relationships, I have developed a series of generative cells and hands-on experiential procedures that inherently allows for such discoveries to occur. The use of bamboo dowels and rubber bands to weave individual flexible cells and cellular membranes makes a wealth of complex forms and structures possible through the emergent organizing properties of the integrated assembly. Shown here are views of an installation using an evolving working process that explores the dynamic generative properties of a square cellular unit and assembly. *Phenomenological Garden* is a work in progress that is intended to explore how complex structures are generated from initially random processes that evolve into morphologically rich collective relationships.

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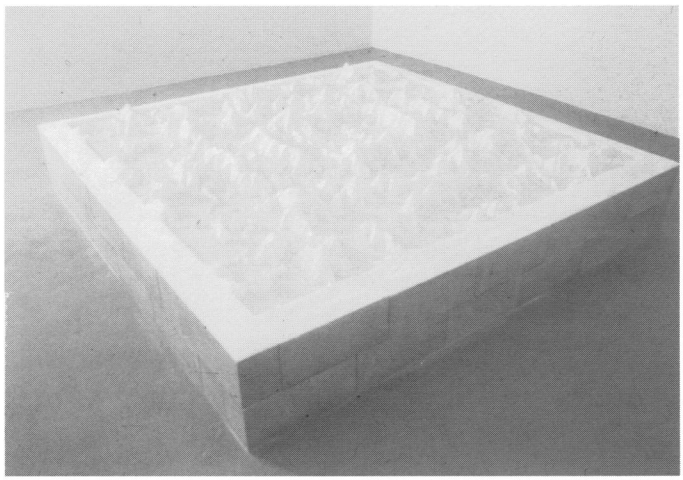

JONATHAN CALLAN

Untitled, powdered cement, cinderblocks, aluminum sheets, 22 × 102 × 102 in, 2000. (top) Full view. (bottom) Detail. (© Jonathan Callan. Courtesy of the artist and Nicole Klagsbrun Gallery. Photos: Jean Vong, New York.)

Curators' Note: As art historian Martin Kemp has also noted, the work of Jonathan Callan brings to mind the late Per Bak's work on "self-organized criticality." Resembling Bak's experiments and simulations with sand piles, Untitled was produced by sifting powdered cement through holes punched into aluminum sheets spaced at unpredictable intervals onto a table of cinderblocks. The powder accumulates in the highest piles where the aluminum sheet contains no holes. If the slope exceeds the critical state of balance necessary to maintain a constant value, the pile collapses until it attains another critical state. For Bak, this kind of complex system does not reach equilibrium, but rather will evolve from one metastable state to the next.

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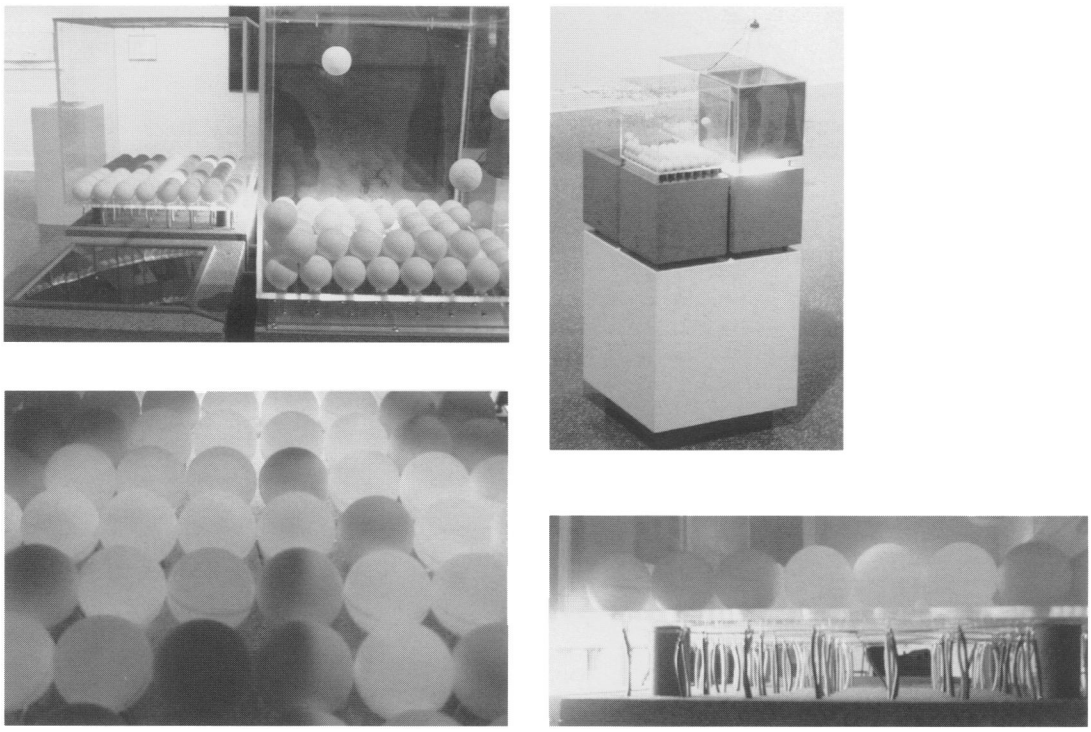

Remo Campopiano, Guy Marsden and Jonathan Schull

Eight-Bit Ant Farm, mixed media, 27 × 27 × 72 in, 2002. (top left) Close-up. (top right) Full view. (bottom left) Red-orange balls. (bottom right) Red balls. (© Collaborative Team of Remo Campopiano, Guy Marsden, Jonathan Schull. Photos: © Guy Marsden.)

Eight-Bit Ant Farm deals with issues of complexity theory, more specifically, with self-referential, semi-autonomous adaptive systems.

We put a camera in the ceiling over the artwork and the art observers and another camera over a glass cube containing a colony of live red ants. One records the changes in the people, the other changes in the colony of ants. The images are digitized every 10 seconds and processed to form a composite image that is shown on a laptop computer. The display screen of the laptop lies at the bottom of a mirror-lined box that reflects this image endlessly out into a curved surface.

Data derived from the change in positions of ants and people is sent to a box of illuminated Ping-Pong balls. Red balls indicate the movement of ants; yellow ones indicate the movement of people. In another box, the ant-movement data also triggers the firing of the Ping-Pong balls into the air.

During the process of creating this piece, we engaged in a three-way e-mail dialogue concerning the meaning of the artwork. Here is an excerpt from this conceptual dialogue:
Schull: This stance is natural and convenient, but it is an illusion. In this artwork we bring attention to this illusion in several ways. For example, our view and our stance when we look down at the gallery are apparently rather similar to our view and our stance when we gaze at the ant colony. "Apparently similar," but deeply different.

Campopiano: Of course, because when we look at the webcam image, we see ourselves.

Schull: Indeed, we see ourselves seeing ourselves.

The complete dialogue can be seen at <http://remo.net/complexity>.

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DAVID GOLDES

(left) Untitled *(Walk the Dog)*, 22 x 18 in, silver gelatin print, 1994. (right) *Jar*, 22 × 18 in, silver gelatin print, 1998. (© David Goldes. Images courtesy of Yossi Milo Gallery.)

Will our most astute insights into the mechanisms of physics and biology appear in 2103 as only charmingly quaint?

I like to think of phenomena as constant and explanatory theories as an ever-evolving variable. It is attention to the constant that drives my work.

Jar and Untitled *(Walk the Dog)* are photographs resulting from my observation of the behavior of water. Sometimes these situations are found, but most often I construct what I call a "performing still life." I am drawn to the ephemeral, fragile, overlooked and unexpected properties of water. I hope that my experiments and play coupled with the properties of photographic description resonate with the significance of water beyond my picture's edge.

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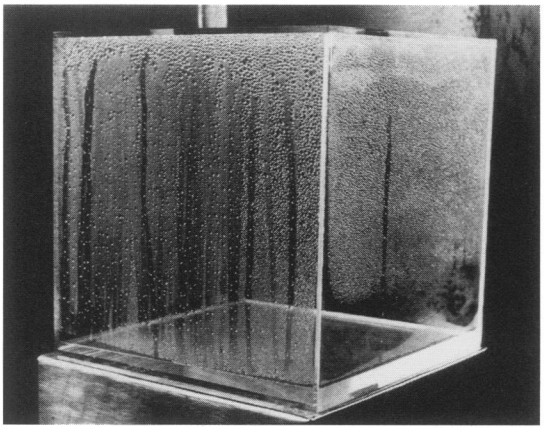

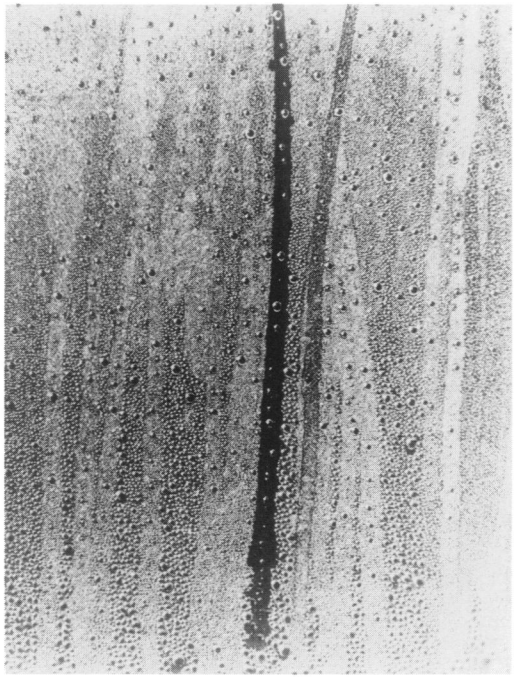

Hans Haacke

Condensation Cube, acrylic, plastic, water, climate in area of display, 12 × 12 × 12 in, 1963–1965. (left) Full view. (right) Detail. (© Hans Haacke, VG Bild-Kunst. Photos: © Hans Haacke, VG Bild-Kunst.)

I have partially filled Plexiglas containers of a simple stereometric form with water and have sealed them. The intrusion of light warms the inside of the boxes. Since the temperature inside the boxes is always higher than the surrounding temperature, the water enclosed condenses: a delicate veil of drops begins to develop on the inside walls. At first, they are so small that one can distinguish individual drops only from a very slight distance. The drops grow hour by hour; small ones combine with larger ones. The speed of their growth depends on the intensity and the angle of the intruding light. After a day, a dense cover of clearly defined drops has developed and they all reflect light. With continuing condensation, some drops reach such a size that their weight overcomes the forces of adhesion and they run down along the walls, leaving a trail. Weeks later, manifold trails running side by side have developed. They too contain drops of varying sizes according to their respective ages. The process of condensation does not end. The box has a constantly but slowly changing appearance that never repeats itself. The conditions are comparable to those of a living organism that reacts in a flexible manner to its surroundings. The image of condensation cannot be precisely predicted. It is changing freely, bound only by statistical limits. I like this freedom.

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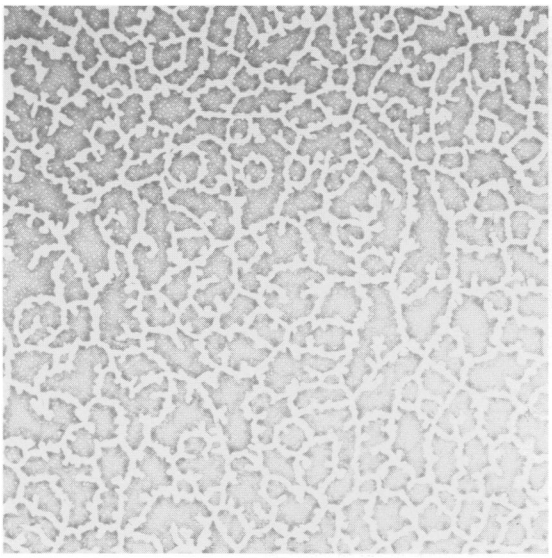

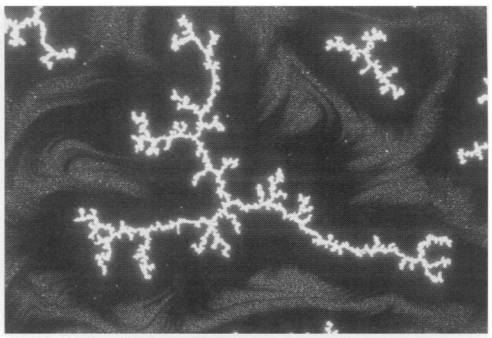

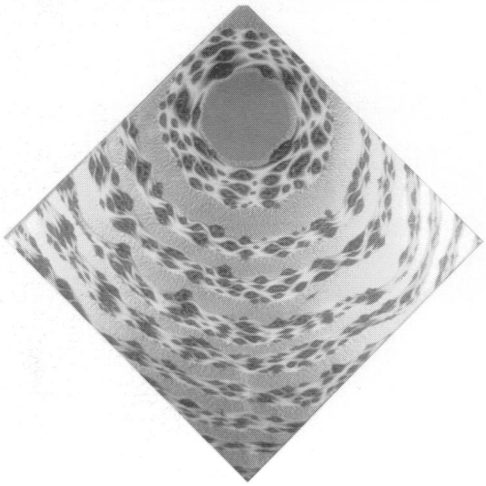

BRIAN LYTLE

(top left) *Untitled,* 24 × 24 in, fluid dynamic phenomena on black acrylic sheet, 1995. (© Brian Lytle)
(top right) *Untitled* (detail), fluid dynamic phenomena of about 8-in length on black glass mirror, 1990. (© Brian Lytle. From the collection of Benoit B. Mandelbrot.)
(bottom right) *Yinging the Yang,* 24 x 24 in, fluid dynamic phenomena on black acrylic sheet, 2002. (© Brian Lytle)

Regarding *Untitled* (1995), I was able to capture this piece at an early growth stage before it had a chance to expand into large, disconnected island morphologies of approximately 6 feet in diameter. The reoccurring dendrite growth in *Untitled* (1990) is one type from a variety of branched island morphologies. These fractal shapes, which recur in all my work, develop from lattice forms into disconnected ones ranging in scale from microscopic to over 9 feet across. The patent-pending process that I utilized in *Yinging the Yang* (2002) involves growth and disaggregation on fluid surface tension. This particular piece was created by applying 17 separate doses of a chemical formulation consisting of sized and sorted metal and prismatic powders suspended in resins into a central location of a 20-×-20-ft water bath. The pigments interacted locally, generating fractal patterns. I then froze and affixed the patterns to a substrate so that they could be viewed as art. The center of this painting consists of silver microscopic fractal growths, and the other rings are of alternating gold rings and larger, denser iridescent fractal growths. The only hand rendering involved in this process occurs when I sometimes remove the denser fractals, leaving a fine outline exposing the negative space as positive (*Yinging the Yang*). The paintings are just a frozen moment in their development. To capture the beautiful dynamics at play, I also work in film and video. I encourage scientists or laypersons who would like to contribute to the theories involved or who are interested in this phenomenon to contact me.

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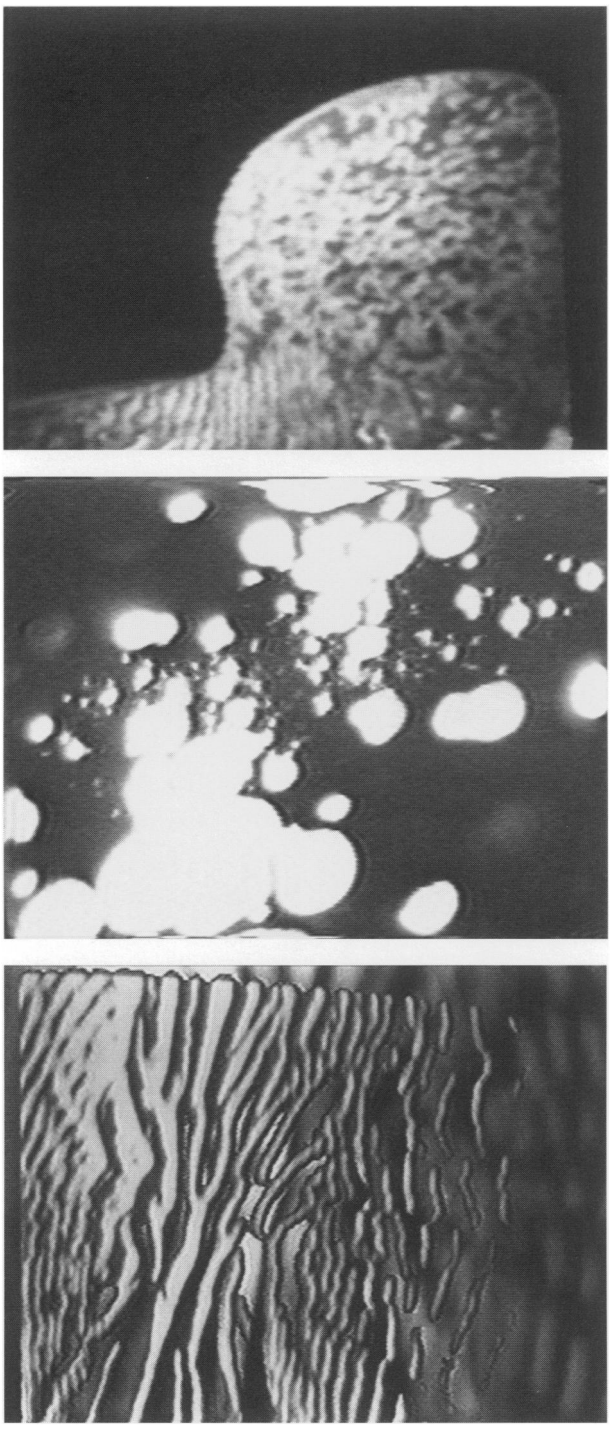

STEINA AND WOODY VASULKA

Still shots from three videos: (top) *Distant Activities,* 1972; (center) *Evolution* (excerpt), 1969; (bottom) *Matrix* (excerpt from *R.F. Feedback*), 1971. (See also Color Plate B No. 1.) (© Steina and Woody Vasulka)

Curators' Note: Video feedback is now cited in scientific textbooks as a canonical example of deterministic chaos, and the early artistic explorations by Steina and Woody Vasulka anticipated contemporary complexity science by many years. They were among the first to use video feedback as a generative system. In conversation about their work, the Vasulkas recommended the 1992 exhibition catalog that accompanied *Eigenwelt der Apparatewelt* for a discussion of issues surrounding video feedback and the pioneers of electronic art.

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