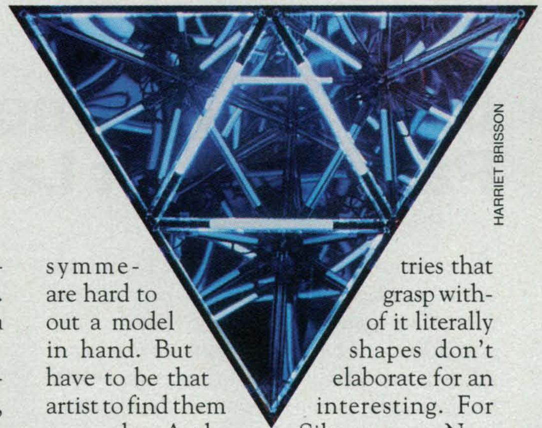
MATHEMATICS

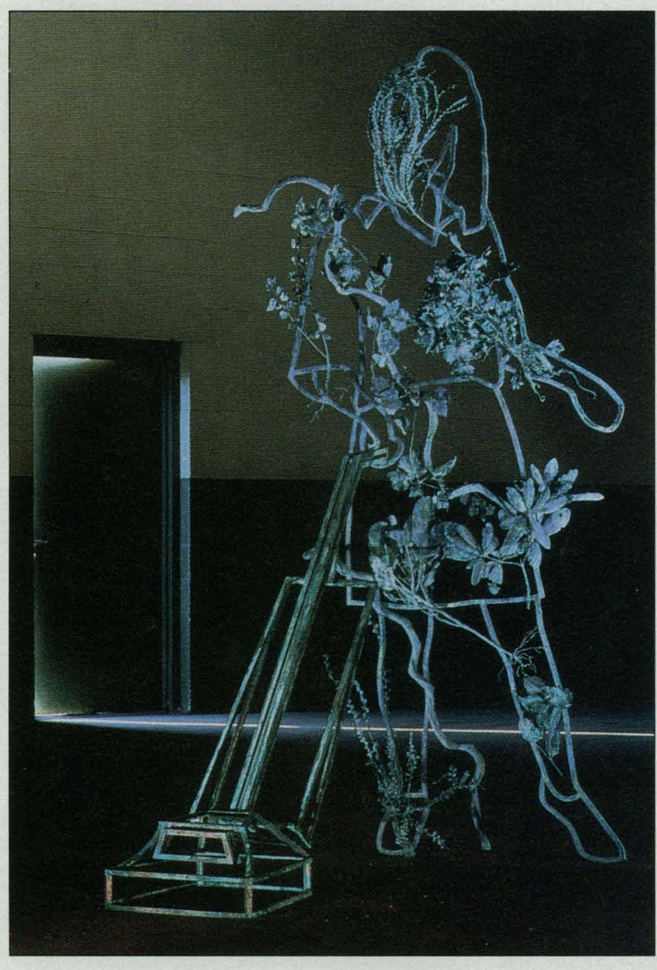
Cross-Disciplinary Artists Know Good Math When They See It...



HARRIET BRISSON

Among the ways to pass time during talks at professional meetings, you can listen and take notes, you can read the latest issue of *Science*, you can drift off to sleep...or you can stick toothpicks into miniature marshmallows.

No, Jay Kappraff wasn't bored when *Science* spotted him doing this at a recent conference at the State University of New York at Albany. He was preparing a prop—a model of an icosahedron—for his own upcoming talk. Kappraff is a mathematician at



RHONDA R. SHEARER

the New Jersey Institute of Technology. But he also considers himself something of an artist. And so did the organizers of Art & Mathematics 92, an unusual gathering of artists with a yin for math and mathematicians with a yang for art. (The conference was held 8 to 11 June.)

At first glance, perhaps, the two subjects couldn't seem further apart. The freely creative, emotional nature of artistic expression seems distant from the rigidly logical, rule-oriented world of mathematics. Art is personal, ambiguous, intuitive; mathematics is strictly axiom, number, and deduction. Right brain, left brain—no such thing as a corpus callosum.

That's a misperception and a mistake, participants at the Albany meeting maintain, and they could point to the mathematically inspired sculpture and paintings displayed in the halls as evidence. "Both [art and mathematics] are based on a certain amount of constraint and a certain amount of freedom," Kappraff observes. The two really go hand in hand. Mathematics provides a framework for artistic expression, while art can awaken mathematical intuition, revealing aspects of mathematics that are otherwise hidden within abstract formulations. For mathematicians and artists who agree with Kappraff—many of whom have little or no formal training in the others' craft—the appeal of crossing disciplines is strong.

Nat Friedman found the appeal strong enough to organize what grew into a 4-day meeting with 3 dozen speakers and nearly 150 participants. Friedman, a professor of mathematics at Albany, began sculpting in the early 1970s and now frequently teaches a course on art and mathematics. He organized the conference in part as a way to meet some of the people whose work he admired—and then found many more he had never heard of. "It sort of took off," Friedman says. "I didn't realize there were that many people out there!"

For many of these mathematically inclined artists, geometry, both plane and solid, provides a stomping ground. The exhibits at the Albany meeting were packed with sculptures exploring the surprises to be found in familiar geometric figures. "One of the nice things about the three-dimensional world is it's totally nonintuitive," says Kappraff. His marshmallow version of an icosahedron is a case in point. The icosahedron exhibits symmetries that are hard to grasp without a model of it literally in hand. But shapes don't have to be that elaborate for an artist to find them interesting. For example, Arthur Silverman, a New Orleans-based physician turned sculptor, has explored the visual properties of tetrahedra in a series of large aluminum and stainless steel works. Silverman manipulates the familiar shape into virtually unrecognizable forms by using isosceles, rather than equilateral, triangles for the faces and standing his tetrahedra on edge so that all four faces are exposed.

Even when the shapes themselves are recognizable, they reveal unexpected symmetries to the eye of an artist. For example, even professional mathematicians often have a hard time seeing that a regular (equilateral) tetrahedron, the seeming epitome of triangularity and threeness, can be cut into halves of exactly equal volume by a plane that intersects it in, of all things, a precise square—a surprise that was described at the meeting by Arthur Loeb, a professor in the department of visual and environmental studies at Harvard University. Even the prosaic cube contains mysteries. "There's so much involved in a cube that you can spend your lifetime on it," Kappraff claims.

William Huff has done something like that. For the past 10 years, Huff and his students in the architecture department at the State University of New York at Buffalo have investigated different ways of "trisecting" the cube: cutting it up into three identically shaped pieces. One obvious way is to slice it into three flat slabs. Another makes use of the threefold rotational symmetry around the cube's interior diagonals: the surprising fact that when you rotate a cube around an axis extending between opposite corners, it looks identical every third of a turn. But Huff and crew have produced whole families of other trisections, some of which are so complex the pieces can be separated in theory only.

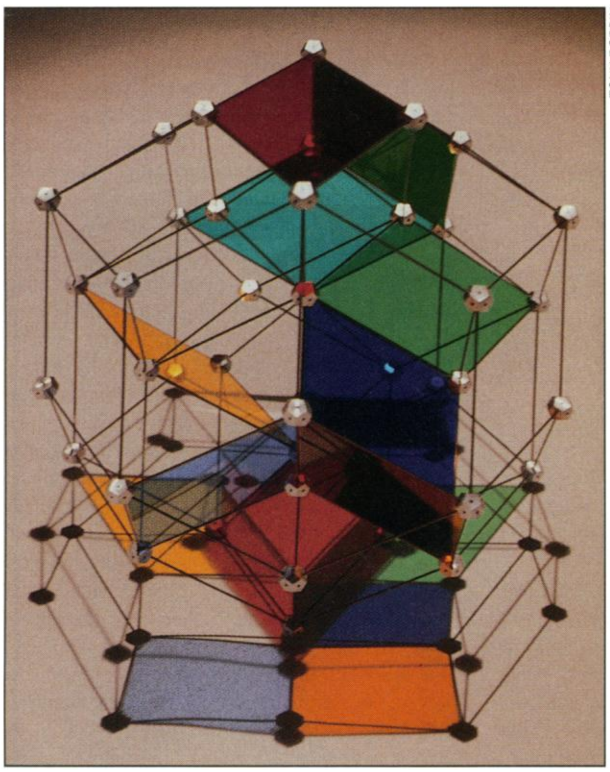
Instead of teasing apart single cubes,

Melding math and art. From left to right: Fractal forms meet rectilinear contours in Rhonda Roland Shearer's "Nina Vacuuming"; shapes "tile" space in Harriet Brisson's "Truncated 600-cell"; Tony Robbin's "Quasicrystal Sphere" explores fivefold symmetry; and Helaman Ferguson celebrates topology in "Alexander's Horned Wild Sphere."

Harriet Brisson, an artist at Rhode Island College in Providence, uses the cube to multiply other shapes. Brisson is interested in shapes that "tile" space, completely filling it the same way tiles completely cover a plane. One such shape is the truncated octahedron, a figure with six square and eight hexagonal faces. Brisson put a single truncated octahedron, fashioned from neon tubing, inside a "magic box"—a cube built with two-way mirrored plexiglass. When the neon light is turned on, the viewer can walk around the cube and see the space-filling shape extending in all directions.

New geometries. While most artists stick to the three-dimensional world, Tony Robbin has plunged into the fourth dimension—at least in his imagination. "I believe it's possible to visualize four-dimensional space and use it as a template for experience," the New York-based sculptor says. "When that happens—when the fourth dimension becomes a part of intuition—our imagination will soar. That's the role of art: to teach us to see new spaces."

For Robbin, who will be exhibiting his work at the Washington headquarters of the American Association for the Advancement of Science from 13 October through 15 January 1993, quasicrystals offer a route into higher dimensions. These objects, which are able to exhibit "forbidden" fivefold rotational symmetries because they lack the regular spatial repetitions associated with ordinary crystals, can be understood—in part—as mathematical "shadows" in two and three dimensions of higher-dimensional lattices. One of Robbin's current projects is a large quasicrystal structure for the Center of Art, Science, and Technology at the Technical University of Denmark in Lyngby. The sculpture, designed to climb up the north wall of the COAST facility, will present passersby with changing three-, four-, and fivefold symmetries as they walk or drive by.



TONY ROBBIN

Such surprising regularities are powerful lures for some artists, but a few others are drawn to the unruly shapes of fractal geometry. Where traditional geometry sticks to straight lines and smooth curves, this new geometry plays with curves so convoluted they are no longer one-dimensional. Many scientists see fractal geometry as the appropriate language for describing the infinite complexity of real-world forms.

Rhonda Roland Shearer, a New York-based sculptor, sees the advent of fractal geometry as an opportunity for artists as well. Two previous revolutions in geometry—the development of perspective geometry in the Renaissance and the discovery of non-Euclidean and higher-dimensional geometries in the 19th century—correspond closely to revolutions in art, namely the three-dimensional realism of the Renaissance period and the birth of modern art, Shearer points out. The creation of a new geometry based on fractal shapes may portend yet another upheaval in the way artists look on the world, perhaps based in the self-similarity of fractals—the way the "whole" is contained in each of its parts.

Shearer has been exploring the boundary between the rectilinear world of Euclidean geometry and the more natural universe of fractals. In a 1989 series of bronze sculptures, for example, Shearer combined the two by "grafting" fractal, plantlike forms onto the five Platonic solids. Her recent work, with titles like "Nina Vacuuming" and "Kiki Ironing," ties those ideas together with a humorous comment on sexual stereotyping: the "masculine" straight lines of the appliances contrast sharply with the curved and fractal forms of the women.

Theorems made vivid. Not all the artists at the meeting draw their inspiration from geometry. Some are less attuned to forms in space than to the shape of space itself—the subject matter of topology. Helaman Ferguson, a mathematician at the Supercomputing Research Center in Bowie, Maryland, embodies the ethereal concepts of topology—but with material that is literally down to Earth. Ferguson carves theorems out of stone and casts them in bronze. His pieces bear titles such as "Knotted Wye," "Wild Sphere," and "Umbilic Torus NC" (the "NC" stands for "numerically controlled," a reference to the computer-driven milling machine employed in the creation of the work).

The multifingered bronze sculpture "Alexander's Horned Wild Sphere," for example, shows one of the many bizarre aspects of topology. While the infinitely bifurcated surface suggested by the sculpture is topologically equivalent to that of a sphere, the space surrounding it is completely different, topologically, from the space that surrounds a sphere. Ferguson's artful rendering makes it possible to "grasp" an otherwise elusive concept.

HELAMAN FERGUSON

Because of their abstract nature, Ferguson's sculptures often look less mathematical than they are. Viewers can appreciate the elegant shapes without ever realizing they're looking at theorems. Mathematicians, however, derive added pleasure from the ideas expressed in Ferguson's art. He has been commissioned to do sculptures for the American Mathematical Society, the Mathematical Association of America, the Geometry Center at the University of Minnesota, and the Mathematical Sciences Research Institute at the University of California, Berkeley.

Although Ferguson continues to do traditional, published research in mathematics, he sees his sculpture as the more vital component of his work. When asked why, he holds up his hands and wriggles his fingers. That represents the number of colleagues who routinely read his papers, he says, and then explains: "In terms of communicating all the mathematics in my soul, this is not enough."

–Barry Cipra