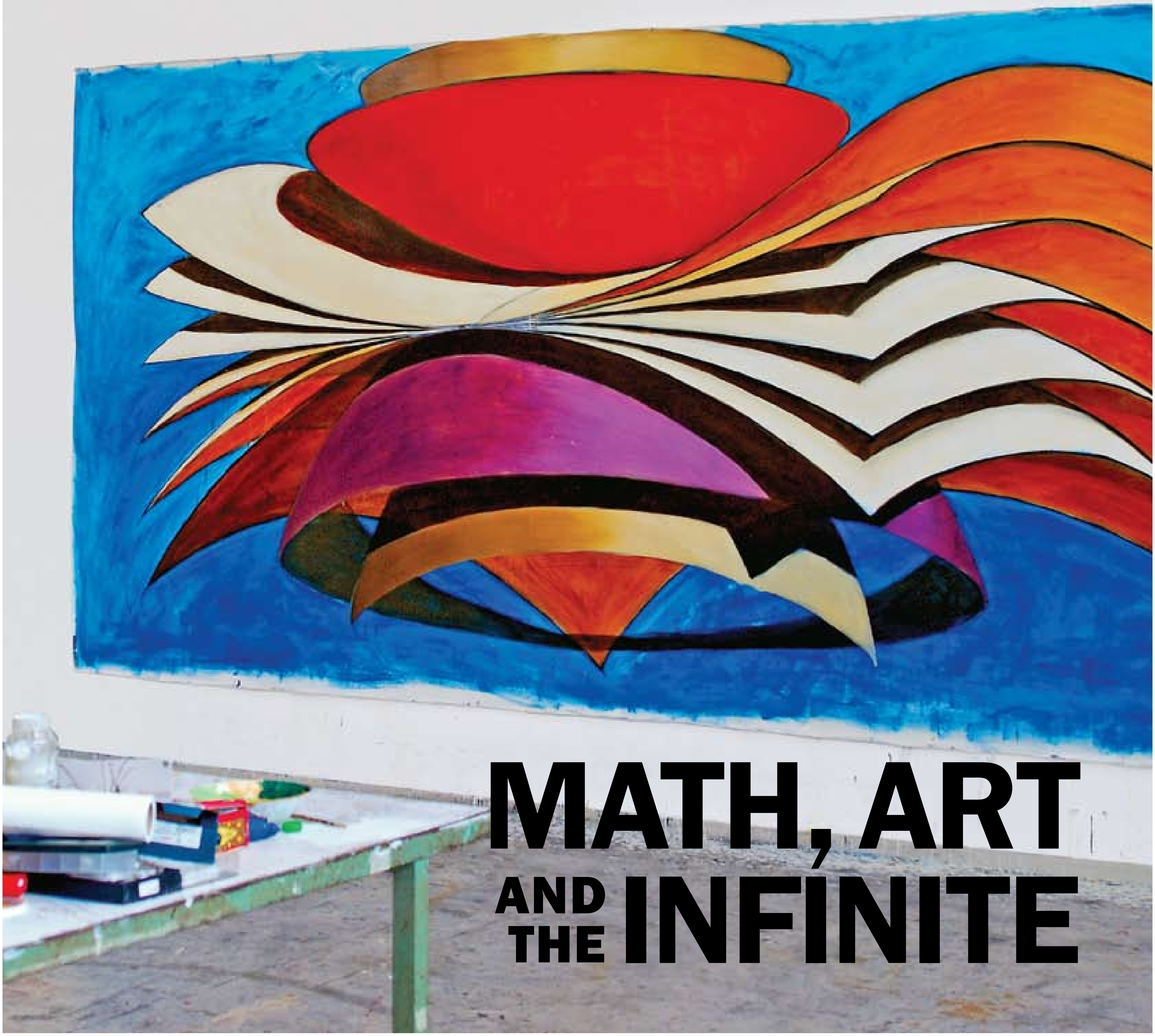
WHY JOHNNY CAN'T MAKE AN ETHICAL DECISION

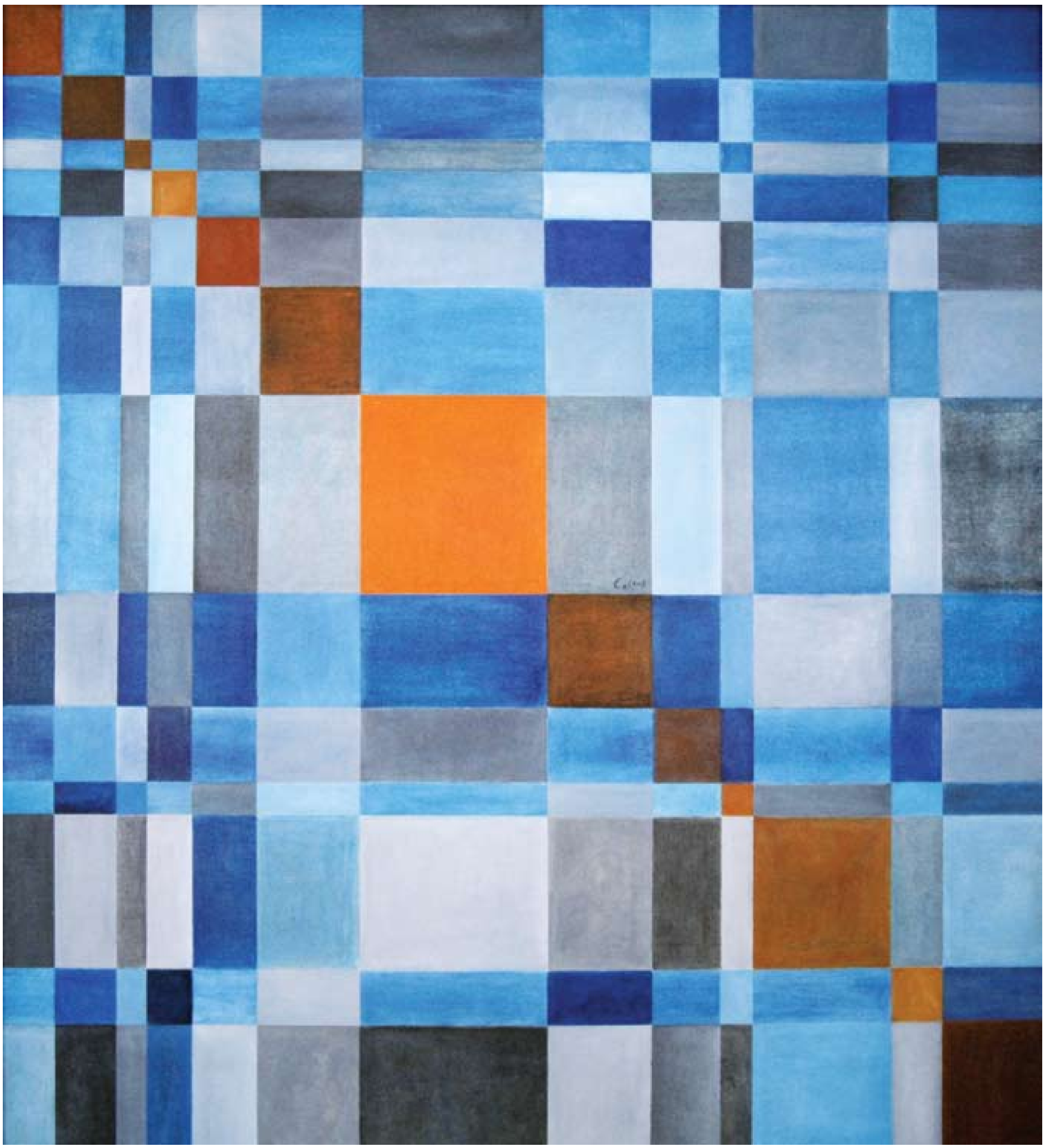
FALL 2009

Tufts MAGAZINE



MATH, ART AND THE INFINITE

MAPPING



REALITY

An artist-mathematician illuminates a world of infinite beauty

ARTWORKS AND TEXT BY LUN-YI TSAI, A92

MATH AND ART ARE TWO SIDES OF THE SAME COIN. I like to think of math as a way of mapping reality, of abstracting certain essential features of the world we experience and specifying how they interconnect. We begin to learn math as infants. Crawling across the floor, we observe that some objects are close—reachable in a small number of movements—while others are distant, requiring many movements. The concept of closeness is fundamental to a branch of math called topology, and topology in turn provides the foundation for calculus, the discipline that studies change, models dynamic physical phenomena, and also allows us to calculate the lengths, areas, or volumes of all sorts of geometric objects. Thus math becomes part of the personal map of reality we all construct—usually unconsciously—as we move through life, collecting data and figuring out how it all fits together.

Art starts to happen when we project these personal maps back out on the world. Each of us has an impulse to express his or her experience of reality. At the most mundane level, we do so through things like conversation, writing, dress, cooking, or doodling on napkins. But when this projecting of personal maps becomes more deliberate, more conscious, we begin to produce what is ordinarily called art—painting, music, literature, and so on.

I have spent much of my life trying to become conscious of both processes—the mapping that gives rise to mathematics and the projecting that gives rise to art. As a college math instructor, I have to explain abstract concepts as vividly and concretely as possible. As a maker of mathematically inspired art—paintings, drawings, and, lately, sculptures—I attempt to translate my understanding of math into visual forms that mean something on an aesthetic level. As it happens, the two occupations reinforce each other.

My art usually begins with a mathematical idea I find intriguing. To make sure I understand it, I work out the steps of the construction or the proof of the proposition—these often appear as handwritten notes in the background of my paintings. As I pore over the mathematical details, a mental image emerges, and when it becomes clear, I'm ready to paint. Just as sketching a person gives me a deeper understanding of the sitter, painting a mathematical concept gives me a deeper knowledge of the math.

Math and art converged for me when I was an undergraduate at Tufts. For much of my teens, I hung out in New York galleries and museums, where I gravitated to abstract painters like Rothko and Pollock. I had a vague sense that I wanted to become such a painter myself, but I couldn't escape the feeling that abstract art was missing something—depth of meaning, perhaps—behind those abstractions. It was while taking multidimensional calculus with Professor Montserrat Teixidor i Bigas that I realized the solution might lie in theoretical math, and immediately switched majors. In essence, I studied mathematics in order to make art.

Although some students have told me they chose to major in math after seeing my work, you don't have to know math to appreciate my paintings and drawings. The point of my art isn't to teach math, any more than the point of Gauguin's Tahitian paintings was to teach people about Tahiti. Like Gauguin, I'm transfixed by the beauty of the world I find myself in, and can't help but represent, in my own idiosyncratic way, my experience of it. If my work should inspire somebody to make the arduous voyage into the world of math, then I'm doubly happy.

1 ***SURPRISED AGAIN ON THE DIAGONAL***
2002, oil on canvas, 72 × 66 in
Permanent Collection, Butler Institute of American Art

Here I refer to a famous theorem known as the uncountability of the real numbers, proved by the German mathematician Georg Cantor in 1891. Cantor showed that the set of real numbers, which include all the numbers we use in daily life, cannot be counted even given infinite time. The theorem marked a turning point in math and logic: there were now at least two infinities—the countable and the uncountable. Cantor went on to show that there are an infinity of infinities. His proof introduced a powerful tool known as Cantor's Diagonal Argument. He started with a list of all real numbers. Then, following a diagonal line down the list and changing each digit along it, he produced a number that couldn't possibly be in the list, proving the real numbers' uncountability. The orange squares represent those diagonal digits.

2 *MICHELLE'S MATH LESSON*

2004, mixed media on canvas, 48 × 48 in

For several months, this canvas served as a "blackboard" for my wife, Michelle. I would give her a math lesson each time she came to my studio, and then I would cover her lesson with a slightly transparent layer of white paint. There are at least a dozen lessons hidden beneath the surface, making this one of my heaviest canvases for its size.

The lesson at the surface is about a theorem from the area of math known as topology, which studies the notions of closeness and continuity. The proof of the theorem, using a tool called Urysohn's Lemma (its discoverer, Pavel Urysohn, was an early-twentieth-century Russian mathematician who drowned at the age of 26), is, to me, visually exciting. The math is complicated, but its graphic depiction isn't. You begin with two disjoint curves and then draw loops around them in a prescribed manner, with the idea that the process goes on to infinity. I decided to float this picture over Michelle's notes about the proof.

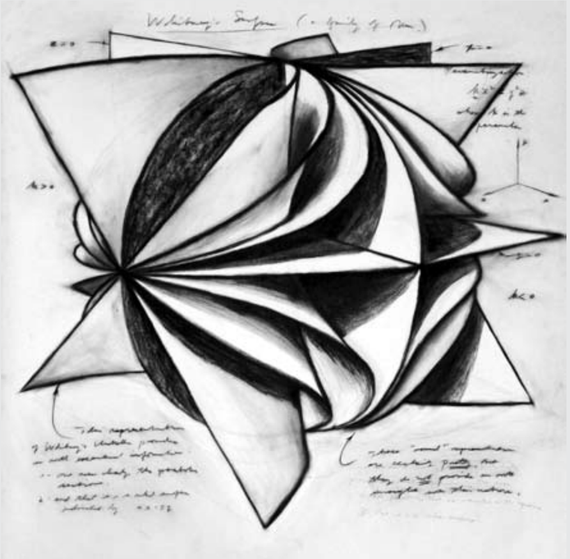
PROOF BY PICTURE [1–3]

Each of these paintings embodies the basic ideas or steps in the proof of a major mathematical statement: 1) the uncountability of real numbers, 2) Urysohn's Lemma, and 3) Euclid's proof of the Pythagorean Theorem. Depending on your knowledge of math, the proof will either reveal itself or remain to be taken on faith.

3 *CHANGE*

2008, encaustic on plywood, 41½ x 38½ in

This is Euclid's proof of Pythagoras's theorem (in a right triangle, the square of the hypotenuse equals the sum of the squares of the other two sides). I painted it just before the 2008 presidential elections—hence the face of Barack Obama. I also embedded newspaper clippings I had found from 1954, which made me wonder what people back then would have thought if they were told that in fifty-four years a woman and a black man would be running for the nation's highest office. I thought it would be interesting to include the clippings in a painting representing an eternal mathematical truth.



CONCEPTS [4–6]

These works explore facets of a single profound concept, parameterization, which has to do with specifying a quantity that, when changed, gives rise to different kinds of things. When my Tufts math professor Loring Tu saw my painting *Some Quadric Surfaces* (6), he gave me the idea of showing how the different surfaces could be created by varying a single parameter of a single equation. Several series of artworks about parameterization have followed.

4 ***WHITNEY FAMILY***

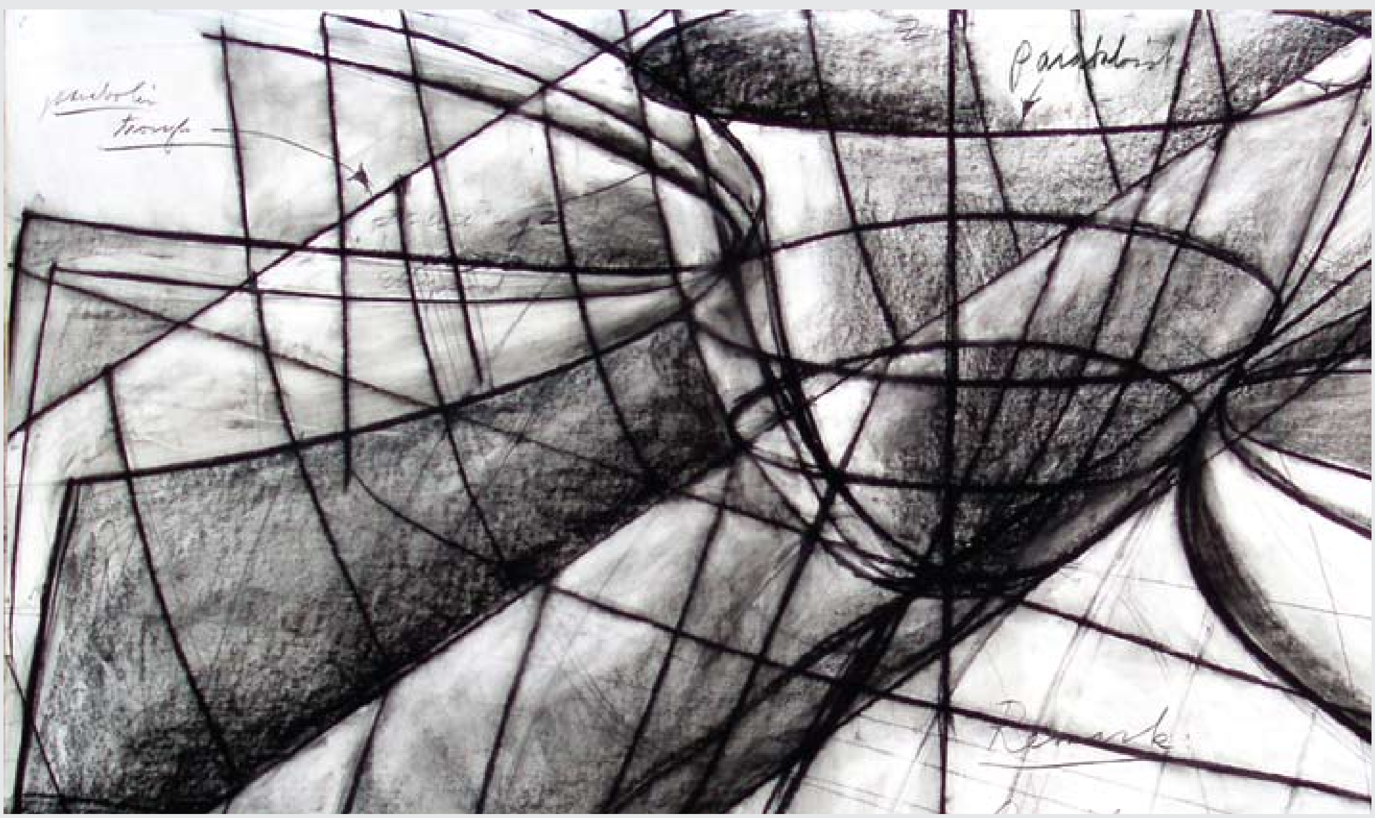
2008, charcoal and graphite on paper, 39 × 39 in

The Whitney Umbrella, a topological surface named for the American mathematician Hassler Whitney, can be thought of as a plane that is cut along a ray and glued back in such a way that it intersects with itself in three dimensions. This parameterization creates a stack of umbrellas sitting on their sides.

5 ***QUADRIC PARAMETERIZATION I***

2006, charcoal and graphite on paper, 42 × 71 in

When I look at this piece, I remember the parameterization, but more strongly I remember the late afternoon light in the New York City neighborhood of my childhood. In the summertime, I would sit on the fire escape outside my window and watch the light fade on the New Museum of Contemporary Art. I took a lot of black-and-white photos of buildings and empty streets. When I began to work in charcoal again several years ago, I was surprised by the nostalgic force of the drawings.



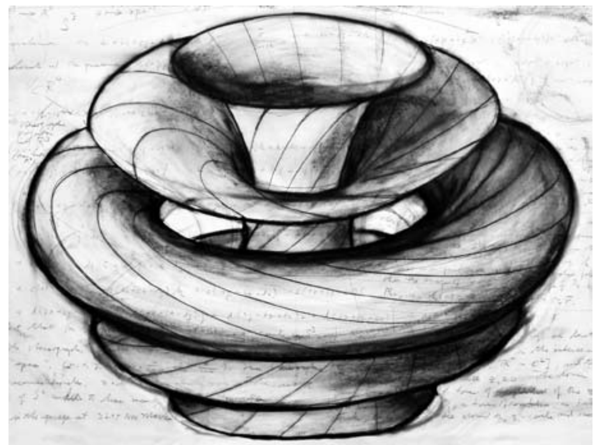
6 **SOME QUADRIC SURFACES**

2004, mixed media on board, 48 × 24 in

At the age of three or four, I had disturbing dreams where I was floating in dark space and a curved white surface would appear, a different shape each time. It would begin small and grow until it was huge enough to crush me. Then I would cry out in my sleep. This painting recalls a wonderful semester with Professor Teixidor when I conquered my fear of smooth surfaces, realizing I could study them with mathematical tools (the gradient and multiple integrals, for example). In the process, I discovered the beauty and excitement of doing math. Although each surface comes from the same kind of equation, I painted each as a separate entity. Professor Tu's suggestion that I look for the parameterization was the flash of light that made me see all these surfaces as a connected whole.

OBJECTS [7–9]

Certain mathematical objects have remarkable qualities that separate them from an infinity of other objects: in one way or another, they differentiate subtle concepts, delineate what is or is not possible, and provide a means to see things both literally and figuratively.



7 ***THE HOPF FIBRATION***

2007, charcoal and graphite on paper 42 × 60 in

When I learned about the imaginary number $i = \sqrt{-1}$ in high school (it's imaginary because there is no real number that, multiplied by itself, equals −1), I thought it sounded rather mysterious. Later, when I learned more about imaginary numbers, I realized how fascinating they are. Just as you can think of real numbers as sitting on a line, you can think of complex numbers as sitting on a two-dimensional plane. When you multiply real numbers together, they move along the line, but when you multiply complex numbers, they spin around the origin (the intersection of the *x*- and *y*- axes).

This drawing shows a three-dimensional sphere as seen through a function called the Hopf Fibration, which shows the connection between it and a two-dimensional sphere. An ordinary sphere—the surface of a ball—is a two-dimensional structure that sits in three-dimensional space. A three-dimensional sphere is an object that sits in four-dimensional space. Since most of us can't see in four dimensions, the best we can do is see its intersection with three dimensions, similar to looking at flat slices of a 3D object in a CT scan. Obviously, a three-dimensional sphere is a very strange object indeed.

8 ***NEWTON BY THE SEA or THE TOPOLOGIST'S SINE CURVE***

2004, mixed media on board, 24 × 48 in

Working on this painting, I thought of the beach in summertime—the sky, the sea, the sand, the children picking up shells and pebbles as they examine the universe, and of course the rolling waves. The natural, periodic behavior of ocean waves is modeled by the sine curve. The *topologist's* sine curve is quite different. Near the origin—the intersection of the *x* and *y* axes—the wave wiggles around like crazy, whether approaching from the left or the right.

9 ***RIEMANN'S INTEGRAL***

2004, mixed media on canvas, 39½ × 39½ in

One of the great mathematical achievements of ancient times was Archimedes' discovery of the volume of a sphere, which anticipated calculus by almost two thousand years. With calculus, we can figure out the areas and volumes of all sorts of geometric objects. We do this by finding a certain limit called the integral, first rigorously formulated by Bernhard Riemann. (The limit is the fundamental tool that allows us to do calculations with infinitely small quantities.) Essentially, the integral is the sum of the areas of infinitely many, infinitely thin vertical rectangles under a curve. (The Greek letter sigma, Σ, which can be seen at the center under the surface, represents "sum.") One can find the area between two curves, as I've shown in this painting, by subtracting the integral of the lower curve from that of the upper curve. The blue and green rectangles show an approximation of this area between the two curves.

▶ **To view slide shows narrated by Lun-Yi Tsai, visit go.tufts.edu/lunyitsai.**

The DaVinci Code

IF THERE'S ONE THING WE KNOW ABOUT SCIENTISTS, it is that they view the world with an icy logic, pretty much like Spock. They shouldn't be confused with those other carbon-based units, artists—who are irrational and flighty, not above lopping off an earlobe to make a point. These are stereotypes, of course, and they completely evaporate the minute you meet someone like Lun-Yi Tsai.

Tsai, A92, author of our cover story, majored in mathematics—the queen of sciences, it is often called—and teaches math at Miami Dade College. But he is also an artist. Art is not just his way of unwinding after a hard day of solving Fermat's Last Theorem. For him, math and art go hand in hand, the math inspiring the art and the art deepening Tsai's understanding of the math. Tsai's work is proof that great things happen when art meets science.

The epitome of the artist-scientist is probably Leonardo DaVinci. With the same skills he employed to create the world's most famous painting, he sketched his scientific observations and worked out his many inventions. Surely there is an important message encrypted in the graceful brown-ink drawings that fill his notebooks.

Galileo got it. A master of perspective and chiaroscuro drawing, he was admitted to the Florentine Academy of Design. It may not be coincidental that in 1609, when he trained his telescope on the moon, he recognized its blotches as the shadows of craters and mountains. Thomas Harriot, an English contemporary who was, shall we say, artistically challenged, saw only a "strange spottednesse." And let us not forget Darwin, Audubon, and Tufts' own David M. Carroll, SMFA65, the naturalist whose striking wildlife images graced our Winter 2007 issue. They all got DaVinci's message.

Deborah Digges got it, too. She was a poet, not a scientist (she is the subject of "Fugitive Soul," page 22)—but she was also an accomplished artist, trained in medical illustration. The flora and fauna that inhabit her poetry are as precisely and vividly depicted as if she had drawn us a picture. She knew how to look at the world.

Art, after all, is as much about seeing and understanding as it is about creating. These skills are too important to be hoarded by artists. When we say scientists must do science and artists must do art, we arbitrarily limit ourselves, like dogs trained to mind an invisible fence. Lun-Yi Tsai ignored the fence, cracking the DaVinci code in the process. And the DaVinci code says this: if you value science, study art.

The New Tufts University Homepage. It's still www.tufts.edu, but we've redesigned it from top to bottom. You're going to love it!

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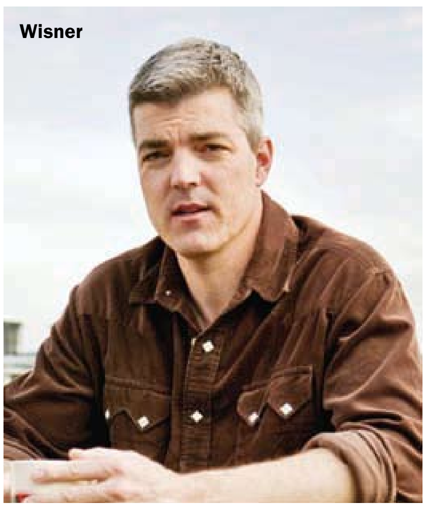

HERB BRODY ("A New Twist on Heredity," page 12) is a Boston-area science and technology journalist. He has been editor in chief of MIT's *Lincoln Laboratory Journal* and an editor of MIT's *Technology Review*.

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REBECCA KAISER GIBSON ("Fugitive Soul," page 22), a lecturer in English and a widely published poet, has been awarded an Artist Fellowship in Poetry from the Massachusetts Cultural Council and been nominated for a Pushcart Prize.

THOMAS M. HART, A68, A05P ("Before YouTube: S-Tube," page 80), is a Vietnam veteran who is self-employed after a career with the U.S. Treasury. He has a lifelong interest in technology and is currently attempting to master the Linux operating system.

A Tisch College senior fellow as well as a contributing writer to *CommonWealth* magazine, **PHIL PRIMACK, A70** ("Edwin Ginn and the Case for Peace," page 36), is a journalist, editor, and policy analyst whose articles have appeared in the *New York Times*, the *Boston Globe*, *Columbia Journalism Review*, and the *Washington Post*.

HELENE RAGOVIN ("No *Vin* Before Its Time," page 10) is a senior writer in Tufts' Office of Publications. In her print newspaper days, she was recognized for editorial and column writing by the New Jersey Press Association.

ROBERT J. STERNBERG ("Liars, Cheats, and Scoundrels . . . and What to Do About Them," page 28) is a professor of psychology and dean of the School of Arts and Sciences. He is also a fellow of the American Academy of Arts and Sciences, as well as president-elect of the International Association for Cognitive Education and Psychology.

Born in Cambridge, Massachusetts, **LUN-YI TSAI, A92** ("Mapping Reality," page 16), grew up in Paris, where his father, a kinetic sculptor, had a studio, and in New York City's SoHo. After Tufts, he received a master's in mathematics from the University of Pittsburgh and spent six years living, working, and making art in China. In 2008, he was a Karl Hofer Gesellschaft artist in residence in Berlin.

FRANZ WISNER, A88 ("The Wonder Year," page 32), is the author of *Honeymoon with My Brother*, the true story of how he was dumped at the altar and then decided to take a two-year honeymoon to fifty-three countries with his younger brother, Kurt. His latest book is *How the World Makes Love*, for which he traveled the globe documenting the state of romance.

columnists

One of the world's leading animal behaviorists, **NICHOLAS DODMAN** ("Animal Instincts," page 41) directs the Animal Behavior Program at the Cummings School of Veterinary Medicine and is the author of four bestsellers in the field. His latest book is *The Well-Adjusted Dog: Dr. Dodman's Seven Steps to Lifelong Health and Happiness for Your Best Friend* (Houghton Mifflin).

In his forty-five years at Tufts, **SOL GITTLEMAN** ("Scholar at Large," page 40) has been a professor of German, Judaic studies, and Biblical literature, and has taught in a variety of departments. Formerly Tufts' provost and chair of the Department of German, Slavic, and Asian Languages, he is now the Alice and Nathan Gantcher University Professor. His most recent book is on the 1949–1953 New York Yankees.

JESWALD W. SALACUSE ("Negotiating Life," page 42) is the Henry J. Braker Professor of Law and former dean of the Fletcher School at Tufts. His most recent book is *Seven Secrets for Negotiating with Government* (AMACOM).

PHOTO: BRAD PARIS (WISNER)