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The Study of Patterns Is Profound

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# The Study of Patterns Is Profound

Trudy Myrrh Reagan

The artist's eye is captivated even from childhood by rainbow stripes on mud puddles or by drifting smoke. The movement of smoke, for example, that mesmerized me when I was small came from my mother's cigarettes or embers in the campfire. Gazing at wisps of smoke is no trivial matter! Drifting upward gracefully, cigarette smoke obeys laws of physics in a most visible way. It loses momentum and curls around in ever-changing patterns. Like smoke injected into wind tunnels for aeronautical research, it traces out air currents. Cool air, which is denser, gently moves toward the cigarette to fill the partial vacuum created by the rising hot air. Where the smoke loses momentum, the warm and cool air circle around each other, hovering. The particles of smoke are supported by the invisible atmosphere, principally nitrogen and oxygen molecules. This is why I found an appealing logic in this apparent disorder.

For 45 years, I have explored comparable patterns in nature in my art. They have turned out to be manifestations of profound truths and a vehicle for expressing philosophical ideas as well.

My father, Philip B. King, illustrated his scientific papers and books with pen-and-ink drawings of crags and erosion patterns. He was well-known for his innovations in the means of visualizing sub-surface geology. I carry a memory of his office lined with colorful geologic maps. As well, I saw rainbow slide shows by his friend, projections of mineral thin sections casting rain-bowed reflections under polarized light.

Entering college in 1954 as a skilled representational artist, I was suddenly expected to generate abstract designs. I had scant facility for it. In my senior year, I discovered the just-published book, *The New Landscape*, by Gyorgy Kepes [1]. In it, things I had seen all my life were honored as worthy art subjects, as much as the nonrepresentational art they resembled.

Nathan Cabot Hale, an art educator, wrote about the dilemma of the representational artist in our time:

The biggest challenge to the artist today is learning the abstract language of art. Long ago it was enough to copy the surface forms of nature, but now it is our task to get at the root of nature's meanings. There is no other way to do this than to learn the kind of reasoning that enables us to look beneath the surface of things [2].

Leonardo did this with his famous sketches of turbulent water. Beginning in the 1880s, Odilon Redon and others were inspired by the "landscapes" of cells under the microscope. The surface of the paintings of the cathedral doors at Rouen by Monet (1904) have a fractal quality, though this was not even a concept or a word before Benoit Mandelbrot began mathematical work on fractals in the 1960s.

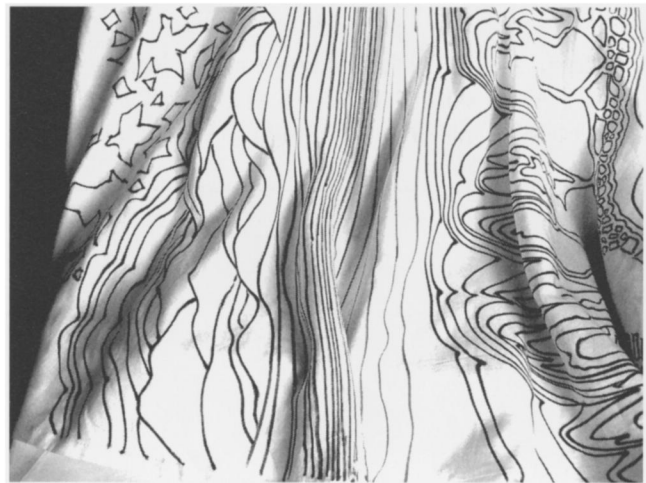
Mandelbrot dubbed fractals "the mathematics of wiggles" [3]. They generated novel geometric designs, and when random numbers were added, computer artists found a tool to model nature. Peaks composed of random polygon shapes became "mountains" [4]. However, geologists noted the lack of erosion patterns in these models, and "behaviors" had to be integrated into the fractal algorithms.

One reason I love drawing is that it is an inexpensive way to "own" what I admire. My basic aesthetic sense began to form when I was exposed to the graceful lines of the contours and patterns, both regular and chaotic, in geologic maps. From science magazine photographs, I mined an amazing array of designs possessing unusual line qualities. Imagine my delight in 1974 to see the patterns I enjoyed analyzed in Peter Stevens's book *Patterns in Nature* [5].

In 1970 I experimented with morphing one category of line quality into another around the circumference of a work called *E Pluribus Unum Skirt*, from straight to contour-like to cellular and, by stages, back to straight lines (Fig. 1).

Several drawings I did in this period revealed that nature's patterns formed a family of motifs, ones that repeated at many scales. For instance, I drew a gigantic leaf with "veins" of capillaries, street maps and so on: diverse, and yet so similar! Nature's tendency toward conservation of energy generates similar forms, whether extremely large or extremely small [6].

Fig. 1. *E Pluribus Unum Skirt*, rayon skirt, 40 inches long, 1969 (lost), recreated in 2005. (© Trudy Myrrh Reagan)



## ABSTRACT

The author has studied natural patterns both by drawing them and by finding analogs for them in crafts materials and processes, including batik, shibori, wrinkled paper painting, paper marbling, moiré, painting and engraving on Plexiglas. She discusses the generation of patterns in nature and how scientists' understanding of them has expanded during the period of her own explorations. She recommends this study for enhancing one's connection to the natural world and the cosmos. The author also explains how she has found patterns useful as metaphors for philosophical ideas.

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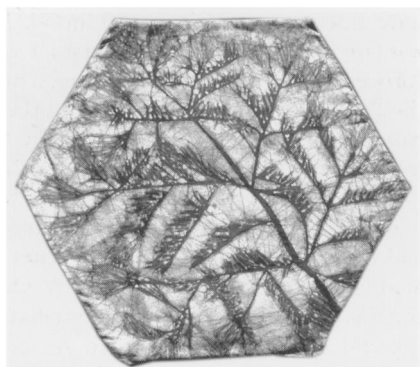


Fig. 2. *Red Fir*, detail from *Animal, Vegetable, Mineral*, 12 × 15 in, batik, 1977. (© Trudy Myrrh Reagan)

Beginning in 1973, I learned batik and adopted hexagonal patterns as a theme in order to work in modules to create large wall pieces. Hexagons, with their 120° angles, tile a plane. Hexagons in nature are plentiful. I found many examples in Ernst Haeckle's *Art Forms in Nature* [7] and soon noticed them all around me. One morning I awoke on a camping trip and gazed into the branches of a red fir, which has perfect 30–60° branching. The batik process added another natural-looking element. Batik is a process of drawing the design on thin fabric in wax, then dyeing the fabric. The waxed areas resist the dye and remain white. Afterwards, the wax is removed from the cloth.

During the dyeing process, the wax develops cracks, which the dye enters. This adds a pattern resembling a network of veins. In *Red Fir* (Fig. 2.), this network resembles the needles of the conifer. This work is part of a larger piece, *Animal, Vegetable, Mineral* (Fig. 3).

As well, I learned the joy of pattern-generating processes of tie-dye. Folding and binding fabric in a systematic way

prevents dye from entering the folds. The result always surprises. Complex results can occur from quite simple manipulations.

I like to draw. I was attracted to Japanese *shibori* (a tie-dye variant), where one draws, say, a bamboo leaf, and stitches along the lines of the image with strong thread. Using the threads as drawstrings, the material is gathered and secured. The tightly-drawn folds are not very deep, and success demands the use of dyes like in-

digo that do not penetrate well but remain on the surface of the bound-up cloth. Cutting the threads and ungathering the folds reveals the pattern. An exciting moment! The work appears not to be handmade, but rather as if created by some natural process.

When the cloth is tightly drawn up, ruffles in the cloth surrounding the design prevent it from dyeing evenly, creating a halo effect. Kirlian photographs capture a halo effect of natural specimens by placing them on an electrically charged photographic plate in a dark room. One of my favorite Kirlian photographs is of a large leaf photographed using this process. *The Kirlian Effect* (Fig. 4) was my interpretation of this process using shibori.

*The Kirlian Effect* uses traditional shibori branching patterns writ large. I then demonstrated that shibori could also be used to simulate erosion patterns. My shibori technique demonstrated that the similarity between branching (a growth process) and erosion (a subtractive process) is pronounced, because both involve bifurcation—that is, at certain points in their development, the stem or the ridge becomes divided.

How does an “erosion” pattern develop through sewing? Sometimes one can stitch following the lines of a drawing,

Fig. 4. *The Kirlian Effect*, shibori on cotton/polyester, 14 × 27 in, 1979. (© Trudy Myrrh Reagan)

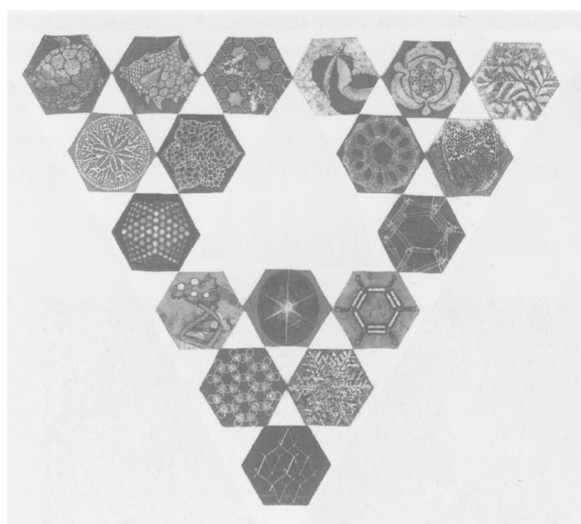
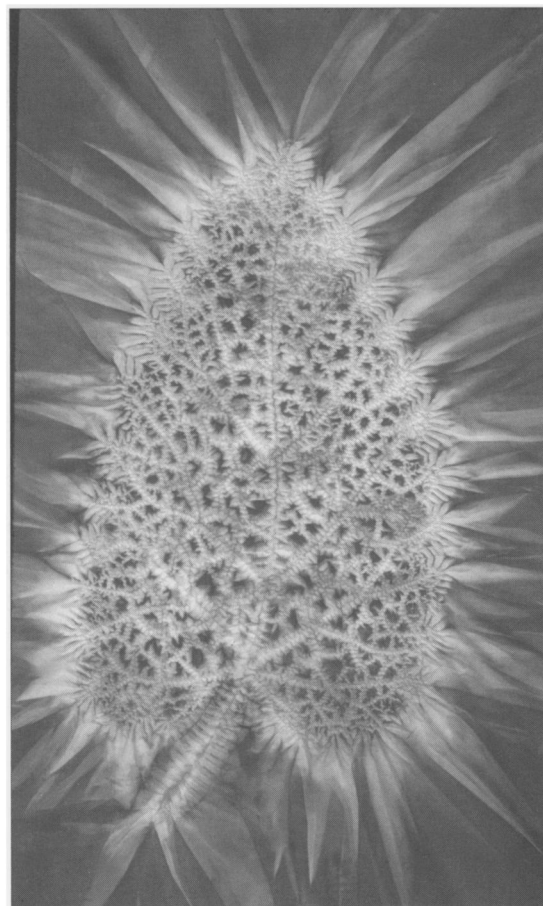


Fig. 3. *Animal, Vegetable, Mineral*, 18 batiks, triangle 9 ft on a side, 1977. (© Trudy Myrrh Reagan)



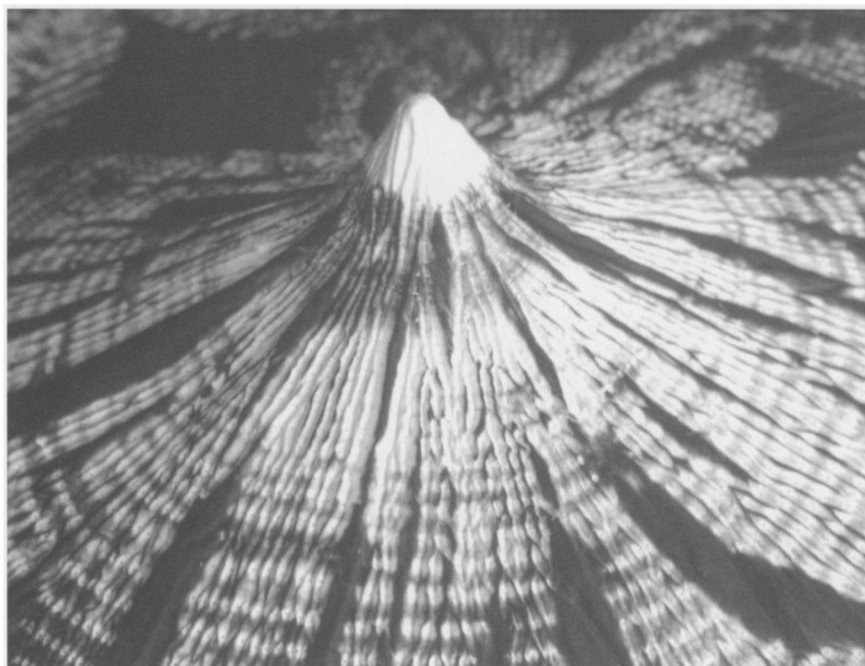


Fig. 5. *Seismic Fuji* (detail), shibori on cotton, 30 × 30 × 5 in, 1982. (© Trudy Myrrh Reagan)

but another method is to stitch perpendicular to the drawn lines. Horizontal rows of stitches create vertical wrinkles that become the design. Offsetting the stitches will cause branching patterns to emerge (*mokume shibori*, or “wood grain”). Sewing a spiral path in the cloth, gathering the cloth into wrinkles and then dyeing the work results in something that looks to me like ridges of a deeply eroded volcano. This is clearly seen in *Seismic Fuji* (Fig. 5).

The shibori process proved very labor intensive, but gave me a feeling for what wrinkles would naturally do. I utilized this intuition in my next series of landscapes that looked like satellite photos and which I dubbed my *N.A.S.A. Series* (*Not Actually Science Achievements*). Combining what I knew about geology and shibori, I wrinkled thin vegetable paper into “mountainscape” reliefs. These I then sprayed from several angles with spray paints. If a water effect was called for, I protected the lowest areas of the relief with a resist of ordinary sand. Unlike the sewn shiboris, these pieces could be swiftly executed. The three-dimensionality and degree of detail seemed uncanny to viewers. I was able to mimic certain geologic formations. For instance, in *Appalachian II* (Fig. 6) one can see the typical pattern that sedimentary rock makes when uplifted by folding and then truncated by subsequent erosion.

A 1989 article about my work in *Kagaku Asahi* [8], a Japanese popular science magazine, raised an interesting question: Could the wrinkling process

be an analog to the natural processes that yield the earth’s features, which are largely caused by erosion? My hunch is that the answer is yes, because the forces that crumple and lift up the earth’s crust create weaknesses in the strata, guiding erosion by water or ice. David Huffman, a mathematician formerly at University of California, Santa Cruz, did an analysis of crumpled brown paper bags, measuring the angles of folds where they joined together. He found several relations that always hold true. For instance, when many folds meet at a point, there is always an even number of them. In such a group he would number each angle, and he found that the sum of the degrees of the odd-numbered angles equals that of the even-numbered ones [9]. The crumpling processes must have similarities to the geologic forces uplifting mountains, or it would not be so very easy to create my illusions! Manipulating actual material, paper, easily yielded results more realistic than the first computer-generated landscapes using fractals.

*Fluid dynamics* are a set of patterns that

have fascinated me since childhood. I was taught in college design courses that “process makes pattern,” such as seen in the deformed water-carved rocks at the base of a waterfall. I spent hours as a child looking at mud puddles rainbowed with oily films and taking snapshots of rapids in mountain streams. In the 1970s, black-and-white graphics of fluid flows generated by computers began to appear. Of the three types of flow, laminar, oscillating and turbulent, I gravitated to the oscillating flow diagrams (such as flow patterns often observed around bridge supports in a river). These had a natural gracefulness I admired.

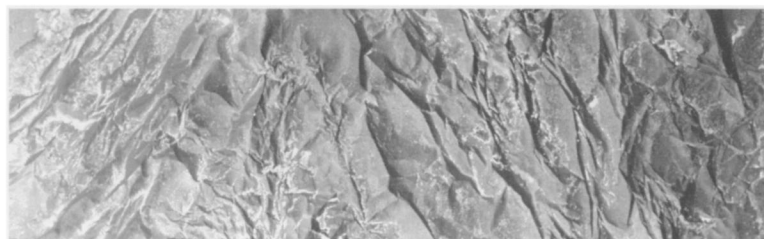
This attracted me to paper marbling. In this craft, used to make the end papers of fine old books, a substrate of water thickened with carrageenan supports droplets of paint. This substrate is unlike plain water: Diluted paint floats on it well. It is viscous and supports a design long enough for it to be captured on paper. The paint, which has a surfactant added to make the paint spread, becomes a film only a few atoms thick floating on the water surface. The surface tension, very strong around the edge of each droplet, is maintained even when the droplet is radically deformed. For this reason, neighboring colors do not mix, and complex stripes result when the surface is combed or blown on. (The result is not unlike computer diagrams of chaos functions.)

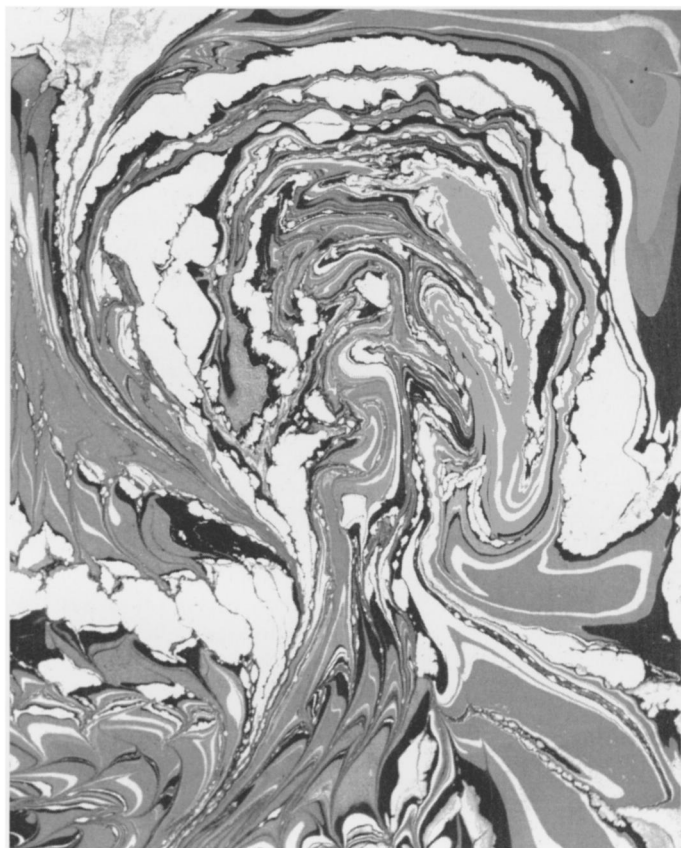
I was amazed to see how combing the surface covered with paint droplets led to the mystifying patterns in traditional marbled paper. The same week that I took the marbling course, Douglas Hofstadter in *Scientific American* discussed magic [10]. He said essentially that we call something magic when we can sense an underlying pattern but we cannot fathom exactly how it arises. Yes, marbling is magic!

I tried blowing on the suspended paint with a straw at a very low angle to achieve fluid flow patterns. I did not succeed in making oscillating patterns, but made many mushroom clouds (Fig. 7)!

After the paint floating in the pan has been manipulated into a design, paper

Fig. 6. *Appalachian II*, crumpled paper painting, 14 × 40 in, 1987. (© Trudy Myrrh Reagan)





**Fig. 7. *Mushroom Cloud Head*, marbling on fabric, 8 x 10 in, 1990. (© Trudy Myrrh Reagan)**

treated with an alum solution is lowered onto the surface. When the paper is picked up, most of the paint adheres to it, since it is chemically more attractive to the paint than is the liquid bath.

I used much of this beautiful paper to make paper polyhedra. In 1970 when I was doing macramé (a large hanging composed entirely of knots in cord), I saw how different knots could aggregate into different shapes, for instance, a helix. I realized that it was similar to the way the various crystal shapes develop, depending on their differently shaped atoms.

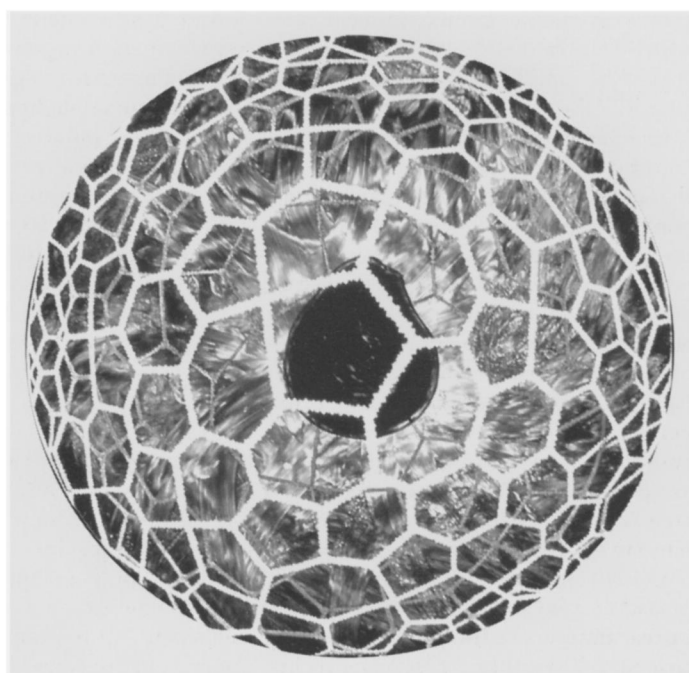
I wish I had the skills to grow wonderful crystals. I have learned to mimic crystallization by hand by engraving a 2D design of closely spaced lines onto Plexiglas using a rotary power tool, lines that catch the light. I also apply paint to the Plexiglas and carve through it. Lit from behind, these works gleam like stained glass.

I gravitated to this new medium after seeing dyes in my batiks and shiboris fade. Pigments are far more colorfast than dyes and will stick to Plexiglas if it is sanded to give it "tooth" to hold the paint. The paint also needs an additive [11]. I select translucent pigments. Opaque black gives me the drama of complete darkness, and the exposed plastic, created with lines engraved through the paint layer, gives me something

brighter than white—a great dynamic range.

"Biocrystals," a 1977 article in *Scientific American* [12], inspired my painting on Plexiglas, *An Essential Mystery: Life Creates* (Fig. 8). "Biocrystals" discussed chemistry at the boundary of the inorganic and the organic, the mineral and the one-celled protist, the dead and the living. Very intriguing! For resource materials, I used

**Fig. 8. *An Essential Mystery: Life Creates*, acrylic paint on 1/4-in Plexiglas with engraved lines, 45-in circle, 1993. (© Trudy Myrrh Reagan. Photo: Judson Allen.)**



D'Arcy Thompson's drawing of a radiolarian (minus the projecting spines) and a micrograph from "Biocrystals" showing crystals building a single strut. As described earlier, I drew the "crystals," line by line, with the power tool. It took weeks, but the thrilling effect lured me on. I learned too late that the crystal structure I had chosen to copy was not that of the silicon dioxide (silicate) found in radiolaria, but that of calcium carbonate.

The painting raised questions in my mind. Soap bubbles' familiar shapes are guided by the mathematics of minimal surfaces. The overall lattice of the radiolarian's crystal structure bore a striking resemblance to bubbles. How could biological growth processes mimic them? A rather new conjecture is that the organism exudes bubbles to form the scaffold for crystal formation. Deciphering how this happens is an active area of research in materials science, some of which has been done since the completion of this painting. Moreover, scientists show us that the crystals formed by microorganisms are very fine, forming rounded shapes, not the coarse, jagged struts shown in my painting. They have a strength unmatched by those that grow inorganically [13]. We humans are trying to emulate these structures to produce stronger industrial materials.

Jacob Bronowski observed,

There are only certain kinds of symmetries which our space can support, not only in man-made patterns, but in the regularities which nature herself imposes on her fundamental, atomic structures [14].



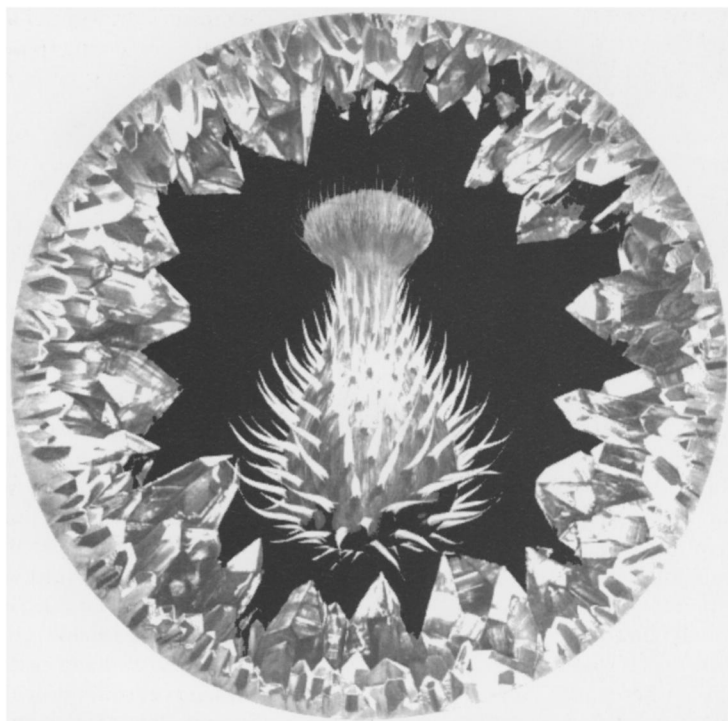


Fig. 9. *An Essential Mystery: Number Governs Form*, acrylic on Plexiglas, engraved lines, 45-in circle, 1994. (© Trudy Myrrh Reagan. Photo: Judson Allen.)

My next painting, *An Essential Mystery: Number Governs Form* (Fig. 9), treats the idea that number relationships underlie all that we see. The notion that these are fundamental in nature goes back at least to Pythagoras. The discoveries made through the interplay of observation and mathematics continue to this day. Computer scientist Rudy Rucker, reflecting upon the work of Stephen Wolfram, goes further:

But in *The Lifebox, the Seashell, and the Soul* I'm arguing that we do best to think of computation itself as fundamental. Under this view, logic and mathematics are invented after the fact to explain the observed patterns of the world [15].

The massively complex computations found in nature, constantly in motion, are deterministic yet reveal something no one would be able to guess. Rucker describes them as "never-repeating lace."

In the late 1980s, I saw a demonstration of cellular automata by Rucker that elaborated on mathematician John Horton Conway's Game of Life. Like the Game, Rucker's cellular automata appeared to be a miniature universe generated on a computer grid that evolved as we watched. A few simple rules generated families of patterns, some of which had surprising behaviors. Rucker had enabled a high-resolution, multicolored grid that displayed pulsating patterns in real time, something unheard of on a personal computer of that era, by in-

stalling an additional computer chip of his own design. When the designs were symmetrical, I had the sensation of seeing a Persian rug being woven. When asymmetrical, the patterns appeared like fast-growing lichens.

In *An Essential Mystery: Number Governs Form*, the circle represents a geode, with amethyst crystals pointing inward. At the center is a much-enlarged Scotch thistle blossom. With both subjects, I used actual specimens to guide my work. The thistle disintegrated into thistledown.

Amethyst is a type of quartz, whose crystal form is hexagonal in cross-section, with six equal rectangular faces. In nature, of course, slight misalignments of atoms in the crystal lattice are commonplace. I took great pleasure in studying the actual specimens and trying to capture their regularity-with-variety. Engraving the lines with a power rotary tool enhanced the crystalline effect. As I mentioned, the plastic had been sanded to accept the paint, making it look frosty. When one looks head-on through a quartz crystal, it is quite transparent, but less so when looking at the oblique faces. My quartz-crystal illusion was greatly enhanced when I polished the plastic on certain areas to restore transparency.

Crystal forms are determined by the atomic properties of their elements. Crystals not only grow in ways determined by the shape of their atoms, like Lego toy pieces, but are constrained by the bind-

ing forces between atoms. Some elements, such as carbon, take different forms (in the case of carbon: diamond and graphite), depending on the binding forces.

When it comes to living things, relatively recent investigations in the physical sciences show that pattern-generating processes, ones that develop through time in an excitable medium, may play a role in generating some biological patterns. Belousov's 1951 experiments with oscillating chemical reactions, ones that spontaneously produced spirals and target shapes in motion (the BZ reaction), touched off a new line of inquiry, as did a 1952 paper by Alan Turing on morphogenesis that suggested hypothetical chemical reactions giving rise to patterns of stripes and spots. In biology, these relate to "a fibrillating heart's pulses, the stripes on leopards, and more . . . all bear a resemblance to oscillating chemical reactions as well as other patterns called Turing patterns that develop through time" [16]. The oscillations are kept going by an interplay between chemicals that activate or inhibit.

The new light this throws on evolutionary theory is worth exploring in some detail. When we say an "eye" pattern forms on a moth's wing because it serves to scare away predators, what kind of explanation is that? How could variations of shuffled genes through dim recesses of time have turned up that particular card? But experiments with oscillating reactions produce similar patterns! DNA code for a simple pattern-generating recipe using the very nature of the materials at hand is straightforward. Natural selection then favors the particular "eye" configuration. There is no "DNA map of a scary eye" as such.

Philip Ball, in *The Self-Made Tapestry*, elaborates on recent, sometimes controversial, research:

These processes suggest that there are certain "fundamental" structures of organisms that are not at all determined by the arbitrary experimentation and weeding out that evolution is thought to involve. Instead, these structures have an inevitability about them, being driven by the basic physics and chemistry of growth. If life were started from scratch a thousand times over, it would every time alight on these fundamental structures eventually. Within the parlance of modern physics, they are attractors—stable forms or patterns to which a system is drawn regardless of where it starts from. . . . [I]f the protagonists of this concept turn out to be validated, that would not by any means bring Darwin tumbling from his pedestal. There is absolutely no question that natural selection operates in the real world and that it has produced

the tremendous variety of organisms with which we share the planet. . . . No one argues, meanwhile, that nature's palette is not constrained by the rules of physics and chemistry. If the formation of patterns by symmetry-breaking proves to pose limitations of evolutionary choices, that will add just one more nuance to Darwin's towering achievement [17].

I painted *Number Governs Form* in 1993. I would later learn of Brian Goodwin's work *How the Leopard Changed Its Spots: The Evolution of Complexity* [18] and of Philip Ball's book. However, it was already well known that the thistle is the product of a recursive growth process that produces thorns on the flower at regular intervals that fit the Fibonacci series of numbers. These numbers are also found in measurements relating to the "Golden Rectangle" of geometry.

As well, the Fibonacci numerical patterns observed in a sunflower spiral and elsewhere are associated with a "Golden Angle" of 137.5°, the angle at which a succession of sunflower seeds form or leaves are offset in a spiral along a growing stem [19]. The sunflower spiral can be replicated by an experiment with magnetic droplets that repel each other.

For a plant to place the next seed or leaf, it need not "know" the correct angle: The dynamics of growth cause it to keep "discovering" it [20]. Experiments are being done with plant hormones to explain the stop-and-start process of stem development that gives rise to these relationships. The hormones inhibit leaf development as the stem grows. When the stem is longer, hormone concentration diminishes, and leaf development resumes. Now, to discover the peculiar mathematical relationships that develop!

The Fibonacci spiral is a rich template for generating designs. Recently, I used several permutations of it to convey an idea that has held me in its grip since 1975, that "all knowledge is one." In 1990, E.O. Wilson wrote *Consilience*, which shows the connections he sees between all branches of knowledge [21]. Therefore, I have named my fourth and most recent version of this piece, completed in 2004, *A Vast Consilience* (Color Plate D No. 1).

The areas of knowledge that I selected to present were:

- the astronomer (who probes the farthest reaches of the universe)
- the biologist (and others who explore the extremely small)
- the artist or composer (who delights in new pattern configurations),
- the mystic (blessed with an emotional appreciation of the Whole).

The center of *A Vast Consilience* shows

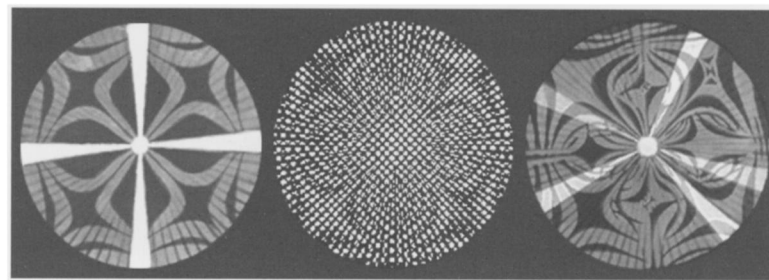


Fig. 10. *Divinity*, acrylic on Plexiglas, flanked by batik panels, 30 x 90 in triptych, 1980. (© Trudy Myrrh Reagan)

an eclipse, because the whole pattern is unknowable—not by us, not by the culture as a whole, or by people in a future epoch. It is interesting that the two Greek words *logos* and *cosmos* have the idea of an underlying order of the universe imbedded in them.

Of course, how we explain what little we can observe is always under question. Geologists, who cannot "repeat the experiment," operate with multiple working hypotheses, hoping that evidence will surface that eventually proves one theory more nearly correct than another. Worse, physicists are confronted with the Uncertainty Principle: Measuring light as a wave is incompatible with measuring it as a particle, yet light appears to be both.

Since I think in metaphors, I felt light was a good analogy for The Divine. It manifests itself so differently to people of various temperaments and through the lenses of different cultures. Like light, The Divine is more than any of its descriptions—indescribable.

In *Divinity* (Fig. 10), I used a moiré pattern to represent the indescribable Divine. Making the moiré was simple, but tedious; the result, magical: When two grid-like patterns are superimposed, a third pattern results. The effect is like the crests and troughs, cancellation and reinforcement patterns, of two sets of waves crossing each other.

For this project, I chose to create a cruciform pattern by superimposing two designs, spots and radiating stripes. I applied the two patterns to two layers of plastic by adhering plastic film to mask portions of the design and spray painting it. I hung the painted layers independently, one in front of the other. One could move them, making the pattern shift dynamically.

To the left I created a strong but static cruciform pattern based on the moiré, one that I named "God" and executed in batik. To the right was a dynamic but less distinct interpretation, "Tao." I did this piece in 1980, after misreading a sentence. It said, "The Tao is a web." I read,

"The Tao is a verb." Suddenly, the Judeo-Christian-Muslim God, and even the Greek "cosmos" (the underlying order, as I had understood it) seemed static. The center moiré I think of as "Neither/Both/More." In this polarized world of loudly competing religious doctrines, *Divinity* is a plea for tolerance.

Another person studying patterns in nature would pursue different paths, but any such path would inspire a deep connection to the universe beyond us. In the 1970s, for example, Peter S. Stevens and the Philomorph study group at Harvard listed various shapes, such as spirals, and showed why they tend to recur at different scales. They found the wonder of a few pattern types manifesting themselves throughout the universe, in galaxies down to the smallest crystal structures [22]. Even some viruses are in the shapes of Platonic solids!

George Johnson writes in *Fire in the Mind*,

Imagine that instead of 92 elements, a continuum. In place of neatly arranged cells, Mendelev's table would become a continuous band. But if the energy levels of electrons are not continuous [quantum theory], if only certain values are allowed, we can explain why the same forms keep turning up in nature [23].

In a recent work, *Catastrophe* (Fig. 11), I murdered a previous painting on Plexiglas by stretching a wrinkled cotton sheet over it and pouring rubbing alcohol (an acrylic paint solvent) on it. I pulled the cloth up, and found a portrait of an explosion that took relatively little effort to revise. Post-Katrina, this is how I expressed the "perfect storm." The prototypical avalanche triggered by just one additional grain of sand, so familiar in chaos theory, is discussed in *Ubiquity* [24]. Its author, Mark Buchanan, shows that phenomena like earthquakes happen continually. On a bell curve, both the miniscule and mammoth ones rest at the extreme edges—that is, are very rare. Moderate ones are common. Which kind will be triggered by the "last grain of



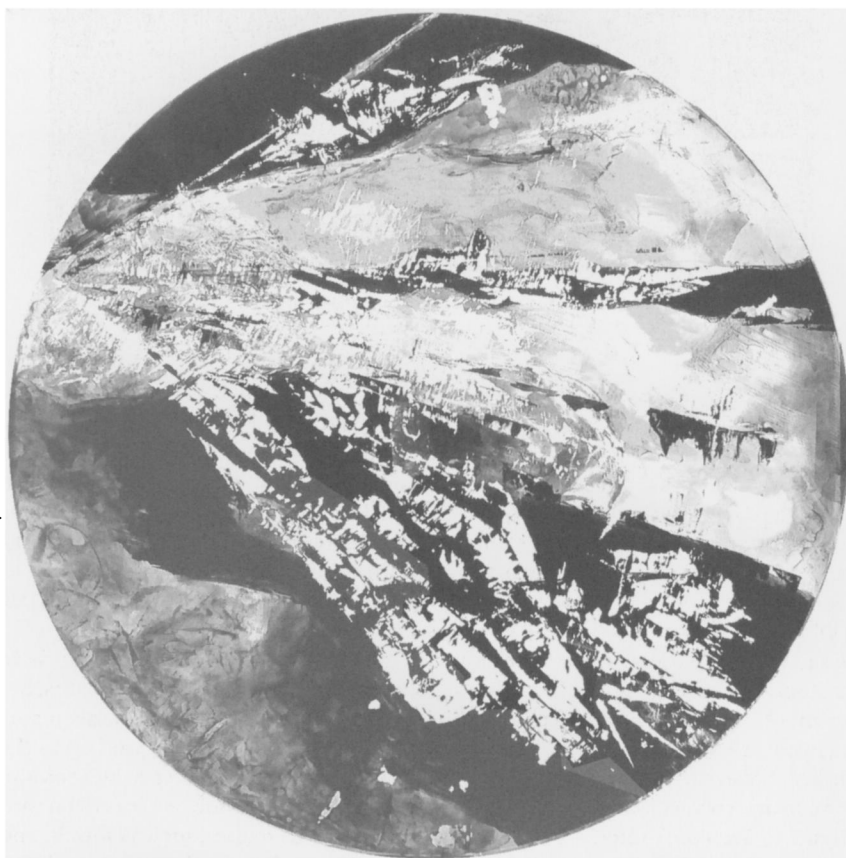


Fig. 11. *Catastrophe*, acrylic on Plexiglas, engraved lines, 45-in circle, 2006.  
(© Trudy Myrrh Reagan)

sand"? It is utterly unpredictable, he declares.

Some argue that such unpredictability is not only more artistically intriguing, but closer to the true nature of reality. I would argue that even different catastrophes have their pattern "signatures," just as one can distinguish modern jazz or klezmer from surprising combinations of improvised notes.

It is fashionable to denigrate "scientific truth," because so much remains unknowable. The "unknowable" is the subject of my work *Divinity*. However, I believe that physical and mathematical rules for pattern generation have great explanatory power, taking us beyond, for instance, the "random process of evolu-

tion" to explain the beauty we observe. We should not abandon our search for truth and universality!

My curious eye has attracted me to certain patterns in nature; learning about them plunged me ever deeper into fundamental questions about how patterns arise and about the very fabric of space and time. The study of patterns in nature is indeed profound.

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8. Itsuo Sakane, "Wrinkled Mountain Ranges," *Kagaku Asahi* 49, No. 1 (1 February 1989) p. 70.

9. David Huffman, lecture at Stanford University mathematics department, 1982 or 1983.

10. Douglas Hofstadter, "The Music of Frédéric Chopin: Startling Aural Patterns That Also Startle the Eye," title of "Metamagical Themas" column in *Scientific American* (April 1982), p. 16: "Phenomena perceived to be magical are always the outcome of complex patterns of nonmagical activities taking place at a level below perception. In other words, the magic behind the magic is pattern."

11. I use Golden liquid acrylic paints diluted with liquid acrylic medium and GAC 200, an additive for inflexible surfaces.

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15. Rudy Rucker, *The Lifebox, the Seashell, and the Soul* (New York: Thunder's Mouth Press, 2005) p. 10.

16. Ball [13] pp. 79, 69.

17. Ball [13] pp. 102–104.

18. Brian Goodwin, *How the Leopard Changed Its Spots: The Evolution of Complexity* (New York: Scribner, 1994).

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20. Ball [13] pp. 104–109.

21. E.O. Wilson, *Consilience* (New York: Knopf, 1998).

22. Stevens [5] pp. 3–4.

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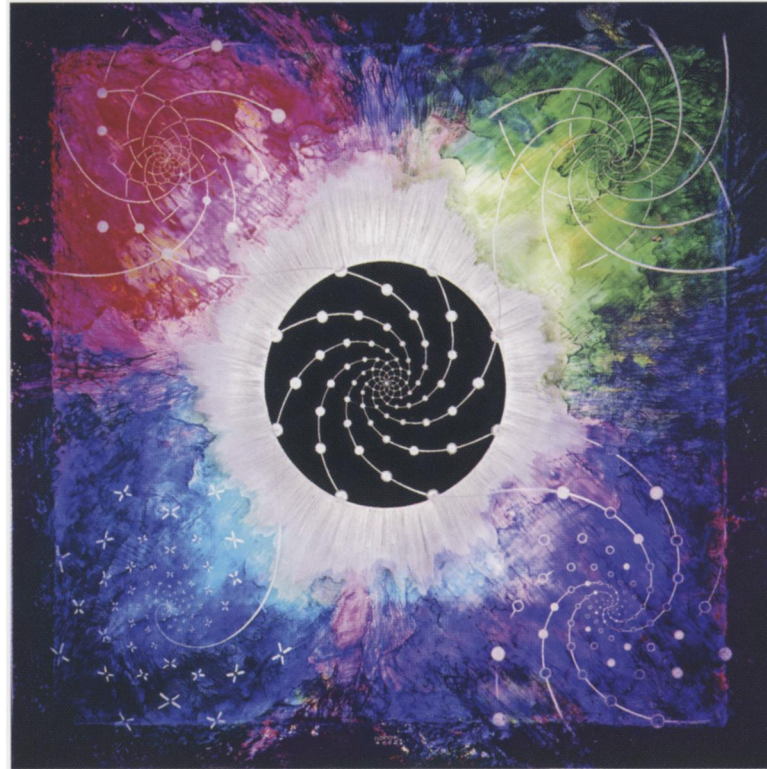
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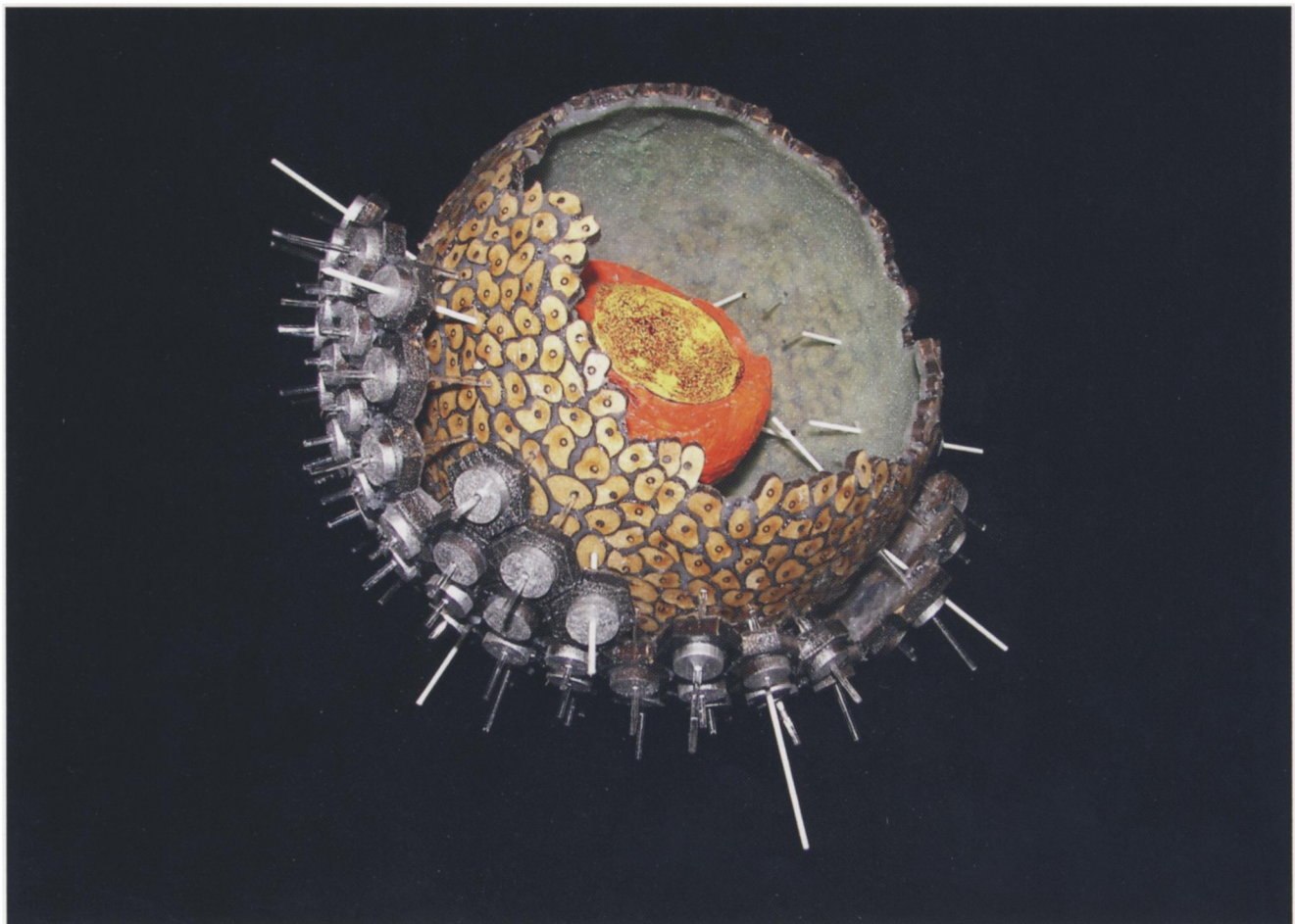
*Trudy Myrrh Reagan is an artist who founded YLEM: Artists Using Science and Technology in 1981. In 2004, she started an interest group within YLEM on the subject of patterns, both natural and mathematical.*



COLOR PLATE D



No. 1. Trudy Myrrh Reagan, *A Vast Consilience*, acrylic on Plexiglas, engraved lines, 48-in square, 2004. (© Trudy Myrrh Reagan. Photo: Richard Johnes.)



No. 2. Todd Siler, *Fractal Reactor: An Alternative Geometry for Nuclear Fusion*, mixed media, 10 × 10 × 8 in, 2000. (© T. Siler)