

The Gettysburg Review

SUMMER 2010

\$10



Wild Turkey

I tell you I saw this once—tangle
of typewriters piled up
on a city street like a pyre
waiting to be lit, levers still
half lifted as if trying to hail
a cab. Oh, they were beautiful,
these discarded messengers
of the machine age, their names,
Olivetti, Royal, Underwood, picked out
in gold, and I almost rescued one,
hefting it from its nest of empty
whiskey bottles—Wild Turkey,
they were, flock decimated
by the light of burning midnight
oil, but ghosts, I think, prefer
the company of ghosts, that's why
we seldom see them, but we hear them,
sometimes, typing away at that life
sentence, bars rising with the press
of fingertips on the keys, unlocking
the words: *send help*.

Nuance, Metaphor, and Molecules:
The Book Cover That Never Was

When my significant other suggested that an image from Michelangelo's Sistine Chapel fresco would make a good cover illustration for my book about fossil molecules, I just rolled my eyes and laughed.

"Stephan," I said. "It's a science book. As in *natural* science. We can't have a sixteenth-century painting of God on there." I said it without thinking, not realizing just how true it would turn out to be. I didn't want to have anything to do with the book's cover, but the editors had asked for suggestions, and Stephan maintained that my coauthors and I would be sorry if we left them to their own devices. He had quite a bit of experience from his own books—but he is a professor of political science, and his books are about people and their institutions.

"It's perfect," he insisted. "Instead of Adam, they could show God pointing to one of your molecules."

He had no training in the language of organic chemistry, but he had been listening to me speak it for years. He knew that organisms make elaborate confectations of carbon and hydrogen atoms, spiced with oxygen, nitrogen, and phosphorus, and that we use an iconic language of lines, letters, pentagons, and hexagons to represent them. At countless dinner parties with his colleagues in Germany, he had urged me to explain—not in the language of chemistry or my native English, but in my clumsy German—how remnants of these molecules could persist long after an organism's death, leaving carbon skeletons that we can identify in ancient sediments and rocks, much as paleontologists identify fossil bones. He had heard me hold forth on the theme *ad infinitum* and knew that these fossil molecules, what we call "biomarkers," document the lives and times of the dazzling assortment of microbes and algae that have graced the earth for billions of years—since long before Michelangelo or God or anyone else dreamed of Adam, or for that matter, a dinosaur, a fish, a tree, or even a simple mushroom.

"Is this the latest in lapsed Catholic humor?" I asked.

"I'm not lapsed."

“Yes you are. You don’t go to church.”

“I go now and then.”

“Funerals.”

He looked hurt.

“Okay. Now and then. You even light candles.” I had actually gone with him to Mass a few times. I was raised an atheist, daughter of a dogmatically atheist Jew and an agnostic Protestant, and Stephan’s quiescent belief in a god was the object of bemused and generally unsuccessful inquiry in our household. It was, I gathered, like trying to explain love to an intelligent robot. “Repentant lapsed Catholic,” I said.

“I’m serious. About your book, I mean.”

I looked at him suspiciously, trying to bring Michelangelo’s painting to mind. Stephan has a penchant for puns, analogies, metaphors, and miscellaneous unidentifiable forms of associative insinuation, often across two languages and cultures. It usually takes me a few minutes to decipher them. Some are funny, others are silly enough to elicit groans from a ten-year-old, and some elude me completely. But occasionally, Stephan’s wordplay offers a subtle, insightful new way of seeing and understanding the familiar, or not so familiar, as the case may be. One has to pay attention.

Our book is terribly interdisciplinary. Its main characters are molecules, its main theme the coevolution of life and Earth. The tangled plot includes tales of ancient ecosystems, of evolutions and mass extinctions, of expanding oceans, changing atmospheres, fluctuating climates . . .

I was going to suggest a photo of Earth from space for the cover, with some of our fossil molecules superimposed, until I realized that photos of Earth from space had been used on dozens of other recent earth science books. “A titanic molecule,” suggested Jürgen, my German coauthor, “like Hercules, holding up the globe.” Our British coauthor, Geoff, thought we needed to convey some sense of history. “They could show Father Time,” he suggested, “half buried in the sediments with the molecules.” But neither Jürgen nor Stephan had ever heard of Father Time. An hourglass, I thought, with some molecules drawn in the sand?

“It’s a beautiful painting,” Stephan insisted. “Everyone knows it.”

He had only read a few short excerpts from the book, but he had a pretty good idea of what we were trying to accomplish with our narrative—the depth of its science, the breadth of its readership. I had introduced the molecular main characters a bit on the sly, so that geologists, oceanographers, paleontologists,



Michelangelo, *The Creation of Adam*, c.1511, from the fresco on the Sistine Chapel ceiling.

and microbiologists would not shy away. The iconographic language of organic chemistry would be as foreign as Chinese to much of the book’s readership, and I had tried to embed it in context so that one could absorb it intuitively, like a child absorbing language. But disciplinary xenophobia ran deep. “A bunch of chicken wire,” I could hear the geologists reciting as they leafed through the book and saw all the little line drawings of molecules. “A bunch of dirty rocks,” I could hear the organic chemists pronouncing as they tossed it aside. I sighed and went back to my desk. Our book crosses disciplines, languages, and literary genres: a beautiful painting that everyone knew on the cover was not, in principle, a bad idea.

I looked up the Sistine Chapel on Wikipedia, and there was Michelangelo’s rendition of God and Adam, immediately familiar and, even viewed on a computer screen, achingly beautiful. I read what some of the art historians had to say. The red cloth around God had been described as everything from a divine cloak to a “uterine mantle.” The woman under God’s arm was said to be Eve waiting in the wings, or perhaps the personification of wisdom. A medical student had detailed the uncanny likeness between the anatomy of the brain and the forms of the red cloth and cherubim. There were notes about Michelangelo’s dissection exercises and knowledge of human anatomy, his sense of humor and fondness for symbolism and puzzles. I saved a copy of the image from Wikipedia and opened it in a simple graphics program.

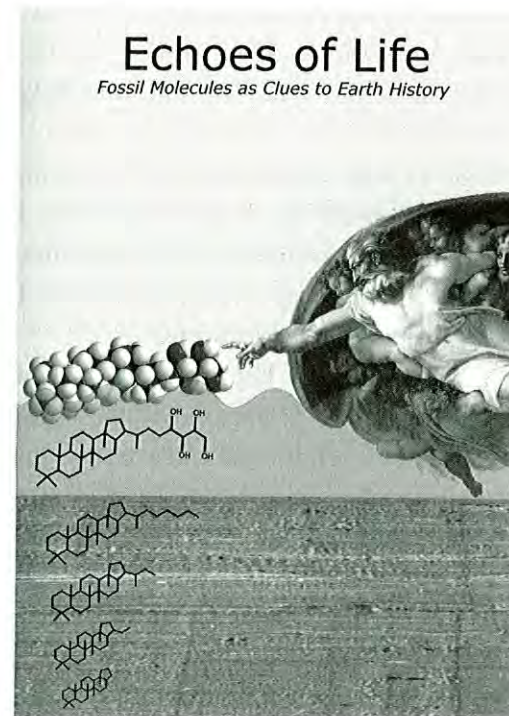
There were two obvious candidates for Adam’s position, our two most famous biomarkers. One was a simple but unusual structure that microscopic marine

algae produce in several different versions according to the water temperature, like making the same jacket in cotton, wool, or down. It can persist unchanged in the sediments for millions of years, and its fame derives from its use as an indicator of past climates. This was the molecule I usually gave as an example for Stephan's colleagues, because I could tie it into global-warming research, which was something that a bunch of political scientists, lawyers, and sociologists might, at least, think worthy of their attention. But this was not, I thought, the molecule Stephan had in mind for our cover.

I thought of how he was always encouraging me to talk about the book to his friends, cheering me on from the sidelines whenever I sang the praises of the biomarkers and their power to elucidate Earth's long, tumultuous love affair with life. I was never sure if he was truly enthralled by my stories or just a personal fan. Indeed, I often wondered if he even understood what I was babbling about. But as I cut Adam out of the picture and replaced him with our other favorite molecule—less useful than the temperature indicator but eminently more worthy of its symbolic role—I knew: Stephan had summed up all my long, convoluted explanations and given them back to me in a funny, almost elegant visual metaphor.

The molecule I chose was one that bacteria use in their cell membranes, the boundary between the living organism and its environment: bacteriohopanetetrol. Awful name, but never mind, I didn't have to name it. There were several types of icons I could use to depict it, and I settled on one where the atoms were drawn to represent the amount of space they take up as well as their positions in the molecule: gray for carbon, white for hydrogen, and nice bright red for oxygen. It seemed a bit more corporeal and worthy of Adam's place than the standard chicken-wire line drawings. I tried to arrange it on the hill so that it looked as relaxed and languid as Adam had, but this is simply not a languid molecule. It has a large inflexible structure of interlocking carbon rings—in fact, this is one of its main charms, as those rings provide some rigidity to the cell membranes, much like cholesterol does in animal cells.

I used line drawings for the fossil molecules, placing them in the hillside beneath the biological one and arranging them in the order they appeared as the sediments aged and were buried: unlike the algae's jacket molecule, this one loses pieces of itself over time, producing a whole series of progressively more whittled down fossil molecules. Geochemists had discovered these fossil molecules in petroleum, rocks, and sediments in the late 1960s, well before biochemists imagined that anything even faintly resembling them existed in bacteria. Loosely



Bacteriohopanetetrol and God: the author's rendition of the Sistine Chapel cover idea.

referred to as "hopanoids" after a compound that had been extracted from certain tropical trees, they were ubiquitous in the sediments, but their actual source was a mystery. The French scientists who figured out their precise chemical structures suspected that hopanoids all derived from one biological parent molecule and dubbed them "orphans." Finally, nearly a decade later, Canadian biochemists stumbled on a plausible parent molecule in vinegar-making bacteria, and it gradually became clear why hopanoid fossil molecules were so omnipresent: the parent molecule was produced by hundreds of varieties of bacteria, and bacteria were ubiquitous and plentiful in natural waters and sediments, and, according to all evidence to date, they had been for most of the earth's history.

"You get it?" I asked Stephan when he came over to look at the image on my computer screen. "That's the biological molecule, with the red oxygens. And those are the fossil molecules. The oxygen disappears right away. Then it starts losing pieces of its arm. Takes a few hundred thousand years, depending on conditions, to get to these molecules at the bottom, with the short arms." I looked up at him. He had heard me describe all this before. But he had never seen a picture.

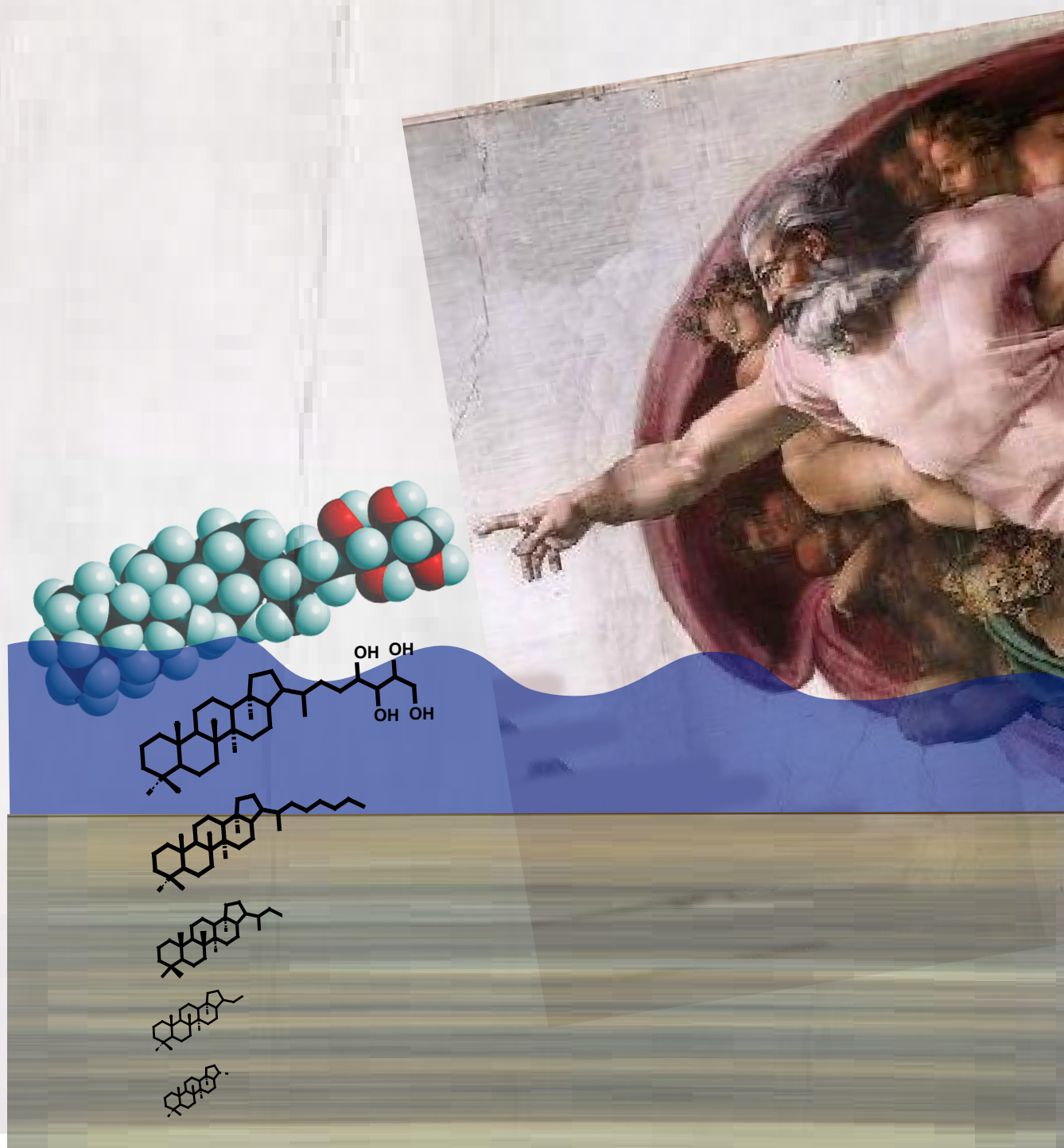
He was staring at the image intently. "Why is the one on the hill sticking up at that funny angle?" he said, finally.

I turned back to the computer screen. "It's trying to relax? You know, like Adam?"

"You should just straighten it out, so it's in line with the fossil molecules. And then send it to your editor." He grinned triumphantly and walked away.

Echoes of Life

Fossil Molecules as Clues to Earth History



I straightened out the bacteriohopanetetrol. I placed a line drawing just underneath the space-filling one, a transitional icon, so it would be easier to see the pattern of ever-more-truncated fossil molecules. But there was still something missing.

Water. I got rid of Adam's hill and made a crude representation of an ocean, setting bacteriohopanetetrol and God afloat. Beneath the water, I patched in a photo of a sediment-core cross section and lined up my series of fossil molecules, making them smaller and smaller, like an echo, sounding through time. Then I added the title across the top as if it were the caption on a caricature.

I was getting attached to the idea. On one side, our hopanoid molecule, a component of the essential cell-delimiting membrane in life's oldest and humblest domain—a molecule that is, nevertheless, the result of an entire symphony of well-tuned biochemical reactions, a small miracle in and of itself. Fossil carbon skeletons like the ones I had drawn beneath it had been found in rocks as old as 2.7 billion years. On the other side, Michelangelo's God, in all its corporeal human male glory: awe, infinite grace, and the mystery of the undiscovered, somehow embodied in a familiar, grandfatherly figure that might, I thought, reassure the uninitiated and make the chemical icons seem more approachable.

I sent it to Jürgen, the most practical of the three of us. "Stephan's idea," I explained apologetically. "Is it too ridiculous?"

"Some kind of horror when I first saw the Sistine Chapel image," he answered. "But then I started to like it. It's a simple, informative, and stimulating fantasy." He added some suggestions for the chemical structures.

Geoff told me his first thought when he opened the file was *What in the world?* But then he decided we were onto something, and the image was eye-catching and provocative.

The editors in New York were enthusiastic. But two weeks after I sent them the idea, when they were about to turn it over to their cover designers, I received a stop-the-show e-mail from Geoff. He was in the U.S. and had just shown my rough draft of the illustration to colleagues at the oceanographic institution where he was on the adjunct faculty.

"I am very worried," he wrote. "There is a consistent reaction here that it suggests a religious content, but even more, that it is suggestive of creationism with all the implications for causing a lot of unwanted negative publicity."

Suggestive of creationism? I looked at the image anew. Was it not just "a stimulating fantasy?" Would our potential readers—mostly scientists of one sort

or another, after all—look at this image, replete with title and subtitle, and take it *literally*? There was *no such thing*, I thought, as a literal depiction of God or a molecule, whatever one believed in—that was the whole point, one that Michelangelo himself might have been making, for all we knew, with his God sheathed in a human brain.

I asked a friend in California for advice. Not a scientist, but a novelist, a writer, a lover of poetry and Shakespeare. "I love Stephan's cover," she wrote back. "But I'm sorry to say that at least here in America, I think your coauthor's colleagues are right. God is no goldanged metafer in these parts—he is a living, breathing Big Brother. Much as I love the Sistine Chapel, I'm afraid the fundamentalists have co-opted that image pretty irredeemably."

I had clearly been out of the States for too long.

Stephan was incredulous.

"Why are *you* surprised?" I asked him. "You're the one who's always telling me that the U.S. is a Christian country."

"Sectarian Christian," he corrected.

I shrugged. It was a long-standing argument that he had long ago won—citing the historic ramifications, the various Christian sects that populated the colonies, and the underpinnings of our legal system—but it never failed to conjure my schoolgirl recitations on the separation of church and state, not to mention a disquieting image of my Jewish grandparents turning over in their oh-so-American graves. He knew about the creationists in the U.S., but like me, he hadn't expected scientists, of all people, to take them so seriously, to be so timid—really, to respond in kind. "And your Catholics?" I asked. "What do they say about all this? After all, it's their painting if it's anyone's."

He looked befuddled. "It's an allegory," he said. "I don't think they take the Bible that literally. They've learned to avoid the issue, let science be science."

"I guess they've come a long way since Galileo," I said dryly.

"Well, yes." He paused, still looking puzzled. "It's *Michelangelo*. It's one of the most enduring icons of Western civilization. There aren't all that many."

I pondered that. The dust jacket of one of Stephan's recent books displayed an allegory for good governance from a medieval Italian fresco. Another employed an etching of a giant, citizen-draped king, taken from a seventeenth-century treatise on political philosophy. But I had to decide quickly. Could one really interpret our book cover as a scientific endorsement of Christianity's God? With Geoff in the U.S. and clearly worried that the cover would prove an embarrass-

ment or worse, and Jürgen at work on a project in Mexico and unavailable for comment, I alerted the editors to the issue. I hoped they would reassure us that Geoff's colleagues had overreacted. Instead, they responded quickly and simply: please send other ideas and images.

We vamped up our list of half-baked ideas. A photo of dinosaur bones with the carbon skeleton of cholesterol superimposed? A leaf and the fossil molecules of chlorophyll? We dutifully sent the whole list to the press, along with miscellaneous images of microbes, algae, molecules, hourglasses, Father Time, fossils, sediments, even an abstract watercolor my artist mother painted for me. We hoped that the editors would sort it all out and some talented designer would create an evocative book cover.

Later, it dawned on me that the word Stephan was searching for when he had called the scientists' reaction *timid*, the appropriate word, was *scared*. Scientists are an oddly marginalized community, always in danger of being misconstrued, and now they were under siege, on the defensive. Some had even gone on the offensive, writing whole books and diatribes on God and religion. It seemed to me they were engaging an argument we had made peace with back in the nineteenth century when science and religion emerged onto their separate, independent paths. That was a discussion that I, personally, did not want to be sucked into: whether God is, or isn't—*whatever* God is, or isn't—is *by definition* not the purview of science. In that sense, I was glad we had withdrawn the purportedly incendiary image.

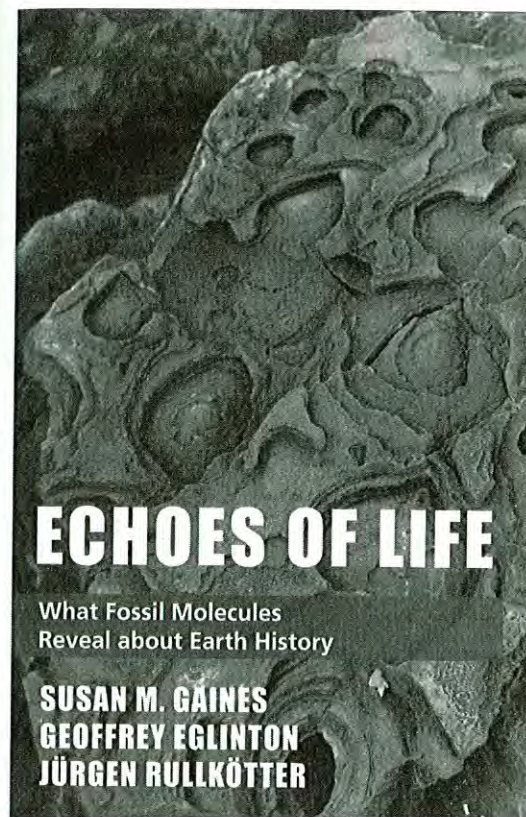
But the editors didn't like any of our other suggestions. They sent back a panoramic photograph of the Grand Canyon at sunset. They said that the marketing department liked it very much and hoped we would approve. They pointed out that it was a slice through two billion years of earth history.

Perhaps if they added a few molecules? we suggested.

No, the editors replied. Marketing objected to molecules. They would scare too many readers away.

But the marketing people had liked the Sistine Chapel design, molecules and all. Had they found Michelangelo's grandfatherly God reassuring, as I had expected? ~~Because they had liked the Sistine Chapel design, molecules and all.~~

"What if they add a sketch of Sherlock Holmes," Geoff suggested, and I warmed to the idea. He could be standing on the canyon floor holding an oversized magnifying glass over a hopanoid molecule imbedded in the rock wall. Sherlock would be almost as reassuring as God.



Oxford University Press's final dust jacket, showing a detail from an ancient stromatolite reef in Australia's Pilbara region. Design: Caroline McDonnell. Photo: Dr. Abigail Allwood.

No, the editors replied, featuring Sherlock Holmes on the cover would take away from the fact that it was a serious science book, not a mystery.

But science *is* a mystery, the three of us intoned.

We pondered the Grand Canyon. Ironically, the stunning commercial photo seemed trite. It looked like something from *Fodor's Guide to the West*. I spent another day collecting photos of ancient rocks and deep sea vents from colleagues—esoteric, unfamiliar places that, at least, figured in our book—sent them to the press, and told them to take their pick. By this time, I was seriously regretting not having stood up for Michelangelo. I wondered if scientists might, in fact, be contributing to their own marginalization with such acts of self-censorship. Why

couldn't we have a sixteenth-century painting of God on our twenty-first-century science book? I had no desire to mix up science and religion, but this reduction of our vocabulary to the literal had me worried. Scientists depend on metaphor and analogy from the everyday world in both their discourse and their initial responses to new observation. We use the sensory to describe the nonsensory, the known to describe the unknown, and the familiar to describe the unfamiliar. We deal in concepts for which no language yet exists, using languages that have evolved, hand in hand with religion, to articulate human sensory, social, and, yes, spiritual perceptions. Metaphor and analogy allow us to frame and visualize the results of our inquiries, they afford an intuitive understanding that complements or even *generates* the more precise formulations—often, as for chemistry, in their



ECHOES OF LIFE

What Fossil Molecules
Reveal About Earth History

SUSAN M. GAINES
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own, newly invented languages—that eventually end up in the scientific literature. How could Darwin ever have imagined, let alone written, *The Origin of Species* if he had limited his field of expression to the literal—what, indeed, of the writings of Alexander von Humboldt or the insights of Charles Lyell that so inspired him?

The books arrived a couple of weeks ago. The dust jacket is attractive, even mysterious and evocative, to the handful of people in the world who might recognize the rock depicted there. It is part of a recently explored reef formation in northwestern Australia, a 3.43-billion-year-old stromatolite that appears, by careful physical and chemical analogy with contemporary formations, to have been generated by thick mats of microbes. It offers some of the most solid evidence to date that complex microbial ecosystems were already up and running within a billion years of the earth's formation, though the biomarker studies that might provide ballast to this interpretation are only just beginning.

When chemists began analyzing traces of organic molecules in rocks in the 1960s, they dreamed of finding clues to the origin of life in the earth's most ancient sedimentary rock formations. If they could find appropriate samples, they thought, then they would eventually encounter evidence from a lifeless Earth—that is, distributions of organic molecules that resembled those produced by random chemical reaction, which is what had been found in meteorites. Instead, they found fossil hopanoid molecules and other evidence of complex biochemical creations in rocks that were over a billion, and 1.5 billion, and even 2.5 billion years old. The stromatolite shown on the cover of our book may well represent the limits of this search for a number of reasons, not least of which is a lack of reliable samples for biomarker analysis. These come from deep beneath the surface of the earth, and scientists have had to depend on the benevolence of mining and oil companies to obtain them from areas where they happen to be working. One of the first noncommercial scientific programs for drilling and exploration in ancient rocks was a victim of Bush administration reductions in NASA funding that targeted astrobiology and early-life research. But if all goes well, and good samples can be obtained, such rocks may provide clues to the microbial ecosystems that populated Earth during its infancy and transformed it from a meteorite-bombarded conglomerate of minerals to a living, evolving planet like no other in the solar system.

For this undeniably atheist chemist, the instrumental traces of molecular structures that were assembled by microorganisms billions of years ago provide a visceral approach to the divine. If I acknowledge that here, will my colleagues

accuse me of scientific heresy? These squiggles on a strip of chart paper fill me with awe and wonder, the yearning to know more—with all the unacknowledged human feelings that drive and nourish the scientific enterprise. But if such traces are present in this 3.43-billion-year-old Australian formation, and it was, as suspected, already home to thriving communities of microbes, then we may never find clues to life's nascence in the rocks, or even the chemical footprints of its first steps: older sedimentary formations where the rocks have not been thoroughly baked and squeezed, their organic molecules destroyed or transformed beyond recognition, have not, to date, been found.

The origin of life seems always to lurk at the edge of our ever-expanding knowledge, and it is here, I realize, in such unsolved mysteries, that gods have long comforted us, whether as symbol or metaphor, myth, icon, or literal incarnation of the yet unknown. One of Stephan's American colleagues—a political scientist who was raised in a Mennonite family—tells me he thinks that fundamentalists would have found our aborted book cover image offensive because of its chemical, rather than spiritual, depiction of life and, in particular, its disregard for the special status of human life. I puzzle for a moment over his words. No matter how disturbing it might be to a Judeo-Christian-Muslim sensibility, humans are beside the point in geologic time: this is explicit in the rock record, in the molecules, in the results from the fifty years of research described in our book. Most scientists would not, I think, shy away from such a reaction. It is certainly not what made me concur in censoring the image. On the contrary. The image focuses attention on the molecular components of life, to be sure, but it also reminds us that life transcends its molecular machinery in ways that we do not fully understand, a transcendence that we might call “spiritual” in the broadest sense. It was *this* inference that had made me most nervous about using it on our book. As much as I had feared that religious fanatics would misconstrue our book and send the cover image echoing across the Internet as a scientific endorsement of a Christian God, I feared that scientists had become so narrow, constrained, and defensive in their thinking that they would decry even this most secular reference to the spiritual. Understanding the molecules of life has been the greatest achievement of late twentieth-century biology; reducing life to its molecules, neglecting the organism as a whole, and failing to define what it is that makes life more than its assembled parts has been its greatest shortcoming and leaves us, in effect, unable to see the forest for the trees—and still unable to render life's origin scientifically fathomable. The more I think about the full implications of our

whimsical cover image and the subtle way it reflects the contents of our book, both molecular and holistic, the more I regret that we didn't send it out into the world and brave the reaction. Must we really forgo such millennia-old symbols—which Michelangelo rendered with such enduring eloquence—strip our languages of history, and purge our already strained and shrinking common vocabularies of spiritual, even philosophical, nuance? Thus, I would argue, is science deprived of both inspiration and intuitive lasso, bullied and squeezed into the dull, colorless shadow of its own misconstrued reductionism. Or worse, into silence.

At the Riverside Chapel

When they gave her son
her wedding ring
he knew she was really dead
and being stripped down
for that final
passage—

bare hands crossed;
naked under
a simple dress;
the kind of frugality
she would have
disdained,

preferring those
sumptuous robes,
those jewels
the pharaohs wore
when they pushed off
on the same journey.



Sherod Santos

Linda Pastan

Jay Neugeboren

Reid Menees Wegner

Gary Fincke

Others

Paintings by Katherine Bradford

Gettysburg
COLLEGE