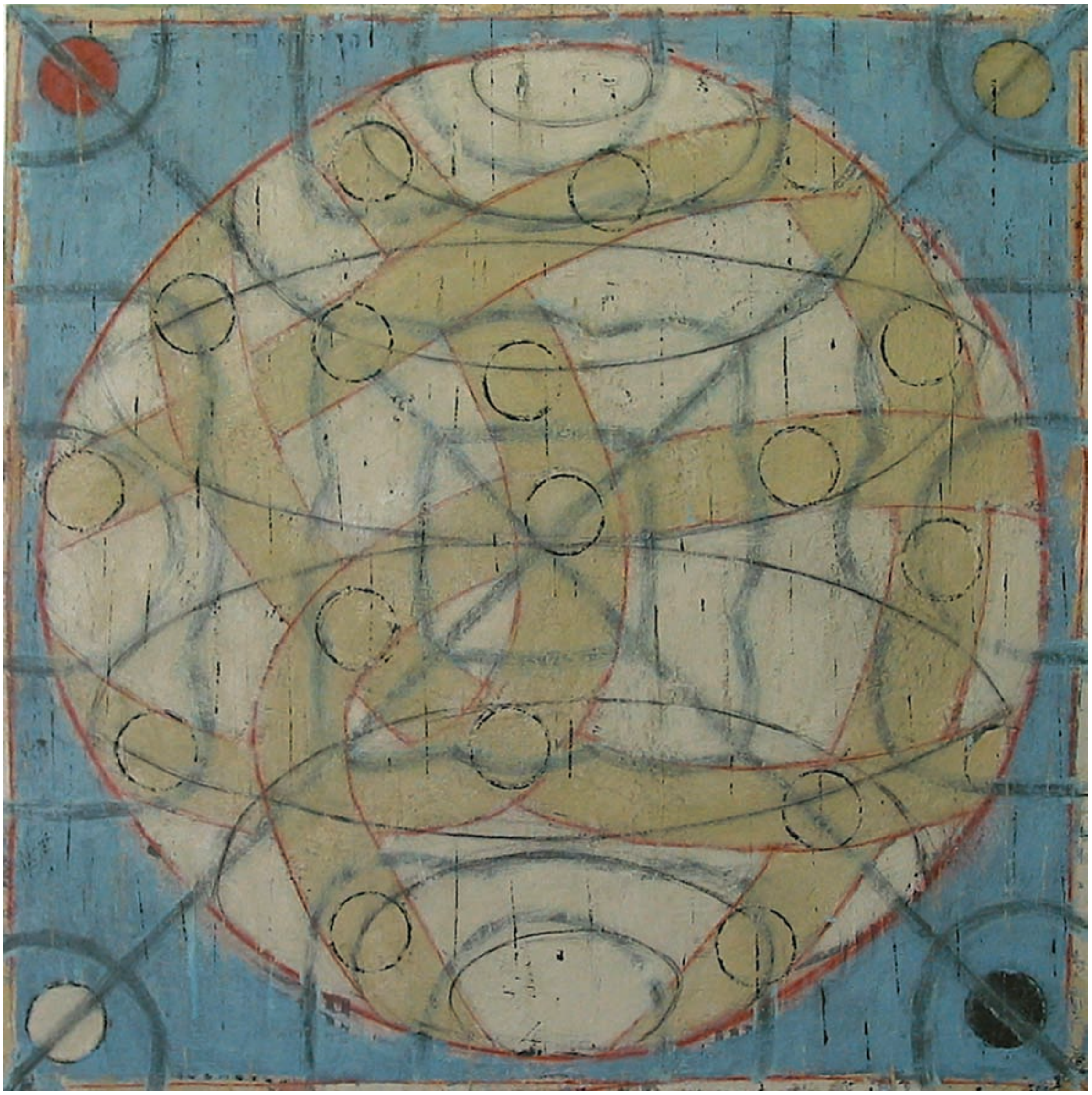

Paul Brigham

Why Science Needs Art

JONAH LEHRER

In the early 1920s, Niels Bohr was struggling to reimagine the structure of matter. Previous generations of physicists had thought the inner space of an atom looked like a miniature solar system with the atomic nucleus as the sun and the whirring electrons as planets in orbit. This was the classical model.

But Bohr had spent time analyzing the radiation emitted by electrons, and he realized that science needed a new metaphor. The behavior of electrons seemed to defy every conventional explanation. As Bohr said, "When it comes to atoms, language can be used only as in poetry." Ordinary words couldn't capture the data.

Bohr had long been fascinated by cubist paintings. For him, the allure of cubism was that it shattered the certainty of the object. The art revealed the fissures in everything, turning the solidity of matter into a surreal blur.

Bohr's discerning conviction was that the invisible world of the electron was essentially a cubist world. By 1923, Louis de Broglie had already determined that electrons could exist as either particles or waves. What Bohr maintained was that the form they took depended on how you looked at them. Their very nature was a consequence of our observation. This meant that electrons weren't like little planets at all. Instead, they were like one of Picasso's deconstructed guitars, a blur of brushstrokes that only made sense once you stared at it. The art that looked so strange was actually telling the truth.

A DEEPENING MYSTERY

It's hard to believe that a work of abstract art might have actually affected the history of science. Cubism seems to have nothing in common with modern physics. When we think about the scientific process, a specific vocabulary comes to mind: objectivity, experiments, facts. In the passive tense of the scientific paper, we imagine a perfect reflection of the real world. Paintings can be profound, but they are always pretend.

This view of science as the sole mediator of everything depends upon one unstated assumption: Scientific knowledge is a linear ascent. The history of science is supposed to obey a simple equation: Time plus data equals understanding. One day, we believe, science will solve everything.

But the trajectory of science has proven to be a little more complicated. The more we know about reality—about its quantum mechanics and neural origins—the more palpable its paradoxes become. As Vladimir Nabokov, the novelist and lepidopterist, once put it, "The greater one's science, the deeper the sense of mystery."

Consider, for example, the history of physics. Once upon a time, and more than once, physicists thought they had the universe solved. Some obscure details remained, but the basic structure of the cosmos was understood. Out of this naïveté, relativity theory emerged, fundamentally altering classical notions about the relationship of time and space. Then came Heisenberg's uncertainty principle and the surreal revelations of quantum physics. String theorists, in their attempts to reconcile ever widening theoretical gaps, started talking about eleven dimensions. Dark matter still makes no sense. Modern physics knows so much more about the universe, but there is still so much it doesn't understand. For the first time, some scientists are openly wondering if we, in fact, are incapable of figuring out the cosmos. ➲

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Or look at neuroscience. Only a few decades ago, scientists were putting forth confident conjectures about "the bridging principle," the neural event that would explain how the activity of our brain cells creates the subjective experience of consciousness. All sorts of bridges were proposed, from 40 Hz oscillations in the cerebral cortex to quantum coherence in microtubules. These were the biological processes that supposedly turned the water of the brain into the wine of the mind.

But scientists don't talk about these kinds of bridging principles these days. While neuroscience continues to make astonishing progress in learning about the details of the brain—we are a strange loop of kinase enzymes and synaptic chemistry—these details only highlight our enduring enigma, which is that we don't *experience* these cellular details. It is ironic, but true: The one reality science cannot reduce is the only reality we will ever know.

THE ART OF PANDEMONIUM

The logic of reductionism implies that our self-consciousness is really an elaborate illusion, an epiphenomenon generated by some electrical shudder in the frontal cortex. There is no ghost in the machine; there is only the vibration of the machinery. Your head contains 100 billion electrical cells, but not one of them is you, or knows or cares about you. In fact, you don't even exist. The brain is nothing but an infinite regress of matter, reducible to the callous laws of physics.

The problem with this method is that it denies the very mystery it needs to solve. Neuroscience excels at unraveling the mind from the bottom up. But our self-consciousness seems to require a top-down approach. As the novelist Richard Powers wrote, "If we knew the world only through synapses, how could we know the synapse?" The paradox of neuroscience is that its astonishing progress has exposed the limitations of its paradigm, as reductionism has failed to solve our emergent mind. Much of our experiences remain outside its range.

This world of human experience is the world of the arts. The novelist and the painter and the poet embrace those ephemeral aspects of the mind that cannot be reduced, or dissected, or translated into the activity of an acronym. They strive to capture life as it's lived. As Virginia Woolf put it, the task of the novelist is to "examine for a moment an ordinary mind on an ordinary day . . . [tracing] the pattern, however disconnected and incoherent in appearance, which each sight or incident scores upon the consciousness." She tried to describe the mind from the inside.

Neuroscience has yet to capture this first-person perspective. Its reductionist approach has no place for the "I" at the center of everything. Artists like Woolf, however, have been studying such emergent phenomena for centuries and have constructed elegant models of human consciousness that manage to express the texture of our experience, distilling the details of real life into prose and plot. That's why their novels have endured: because they *feel* true. And they feel true because they capture a layer of reality that reductionism cannot.

By taking these artistic explorations seriously, neuroscientists can better understand the holistic properties they are trying to parse. Before you break something apart, it helps to know how it hangs together. In this sense, the arts are an incredibly rich data set, providing science with a glimpse into its blind spots. If neuroscience is ever going to discover the neural correlates of consciousness, or find the source of the self, or locate the cells of subjectivity—if it's ever going to get beyond a glossary of our cortical parts—then it has to develop a new method, one that's able to construct complex representations of the mind that aren't built from the bottom up. Sometimes, the whole is best understood in terms of the whole. William James realized this first. The eight chapters that begin his epic 1890 textbook, *The Principles of Psychology,* describe the mind in the conventional third-person terms of the experimental psychologist. Everything changes, however, with chapter nine. James starts this section, "The Stream of Thought," with a warning: "We now begin our study of the mind from within."

With that single sentence, as radical in sentiment as the modernist novel, James tried to shift the subject of psychology. He disavowed any scientific method that tried to dissect the mind into a set of elemental units, be it sensations or synapses. Such a reductionist view is the *opposite* of science, James argued, since it ignores our actual reality.

Modern science didn't follow James's lead. In the years after his textbook was published, a "New Psychology" was born, and this rigorous science had no need for Jamesian vagueness. It wanted to purge itself of anything that couldn't be measured. The study of experience was banished from the laboratory.

But artists continued creating their complex simulations of consciousness. They never gave up on the ineffable or detoured around experience because it was too difficult. They plunged straight into the pandemonium. No one demonstrates this better than James Joyce. In *Ulysses,* Joyce attempted to capture the mind's present tense. Everything in the novel is seen not from the omniscient perspective of the author, but through the concave lenses of his imaginary characters. We eavesdrop on their internal soliloquies, as Bloom, Stephen, and Molly think about beauty, and death, and eggs in bed, and the number eight. This, Joyce says, is the broth of thought, the mind before punctuation, the stream of consciousness rendered on the page. *Ulysses* begins where William James left off.

Similarly, Samuel Taylor Coleridge, enchanted with opium, was writing poetry about the "the mind's self-experience in the act of thinking" long before there was even a science of the mind. Or look at the world of visual art. As the neuroscientist Semir Zeki notes, "Artists [painters] are in some sense neurologists, studying the brain with techniques that are unique to them." Monet's haystacks appeal to us, in part, because he had a practical understanding of color perception. The drip paintings of Jackson Pollock resonate precisely because they excite some peculiar circuit of cells in the visual cortex. These painters reverse-engineered the brain, discovering the laws of seeing in order to captivate the eye.

Of course, the standard response of science is that such art is too incoherent and imprecise for the scientific process. If it can't be plotted on a line graph or condensed into variables, then it's not worth taking into account. But isn't such incoherence an essential aspect of the human mind? Isn't our inner experience full of gaps and non sequiturs and inexplicable feelings? In this sense, the messiness of the novel and the abstraction of the painting are actually a mirror. As the poetry critic Randall Jarrell put it, "It is the contradictions in works of art which make them able to represent us—as logical and methodical generalizations cannot—our world and our selves, which are also full of contradictions." Until science sees the brain from a more holistic perspective—and such a perspective might require the artistic imagination—our scientific theories will be detached from the way we see ourselves.

SCIENCE AS METAPHOR

At first glance, physics seems particularly remote from the subjective sphere of the arts. Its theories are extracted from arcane equations and the subatomic debris of supercolliders. This science continually insists that our most basic intuitions about reality are actually illusions, a sad myth of the senses. Artists rely on the imagination, but modern physics *exceeds* the imagination. To paraphrase Hamlet, there are more things in heaven and earth—dark matter, quarks, black holes—than could ever be dreamt up. A universe this strange could only be discovered.

But the surreal nature of physics is precisely why it needs the help of artists. The science has progressed beyond our ability to understand it, at least in any literal sense. As Richard Feynman put it, "Our imagination is stretched to the utmost, not, as in fiction, to imagine things which are not really there, but just to comprehend those things which *are* there." It's a brute fact of psychology that the human mind cannot comprehend the double-digit dimensions of string theory or the possibility of parallel universes. Our mind evolved in a simplified world, where matter is certain, time flows forward, and there are only three dimensions. When we venture beyond these innate intuitions, we are forced to resort to *metaphor.* This is the irony of modern physics: It seeks reality in its most fundamental form, and yet we are utterly incapable of comprehending these fundaments beyond the math we use to represent them. The only way to know the universe is through analogy.

As a result, the history of physics is littered with metaphorical leaps. Einstein grasped relativity while

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thinking about moving trains. Arthur Eddington compared the expansion of the universe to an inflated balloon. James Clerk Maxwell thought of magnetic fields as little whirlpools in space, which he called vortices. The big bang was just a cosmic firecracker. Schrödinger's cat, trapped in a cosmic purgatory, helped illustrate the paradoxes of quantum mechanics. It's hard to imagine string theory without its garden hose.

These scientific similes might seem like quaint oversimplifications, but they actually perform a much more profound function. As the physicist and novelist Alan Lightman writes, "Metaphor in science serves not just as a pedagogical device but also as an aid to scientific discovery. In doing science, even though words and equations are used with the intention of having precise meaning, it is almost impossible not to reason by physical analogy, not to form mental pictures, not to imagine balls bouncing and pendulums swinging." The power of a metaphor is that it allows scientists to imagine the abstract concept in concrete terms, so that they can grasp the implications of their mathematical equations.

But relying on metaphor can also be dangerous, since every metaphor is necessarily imperfect. The strings of the universe might be *like* a garden hose, but they are *not* a garden hose. The cosmos isn't a plastic balloon. When we chain our theories to ordinary language, we are trespassing on the purity of the equation. To think in terms of analogies is to walk a tightrope of accuracy.

This is why modern physics needs the arts. Once we accept the importance of metaphor to the scientific process, we can start thinking about how we can make those metaphors *better.* Poets, of course, are masters of metaphor: The power of their art depends on the compression of meaning into meter; vague feelings are translated into visceral images. It's not a coincidence that many of the greatest physicists of the twentieth century—eminent figures such as Einstein, Feynman, and Bohr—were known for their distinctly romantic method of thinking. These eminent scientists depended on their ability to use metaphor to see what no one else had ever seen, so that the railroad became a metaphor for relativity and a drop of liquid helped symbolize the atomic nucleus. Poets can speed this scientific process along, helping physicists to invent new metaphors and improve their old ones. Perhaps we can do better than a garden hose. Maybe a simile will help unlock the secret of dark matter. As the string theorist Brian Greene recently wrote, the arts have the ability to "give a vigorous shake to our sense of what's real," jarring the scientific imagination into imagining new things.

There's another way that artists can bring something to the cosmic conversation: They can help make the scientific metaphors *tangible.* When the metaphysical equation is turned into a physical object, physicists can explore the meaning of the mathematics from a different perspective. Look, for example, at a Richard Serra sculpture. His labyrinths of bent metal let us participate in the theoretical, so that we might imagine the strange curves of space-time in an entirely new way. The fragmented shapes of cubism, which engaged in such a fruitful dialogue with the avant-garde physics of its time, served a similar purpose. Picasso never understood the equations—he picked up non-Euclidian geometry via the zeitgeist—but he was determined to represent this new way of thinking about space in his paintings. A century later, physicists are still using his shattered still lifes as a potent symbol of their science. Abstract art lets us comprehend, at least a little bit, the incomprehensible.

It's time for the dialogue between our [these] two cultures to become a standard part of the scientific method. But it's also crucial to take our scientific metaphors beyond the realm of the metaphorical, so we can better understand the consequences of our theories. Art galleries should be filled with disorienting evocations of string theory and the EPR paradox. Every theoretical physics department should support an artist-in-residence. Too often, modern physics seems remote and irrelevant, its suppositions so strange they're meaningless. The arts can help us reattach physics to the world we experience.

Neuroscience can also benefit from the reactions of artists. Novelists can simulate the latest theory of consciousness in their fiction. If a theory can't inspire characters that feel true, then it probably isn't true itself. (Woolf, for example, was an early critic of Freudian theory, dismissing the way it turned all of her "characters into cases.") Painters can explore new theories about the visual cortex. Dancers can help untangle the mysterious connection between the body and emotion. By heeding the wisdom of the arts, science extends to art the invitation to participate in its conversation and the opportunity to add science to its repertoire. And by, in turn, interpreting scientific ideas and theories, the arts offer science a new lens through which to see itself.

CROSSING THE CULTURAL DIVIDE

Right now, science is widely considered our sole source of Truth, with a capital "T." But the epic questions that modern science must answer cannot be solved by science alone. Bringing our two cultures together will allow us to judge our knowledge not by its origins, but in terms of its usefulness. What does this novel or experiment or poem teach us about ourselves? How does it help us understand who we are or what the universe is made of? What long-standing problem has it engaged, perhaps even solved? If we are open-minded in our answers to these questions, we will discover that poems and paintings can help advance our experiments and theories. Art can make science better.

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