Mark Alpert

Saint Joan of New York

A Novel About God and String Theory

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Introduction: Physics and the Search for Meaning

This novel, as the subtitle says, is about God and string theory. Its heroine is a modern-day version of Joan of Arc; she's a New York City teenager who has an extraordinary talent for math and physics. The novel's plot mixes science and religion, which is perhaps a questionable strategy, more likely to upset readers than to please them. When you write about God, you're almost certain to offend someone.

So why did I write such a strange book? It all goes back to the fall of 1981, when I was studying astrophysics at Princeton University.

My faculty adviser at the time was J. Richard Gott III, an expert on Einstein's general theory of relativity. In contrast, I was a neophyte, unskilled but eager. My research project was straightforward: determine how the theory of relativity would work in a hypothetical universe that has only two spatial dimensions (plus the dimension of time). In other words, imagine a cosmic Flatland that resembles a vast sheet of paper, with infinite length and width, but zero thickness. According to Einstein's theory, how would a massive body in this universe affect the space-time around it? Would there be gravity in Flatland?

The math really wasn't that hard. The Einstein Field Equations are much easier to solve in a hypothetical (2 + 1)-dimensional universe than in our actual (3 + 1)-dimensional cosmos. The infamously intricate tensors in those equations—the Einstein tensor (which describes the curvature of space-time) and the stress-energy tensor (which describes the density and flux of energy and momentum)—have only nine components in Flatland, versus the usual sixteen. Even with my poor math skills, I was able to find a solution that showed the shape of (2 + 1)-dimensional space-time around a point mass.

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Unfortunately, I couldn't figure out the meaning of this mathematical formula. So I showed it to Professor Gott. I rushed to his office and turned to the page in my notebook on which I'd written the space-time metric in pencil. That was the moment when he gave me the best compliment that one theorist can give to another.

"This solution is non-trivial!" he exclaimed.

Basically, we found that there would be no attraction between masses in Flatland, and the geometry of space-time around a point mass would be a cone.[1] More important, though, I experienced the rare, gratifying wonder of making a scientific discovery. The results of our calculations were neither obvious nor insignificant. They revealed something that was both true and surprising, true and beautiful.

In all the years since then, as I've worked as a researcher, science journalist, magazine editor, and novelist, I've been obsessed with non-trivial cosmic truths. How did the universe start, and how will it end? What are the most fundamental laws of physics, and how did they arise? And do those laws show any sign that the universe has a plan, a purpose? I didn't expect to see all those mysteries resolved in my lifetime, but I assumed that scientists would come closer to the answers. Recently, however, physicists have hit a few stumbling blocks. The universe isn't giving up its secrets so easily.

In 1998 I joined the Board of Editors at *Scientific American*, where I oversaw the publication of articles written by some of the world's foremost researchers. That same year, astronomers redrew our picture of the cosmos by discovering that supernovas in distant galaxies were farther away than they'd expected. Their theories had predicted that the expansion of the universe should've slowed down over its 14-billion-year history due to the combined gravity of all its matter, but the supernova results showed just the opposite. The cosmic expansion is actually accelerating.

In an attempt to explain the findings, theorists proposed that an entity called dark energy pervades the universe with a repulsive force that works against gravity. But they could only guess what dark energy is: An inherent property of empty space? A type of dynamic field that's remodeling the universe? And over the past two decades, they haven't come much closer to figuring it out. There's been a similar lack of progress in identifying the nature of dark matter, the unknown substance whose gravity seems to hold galaxies and galactic clusters together. The physicists' ignorance is especially embarrassing

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[1] For more details, see "General Relativity in a (2 + 1)-Dimensional Space-Time," J. Richard Gott III and Mark Alpert, *General Relativity and Gravitation*, March 1984, Vol. 16, Issue 3, pp. 243–247 (https://link.springer.com/article/10.1007/BF00762539).

because dark energy seems to constitute 68 percent of the universe's energy content, and dark matter comprises another 27 percent. The total amount of ordinary matter—all the stars, planets, gas clouds, and so on—accounts for only 5 percent. In other words, we understand just a tiny sliver of the cosmos.

Researchers have tried to find answers using the tools of particle physics, but those efforts have fallen short. The Standard Model of particle physics, which is a type of quantum field theory, describes all the known elementary particles and explains three of the four known fundamental forces (electromagnetism and the strong and weak nuclear forces). But it can't explain gravity. Quantum theory, which does an excellent job of describing how particles and forces interact at the atomic and subatomic scales, is mathematically incompatible with general relativity, which explains large-scale phenomena such as galaxies and gravity.

Starting in the 1970s, physicists attempted to merge these two disciplines by developing a theory of quantum gravity that would describe the gravitational force at the smallest scales and highest energies. The most prominent effort involved reimagining the elementary particles as vibrating strings. Dubbed string theory, this project advanced rapidly in the 1980s. The big advantage of string theory is its potential ability to describe *all* particles and forces as different manifestations of a fundamental one-dimensional object, a string that is infinitely slender and only 10^{-35} meter long (that is, about a trillionth of a trillionth of a trillionth of a meter). A closed string—that is, a minuscule loop—would have the properties of a graviton, the hypothesized carrier of the gravitational force. An open string, with two endpoints, could describe any of the other particles, depending on its mode of vibration; a string vibrating in one type of pattern would be an electron, for example, and strings vibrating in other patterns would be quarks, photons, neutrinos, and so on.

String theory, though, has big disadvantages too. To generate all those particles and forces, the infinitesimal strings must vibrate in nine spatial dimensions, six more than the number we've observed in our (3 + 1)-dimensional universe. String theorists deal with this discrepancy by postulating that the extra dimensions are curled up into manifolds too microscopic to be observed, like the tiny curls of fabric in a seemingly flat carpet. But when physicists tried to derive equations and predictions using this approach, it proved to be hideously complex. Instead of discovering a unique Theory of Everything, they developed five intriguing but incomplete theories. In each theory, moreover, there's a huge number of ways to fold up the extra dimensions. And because the shape of each possible manifold would determine the properties of all the strings vibrating within it, the theory allows for a vast array of possible universes instead of specifically describing the universe we inhabit.

In the 1990s researchers proposed that all the ten-dimensional string theories were part of an eleven-dimensional framework called M-theory. (The M stands for mystery, magic, or membrane, depending on whom you ask.) But M-theory is maddeningly sketchy. So far, it hasn't yielded any equations describing our universe, much less any predictions. Physicists have focused instead on studying the "string landscape," the collection of all the universes that can be created by varying the theory's parameters.

This landscape is immense. Estimates of the number of theoretical possibilities range as high as $10^{272,000}$. What's more, each possible universe in the landscape could be just as real as our own. According to the theory of inflation, which cosmologists developed to explain the origins of the Big Bang, a swiftly expanding proto-universe not only gave rise to our cosmos, but it might be perpetually generating other universes as well, like bubbles in boiling water. Each universe in this so-called multiverse might have radically different physical laws and constants, perhaps dictated by its position in the string landscape. The wild expansion of the multiverse would keep the bubble universes well separated, preventing us from ever visiting any of the other realms, but our bubble could've collided with another while they were forming, leaving an imprint on our cosmos that we might be able to detect.

Some scientists welcomed the multiverse concept because it would explain why so many of the physical constants in our universe seem to be fine-tuned—that is, their values are within the ranges that allow for the creation of stars, planets, and life. If, for example, the fine-structure constant (which specifies the strength of the electromagnetic force) were much larger, atoms couldn't form; if it were much smaller, stars couldn't shine. This fine-tuning unsettles many physicists because it seems to imply that either the universe was designed to support life, or we are the lucky beneficiaries of an unlikely cosmic accident. But if a multiverse truly exists, and if each universe in the vast landscape has a different set of physical constants, then it would be no surprise to find ourselves in one of the few universes suited for life, because no observers would ever evolve in the less hospitable universes.

Other physicists, however, believe the multiverse idea is unscientific, because it probably can't be tested. If no other universes ever collided with ours, how can we prove they exist? Furthermore, some researchers have recently proposed that string theory can't predict a universe like ours—a cosmos expanding at an accelerating rate—because those kinds of theoretical possibilities are logically inconsistent. (This proposal has been called the swampland conjecture, since it posits that our universe lies in a mucky, nonviable part of the string landscape.) And other physicists are reluctant to give up their long-held dreams of a unique Theory of Everything. They still yearn to explain gravity, quantum fields, and all the physical constants as the inevitable consequences of a beautiful, unified theory that can be expressed as a set of solvable, testable equations.

Could string theory or M-theory ultimately lead us to this putative Theory of Everything? String theorists had expected to find support for their approach in the recent experiments conducted at the Large Hadron Collider (LHC), the world's most powerful particle accelerator, a 27-kilometer underground ring that straddles the border between France and Switzerland. Starting in 2009, researchers at the LHC accelerated beams of protons around the giant ring and smashed them together at velocities very close to the speed of light, producing collisions with energies as high as 13 trillion electron volts (TeV). The debris from the high-energy proton impacts can reveal the existence of new particles; in 2012, for example, LHC researchers detected the Higgs boson, which was the last particle predicted by the Standard Model to be discovered.

But the great hope of the string theorists was that the LHC would also reveal supersymmetric particles. String theory is built upon the principle of supersymmetry, which stipulates that every particle described in the Standard Model must have a heavier partner. If string theory is indeed a correct description of the universe, those superpartner particles must exist. So far, though, LHC researchers have found no evidence of the superpartners in the collision debris. This negative result doesn't necessarily mean that the supersymmetric particles don't exist; they may be so massive that the proton collisions in the LHC aren't energetic enough to produce them. The findings, however, have ruled out the simplest and most elegant versions of supersymmetry, and the prospects of string theory seem dimmer as a result.

What makes physicists even more worried is that they're not getting enough experimental data to guide the development of their theories. Conducting experiments that gather new information about fundamental physics—discoveries about particles, forces, cosmology, and space-time—is growing more difficult and expensive. It cost $8 billion to build the LHC, and constructing a next-generation collider that could search for particles at higher energies could cost three times as much. In a way, physics is a victim of its own success: all the easy experiments have already been done. Gaining new knowledge will require bigger tools and cleverer studies.

And even if the scientific community somehow finds the money to build a 100-kilometer accelerator ring that could produce proton collisions with energies up to 100 TeV, there's no guarantee that those experiments will reveal new phenomena. The supersymmetric particles, if they exist, might well be more massive than 100 TeV, in which case the next-generation collider would fail to discover them. To thoroughly plumb the details of fundamental physics, researchers would have to produce collisions that approach the Planck energy, which would bend space-time violently enough to reveal the effects of quantum gravity. The Planck energy, however, is about *a quadrillion times higher* than the LHC's collision energies. Reaching that threshold would require a particle collider the size of the Milky Way galaxy.

Fortunately, there's another way to catch a glimpse of Planckian physics. In the first moments of the Big Bang, matter and energy were so compressed that quantum gravity might have influenced the early history of the universe. In particular, it might've left an imprint on the cosmic microwave background (CMB), the radiation emitted when the first hydrogen atoms formed and the universe turned transparent, which occurred 380,000 years after the Big Bang started. New telescopes are trying to detect a special kind of polarization of the CMB—called B-mode—which would indicate the presence of gravitational waves produced by the hypothesized process of inflation. Earlier searches for this CMB polarization (notably, the BICEP2 results reported in 2014) were marred by stray microwaves reradiated by galactic dust, but the newer observatories might detect the subtle cosmic signals hiding amidst the noise. If not, perhaps the primordial gravitational waves could be revealed by the Laser Interferometer Space Antenna, a proposed space-based detector scheduled to be launched in the 2030s.

Other clues to fundamental physics might come from ongoing studies of dark energy, the mysterious entity that seems to be speeding up the expansion of the universe. Astronomers are carefully measuring the spatial distribution of galaxies and galactic clusters to determine how the rate of cosmic expansion has varied over the past 14 billion years. More precise measurements of distances and redshifts will come from planned space telescopes such as Euclid and WFIRST. Investigations of dark energy and dark matter might indicate that gravity works differently at galactic distances than it does at smaller scales. If that's true, scientists will need to revise the general theory of relativity.

Until those experimental results come in, however, physicists may have to endure a long period of uncertainty and stasis. Although string theorists continue to propose new ideas, and other researchers are working on alternative approaches—loop quantum gravity, asymptotically safe gravity, causal dynamical triangulations, and so on—the search for a fundamental theory will be difficult without guidance from new data. How can scientists decide if a theory is worth pursuing if they don't have enough facts to prove it right or wrong? And here's the nightmare scenario for fundamental physics: what if certain crucial facts are simply unattainable?

In the absence of experimental data, some theorists appear to be using dubious criteria when choosing which theories to work on. Sabine Hossenfelder, a research fellow at the Frankfurt Institute for Advanced Studies, notes that many physicists have a bias against theories that seem to have unlikely numerical coincidences. For example, some theorists believe the Standard Model is "ugly" because it requires the near-cancellation of two very large and almost equal parameters to calculate the mass of the Higgs boson. But in her recent book, *Lost in Math: How Beauty Leads Physics Astray*, Hossenfelder points out that you can't say the Standard Model's parameters are unlikely if you don't know their probability distribution. She argues that the general preference for "natural" theories that have no awkward-looking terms is really an aesthetic choice. Physicists want to work on beautiful theories, but beautiful ideas aren't always correct.

Beauty is in the eye of the beholder, of course, and our appreciation of it is linked to our sense of wonder. So I would go a step further than Hossenfelder and declare that a more primitive instinct is motivating physicists to construct elaborate mathematical frameworks that may have little or no connection to the real world. Although most scientists would hotly dispute this characterization, they seem to be searching for divine order in a messy universe.

* * *

I should make it clear at this point that I have no religious agenda. I'm not a believer. I'm not a committed atheist either. When I worked as a researcher and a science journalist, my job was ferreting out the truth, no matter where it led. *Scientific American* was especially diligent about exposing the falsehoods of "Intelligent Design" proponents who claimed to see God's hand in the fashioning of complex biological structures such as the human eye and the bacterial flagellum. In 2002 we published "15 Answers to Creationist Nonsense," which demolished the unscientific arguments against evolution and became one of the most widely shared articles in the magazine's history.

But after ten years as an editor at *Scientific American*, I stepped away from journalism and started writing fiction. I wrote novels about physics and Albert Einstein and quantum theory. And though I'm not a big fan of organized religion (and my position on the moral spectrum is definitely below average), ideas about God keep popping up in my books.

I've been inspired by Flannery O'Connor, the Georgia-born, mid-twentieth-century author famous for her Southern Gothic fiction and her fixation on religious themes. In her short story, "A Good Man is Hard to Find," O'Connor focuses on the Misfit, a murderer who escapes from prison and encounters an ordinary (but very dysfunctional) family of tourists on a lonely country road. While the Misfit's henchmen escort the family members into the woods, one by one, to be executed, the family's grandmother pleads for her life by appealing to the criminal's belief in Jesus. "Pray!" she cries. "Jesus, you ought not to shoot a lady." The Misfit, though, is unmoved. He seems troubled by the possibility that God exists, but he says he wouldn't change his ways unless he personally witnessed Jesus raise the dead. "I wisht I had of been there," he says. "If I had of been there I would of known and I wouldn't be like I am now." Then he shoots the grandmother three times in the chest and starts to clean his glasses.

Like the Misfit, scientists yearn for hard facts about mysterious phenomena. But should they even try to answer questions about the purpose of the universe? Most researchers operate under the assumption that science and religion are completely separate fields—or, in the phrase coined by evolutionary biologist Stephen Jay Gould, "non-overlapping magisteria." According to this premise, the tools of science can't answer questions of faith, and religious beliefs shouldn't influence the scientific method. But as physicists investigate the most fundamental characteristics of nature, they're tackling issues that have long been the province of philosophers and theologians: Is the universe infinite and eternal? Why does it seem to follow mathematical laws, and are those laws inevitable? And, perhaps most important, why does the universe exist? Why is there *something* instead of *nothing*?

These questions are similar to the ones that medieval philosopher St. Thomas Aquinas tried to resolve in the thirteenth century. In his book *Summa Theologica*, Aquinas presented five arguments for God's existence, which he called the Five Ways. In his first argument, he observed that all worldly objects can change from potential to actuality—an ice cube can melt, a child can grow—but the cause of that change must be something besides that object (warm air melts the ice cube, food nourishes the child). The history of the universe can thus be seen as an endless chain of changes, but Aquinas argued that there must be some transcendent entity that initiated the chain, something that is itself unchanging and already possesses all the properties that worldly objects can come to possess. In his second argument, he claimed that this entity must be eternal; because it is the root of all causes, nothing else could've caused it. And in the third argument, Aquinas added that unlike all worldly objects, which may or may not come into existence, the transcendent entity is necessary—it *must* exist.

Aquinas defined that entity as God. Over the following centuries this line of reasoning came to be known as the cosmological argument, and many philosophers elaborated on it. In the late seventeenth century, German philosopher Gottfried Leibniz was the first to explicitly ask, "Why is there something instead of nothing?" To answer the question, he proposed the principle of sufficient reason, which states that there must be a reasonable explanation for every entity and phenomenon in the universe, but the ultimate and sufficient reason for all worldly things must lie outside the long succession of contingent causes and events. According to Leibniz, this ultimate reason is God, whom he described as "the necessary being which has in itself the reason for its existence." It's interesting to note that Leibniz was also a mathematician and physicist; in fact, he invented differential and integral calculus at about the same time that Isaac Newton did. (They developed the math independently.) Both Leibniz and Newton considered themselves natural philosophers, and they freely jumped back and forth between science and theology.

By the twentieth century, most scientists no longer devised proofs of God's existence, but the connection between physics and faith hadn't been entirely severed. Einstein, who frequently wrote and spoke about religion, didn't believe in a personal God who influences history or human behavior, but he wasn't an atheist either. (I'm focusing on Einstein because I wrote a novel about him. I've internalized his point of view.[2]) He preferred to call himself agnostic, although he sometimes leaned toward the pantheism of Jewish-Dutch philosopher Baruch Spinoza, who proclaimed in the seventeenth century that God is identical with nature. Likewise, Einstein compared the human race to a small child in a library full of books written in unfamiliar languages: "The child notes a definite plan in the arrangement of the books, a mysterious order, which it does not comprehend, but only dimly suspects. That, it seems to me, is the attitude of the human mind, even the greatest and most cultured, toward God. We see a universe marvelously arranged, obeying certain laws, but we understand the laws only dimly."

Einstein often invoked God when he talked about physics. In 1919, after British scientists confirmed Einstein's general theory of relativity by detecting the bending of starlight around the sun, he was asked how he would've reacted if the researchers hadn't found the supporting evidence. "Then I would have felt sorry for the dear Lord," Einstein said. "The theory is correct." His attitude was a strange mix of humility and arrogance. He was clearly awed by the

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[2] *Final Theory*, Mark Alpert (Simon & Schuster, 2008).

laws of physics and grateful that they were mathematically decipherable. ("The eternal mystery of the world is its comprehensibility…The fact that it is comprehensible is a miracle.") But during the 1930s he fiercely opposed the emerging field of quantum mechanics because it clashed with his firm beliefs about the universe.

Einstein assumed that the world is deterministic—that is, physical actions always have predictable effects. Quantum theory, though, doesn't make exact predictions about particle interactions. The theory describes every particle as a wave function, which doesn't specify the quantum state of the particle; instead it provides a distribution of probabilities for the particle's position, momentum, and other observable properties. So theorists, for example, can predict the chance that an interaction such as radioactive decay will happen within a certain amount of time, but they can't predict exactly when a particular atom will decay. Einstein famously criticized the indeterminacy of quantum theory by saying, "God does not play dice with the universe." (Niels Bohr, the father of quantum mechanics, famously replied, "Einstein, stop telling God what to do.")

Although quantum theory is now the foundation of particle physics, many scientists still share Einstein's discomfort with its implications. According to the wave-function formulas, a particle can be in more than one quantum state at the same time—its spin, for example, can be oriented upward and downward simultaneously. But this so-called superposition only lasts until an observer measures the particle's properties. In that instant, the wave function "collapses" to a single state; the particle's spin, for example, becomes oriented either upward or downward. (Measurements can also clarify the particle's position and momentum, but only within the limits of the uncertainty principle, which states that both properties can't be precisely known at the same time.) The theory thus incorporates observers into its framework, because they play an important role in quantum processes. But how would the theory work in a universe without observers? And how exactly does the act of observation change the physical state of a particle?

Bohr and other physicists dodged these questions by arguing that a more complete, deterministic description of particles might not be possible. In their view, which is often called the Copenhagen interpretation, quantum theory explains our observations of the subatomic world without detailing all its inner workings, and this explanation might be the best we can hope for. And because the quantum formulas calculate the probabilities of particle interactions so well, many physicists urged their skeptical colleagues to simply "shut up and calculate." But other researchers sought different explanations, hoping to shore up the logical foundations of quantum theory or perhaps discover a more fundamental framework beneath it. Hugh Everett, for example, proposed the many-worlds interpretation, which claims that the wave function doesn't collapse at the moment of observation; instead, each possible outcome of a particle measurement occurs in an alternate reality. In our world, we detect that the particle's spin is pointing up, but at that moment another reality splits off from ours, and in that world our alternate selves detect that the particle's spin is pointing down.

And there are many more examples of quantum weirdness. Physicists can put two particles in a state of quantum entanglement, which forces the properties of one particle to correlate with those of the other. In an entangled pair of electrons, for instance, if one particle is in a superposition of two spin states (say, up/down), then the other particle must be in the complementary superposition (down/up). This correlation will persist as long as neither electron interacts with its environment, even if the researchers separate the entangled particles by thousands of kilometers. But if an observer measures the spin of one particle and its wave function collapses to the up-spin state, then the wave function of the other particle will collapse to the down-spin state *instantaneously*. This violates the principle of locality—how can the effects of a physical event travel across the universe faster than the speed of light? Somehow, quantum entanglement can create a direct connection between far-flung parts of the cosmos. Einstein derisively called it "spooky action at a distance," but many experiments have demonstrated the phenomenon.

In short, physicists have revealed aspects of nature that seem supernatural. We live in a universe where the act of observing something can alter its reality, and where distant pieces of space-time can be woven together. Its laws are eerily mathematical, but when we try to apply them to certain situations (small scales, high energies) the equations sometimes yield nonsensical infinities. Worse, those laws put some strict limits on what we can learn about the universe. We probably can't test the multiverse hypothesis or the many-worlds interpretation, because those parallel realms are unlikely to be observable. And here in our own corner of the cosmos, we can't peer inside black holes or view anything that lies beyond the distance that light has traveled since the start of the Big Bang. Despite centuries of scientific exploration, we still face confounding mysteries. I can't help but think of the traditional fisherman's prayer: "Oh God, thy sea is so great and my boat is so small!"

Is there a place in this universe for the causative God of Aquinas and Leibniz? Or maybe the more diffuse and impersonal God of Spinoza? Particle physicist Victor Stenger addressed this question in his 2007 book *God: The Failed Hypothesis*. (To make his position absolutely clear, he gave the book the subtitle "How Science Shows That God Does Not Exist.") Stenger quickly dismisses the theist notion of a God who responds to prayers and cures ill children, because scientists would've noticed that kind of divine intervention by now. Then he argues, less convincingly, against the existence of a deist God who created the universe and its laws and then stood back and watched it run.

Stenger claims that the fundamental parameters of the universe that determine the strengths of the forces and the masses of the particles aren't so fine-tuned after all. The physical constants, he says, could've been set at substantially different values and still allowed for a cosmos capable of supporting life. What's more, he contends that many laws of nature (such as the conservation of energy) follow inevitably from the observed symmetries of the universe (there's no special point or direction in space, for example). Other laws resulted from the spontaneous breaking of symmetries that prevailed during the explosive start of the Big Bang. Stenger concludes: "There is no reason why the laws of physics cannot have come from within the universe itself."

Explaining the creation of the universe is trickier, though. Cosmologists don't know if the universe even had a beginning; instead, it might've had an eternal past *before* the Big Bang, stretching infinitely backward in time. Some cosmological models propose that the universe has gone through endless cycles of expansion and contraction, and some versions of the theory of inflation postulate an eternal process in which new universes are forever branching off from the speedily expanding "inflationary background." But other cosmologists argue that inflation had to start somewhere, and the starting point could've been literally *nothing*. As we've learned from quantum theory, empty space isn't totally empty; the vacuum has energy—a small amount, but detectable—because it's always churning with virtual particles briefly popping in and out of existence. In other words, nothingness is unstable. Over a long stretch of time, all kinds of improbable things can happen in empty space, and one of them might've been a sudden drop to a lower vacuum energy, which would've triggered the exponential expansion. In the most mind-blowing example of quantum weirdness, a random fluctuation in a speck of primordial emptiness could've set off the furious growth of the multiverse.

For Stenger, this theoretical possibility is evidence that God isn't needed for Creation. "The natural state of affairs is something rather than nothing," he writes. "An empty universe requires supernatural intervention—not a full one." But this conclusion seems a bit hasty. Scientists don't fully comprehend the quantum world yet, and their hypotheses about the first moments of Creation aren't much more than guesses at this point. We need to discover and understand the fundamental laws of physics before we can say they're inevitable. And we need to explore the universe and its history a little more thoroughly before we can make such definitive statements about its origins.

Just for the sake of argument, though, let's assume that this hypothesis of Quantum Creation is correct. Suppose we do live in a universe that generated its own laws and called itself into being. Doesn't that sound a lot like Leibniz's description of God ("the necessary being which has in itself the reason for its existence")? It's also similar to Spinoza's pantheism, his proposition that the universe as a whole is God. Instead of proving that God doesn't exist, maybe science will broaden our definition of divinity. The Universal God might provide less solace than the traditional version does; there's no love or goodness in the new definition, no place for immortal souls or a metaphysical afterlife. Pantheism, however, might offer its own benefits. If we treated every part of our planet as a manifestation of God—every person, animal, forest, and river—then perhaps we wouldn't be so quick to ravage our environment and our fellow humans.

But let's not get ahead of ourselves. If we truly want to contribute to humanity's search for meaning, we should prioritize the funding of advanced telescopes, detectors and other scientific instruments that can provide the desperately needed empirical data about particles, forces, space-time, and the history of the universe. Once researchers have more facts to analyze, they're bound to find more clues to fundamental physics. And until the new observations come in, I believe the priority for theorists should be to rethink the logic behind quantum theory. Are its assumptions sound? Are alternative formulations possible? Reexamining these foundational questions might help resolve some of the troubles confronting string theory, which is based on quantum principles.

Maybe this effort will lead to breakthroughs in theology as well. The pivotal role of observers in quantum theory is very curious. Is it possible that the human race has a cosmic purpose after all? Did the universe blossom into an untold number of realities, each containing billions of galaxies and vast oceans of emptiness between them, just to produce a few scattered communities of observers? Is the ultimate goal of the universe to observe its own splendor?

Perhaps. We'll have to wait and see.

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In conclusion, it seems clear that the theologians haven't proved the existence of God, but the physicists haven't disproved it either. In a 1952 essay titled "Is There a God?" British philosopher Bertrand Russell argued that the burden of proof lies with the believers rather than the skeptics. Russell compared the God hypothesis with another claim that can't be proved false: that a china teapot might be floating in outer space, orbiting the sun between Earth and Mars. Because this hypothetical teapot would be too small to be spotted by any telescope, astronomers could never rule out its existence, and yet any reasonable person would dismiss the possibility. ("A teapot in space? How ridiculous! How would it get there?") Other philosophers have noted, however, that the analogy between God and the orbiting teapot is flawed. If God is a transcendent entity that lies beyond the realm of empirical detection, then faith in such a deity is very different from a belief in celestial chinaware.[3]

So, after hundreds of years of debate and scientific discoveries, there's still plenty of room for choice when it comes to religious beliefs. And that's the point I wanted to make when I wrote my novel *Saint Joan of New York*.

I used the Joan of Arc story as the framework for this book because it nicely dramatizes the conflict between faith and doubt. In the small French village of Domrémy in the early fifteenth century, a teenage peasant girl named Jeanne d'Arc told her family and friends that she'd had spiritual visitations from three key figures of medieval Christianity: Saint Margaret, Saint Catherine, and the archangel Michael. They'd spoken with her many times, she said, usually while she tended her family's flock of sheep. And they'd given Jeanne a holy mission: God had commanded her to anoint the French king and help him drive the English invaders out of the country. (France and England were fighting the Hundred Years' War, which was going very badly for France. The previous French king had gone mad and lost much of his kingdom to the English. His son, Charles VII—called the Dauphin because he hadn't been crowned yet—had retreated to central France and considered fleeing the country altogether.)

Now remember, this was the Middle Ages, and reports of divine visitation were taken much more seriously in those days. Nevertheless, most of Jeanne's neighbors in Domrémy must've thought she was insane.

But by 1428 she'd convinced her uncle to take her to the nearby town of Vaucouleurs to see Robert de Baudricourt, a military captain who could arrange safe passage to the French royal court. At first Baudricourt dismissed Jeanne and sent her back to Domrémy, but she kept returning to entreat him. In 1429 he finally relented, ordering his knights to escort her to the Dauphin. At the French court she won over Charles VII, who allowed her to join his army and fight the English soldiers besieging the city of Orléans. Inspired by Jeanne's piety and bravery in battle, the French troops lifted the siege and then won victory after victory against the English. Under her direction, the French

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[3] *Is God a Delusion?*, Eric Reitan (Wiley-Blackwell, 2008).

army marched in triumph to the cathedral city of Reims, where Charles VII was anointed with oil and crowned.

The obvious question is, how did she do it? In a matter of weeks an illiterate seventeen-year-old with no military training took control of an army. She mastered the skills of leadership, horsemanship, and medieval combat. (According to her fellow commanders, she was particularly expert at arranging the placement of cannons, which were relatively new to European warfare.) She clearly had some extraordinary qualities—intelligence, charisma, fortitude—but are they enough to explain her astounding success? And in 1431, after her enemies captured her in battle and put her on trial for heresy, where did she find the strength and cleverness to endure the many weeks of interrogation, not to mention her excruciating execution? If God wasn't guiding her, what was?

Of course, I'm not the first writer to reexamine this story. Mark Twain spent fourteen years researching and writing his novel *Personal Recollections of Joan of Arc*. George Bernard Shaw's play *Saint Joan* premiered in 1923, three years after the Catholic Church finally canonized her. (Joan's sainthood was delayed for several centuries, partly because the church worried about antagonizing the English.) Twain and Shaw had a wonderful resource to help them illuminate Joan's character: the preserved transcripts of the 1431 trial that sentenced her to death and the retrial that posthumously declared her innocent 25 years later. Thanks to those records, historians and writers know Joan better than they know almost anyone else who lived during the Middle Ages.

But I think I can safely say that I'm the first writer to reimagine Joan as a math prodigy. Instead of portraying a conflict between nations, I wanted to show a war of ideas, and fundamental physics has become a battleground in that war. Scientists are exploring the foundations of reality, and believers and atheists are analyzing the discoveries, looking for anything that can buttress their philosophical arguments. I saw Joan as a mediator in that conflict, someone who could bring the two sides together. As a result, there's a good chance that neither the religious nor the nonreligious will be satisfied with the story I've told. But that's okay. You can read it any way you want to.

The best argument for God's existence, I think, isn't in the Bible or any theological tract. It isn't in any work of science or philosophy either. It's in Yann Martel's novel *Life of Pi*. This book tells the improbable story of Pi Patel, a religious young man who survives a shipwreck and floats across the Pacific Ocean in a lifeboat he shares with a Bengal tiger. When he finally reaches land, the tiger disappears into the jungle, and when Pi is questioned about the shipwreck, he explains how he managed to live in close quarters with a man-eating predator for seven months. His interrogators are understandably skeptical of his tale, so after some prodding he gives them an alternative story of the shipwreck. This account is more gruesome than the first story, but also more believable, because it omits the tiger. Seeing that his questioners are now satisfied, Pi asks them which is the better story, the one with the tiger or the one without it. The interrogators admit that the first story is better. Pi responds, “And so it goes with God.”

What about the Joan of Arc story? Is it more interesting to imagine that God inspired and sustained her, or that Joan herself dreamed up a glorious plan and pursued it with every ounce of her will, changing history in the process? Does God make the story better or worse?

I’ll leave it for you to decide.

Saint Joan of New York

A Novel About God and String Theory

Part One: The Magic Number

Chapter One

I'll start at the beginning, okay? My name is Joan Cooper, and I'm seventeen years old. I'm going to tell you about the first time I saw God.

It happened last October, on a Saturday afternoon. I was in the Bronx, running in the biggest race of the cross-country track season, the city championship for New York's high schools. And I was doing great, even better than I'd hoped. I sprinted down the trail through the woods of Van Cortlandt Park, way ahead of all the other girls on the five-kilometer course. By the time I reached the halfway point, I had a fifty-yard lead on the pack behind me.

Seriously, I was killing it. I felt strong, pumped. But most of all, I felt relieved. The beginning of my senior year had been a nightmare. I hadn't smiled in months. But now I was practically laughing as I charged up and down the wooded hills. I knew I was going to win the race, and winning still felt good.

That's when I saw the Lord Almighty, although I didn't realize at the time that I was looking at the Creator. I thought I saw a fallen runner, a puny African-American boy who'd collapsed on the trail.

He was at the bottom of the course's steepest hill, a hundred feet ahead. The boy lay facedown on the edge of the trail, half-on and half-off the path, his skinny legs splayed across the mud and dead leaves. He wore a team uniform—bright red shorts and a sleeveless track shirt—so I assumed he was one of the runners in the Boys Junior Varsity race, which had started twenty

M. Alpert, *Saint Joan of New York*, Science and Fiction,
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