An elegant multiverse? Professor Brian Greene considers the possibilities

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You might think it's hard to have a conversation with theoretical physicist Brian Greene. His research specialty is superstring theory, the hypothesis that everything in the universe is made up of miniscule, vibrating strands of energy. Luckily for an interviewer, Greene has a knack for explaining difficult concepts to non-scientists.

His first book, the best-selling The Elegant Universe, which explains the quest to unify all the laws of nature, was a finalist for the Pulitzer Prize and led to an award-winning PBS series. He is a co-founder of the World Science Festival, an annual event in June whose aim is to make "the esoteric understandable and the familiar fascinating," which pretty much sums up Greene's modus operandi.

"Science is a living, breathing, exciting, evolving subject," he says. "A large part of my motivation in reaching out to a general audience is to show people that science is not this finished subject where all of the results are in these thick textbooks that you lug around when you're taking a science course."

Greene, 48, grew up on the Upper West Side and spent many a rainy day at the Hayden Planetarium, when it was a dark and musty place and not the shiny glass cube it is today. "That definitely played a part in my excitement for these ideas." But it was the pure beauty of mathematics that really grabbed him.

"As a kid I was playing with numbers all the time," he says. "And when I learned that those numbers could be more than a game, those numbers could actually describe stuff that was out there in the real world, that's when I was hooked for good."

His latest book, The Hidden Reality, explores another mystery: whether there are other universes beyond ours.

Q. Your new book talks about the concept of a multiverse. Can you explain what that means?

When we hear the word "universe," we think that means everything: every star, every galaxy, everything that exists. But in physics, we've come upon the possibility that what we've long thought to be everything may actually only be a small part of something that is much, much bigger. The word "multiverse" refers to that bigger expanse, the new totality of reality, and our universe would be just a piece of that larger whole.

Q. So what kinds of other worlds might there be?

Scientists have many proposals. In some, the other universes have the same laws of physics and the same particles making up matter. So except perhaps for some environmental differences, pretty much what we see here is what happens there. In some multiverse proposals, the other universes could be radically different from what we know, the particles could be different, the laws of physics could appear different. And in others—ones that frankly don't compel me—even the kinds of mathematics that govern the physics in those realms might be different from the math that we are familiar with.

Q. Do you think that one of the multiverse theories

will be proven in your lifetime?

You never know when that big breakthrough is going to happen. I could come to work tomorrow, go to the website that posts all of the physics papers that people completed in the previous day, and there could be the paper that shows how to test string theory, or how to test some of these multiverse proposals. Could it be tomorrow? Could it be 10 years from now, or a hundred years? That's part of what the excitement is.

Q. Do you have a favorite among the theories?

All of the ideas are compelling and come from a sober assessment of certain mathematical developments. Which do I think has a chance of being experimentally verified in the next few decades or within our lifetime? I would suggest the brane multiverse, in which our universe is envisioned to reside on a giant membrane, an ingredient that comes out of string theory. It's actually a three-dimensional membrane, but thinking in two-dimensional terms is easier. Think of our universe as if it were a huge slice of bread, with all the stars and all the galaxies sprinkled across its surface. The math of string theory suggests this picture, along with the possibility that there are other universes, other slices of bread, all constituting a big cosmic loaf. This is an idea that might be testable at the Large Hadron Collider, the big accelerator in Geneva, where protons are slammed against each other at fantastically high velocity. Calculations show that some of the debris created in those collisions might be ejected off our universe, off our slice of bread, and if so, that debris would carry away some energy. Scientists will look for these missing energy signatures for evidence that we live on one of these membranes and that there are other membranes out there.

Q. How does string theory research tie in with Einstein's search for a unified theory?

Einstein's goal was to find what he called a unified theory of physics. By that he meant a theory that might embrace all the known laws of physics and describe them within a single mathematical framework. He didn't find the unified theory, and since his day we've recognized that in some ways the problem is even more difficult than he envisioned. He was really only aware of the force of gravity and the electromagnetic force. We now know about the strong nuclear force and the weak nuclear force, operating inside of atoms according to the rules of quantum mechanics. We believe string theory may be the unified theory that Einstein was looking for. It unites quantum mechanics and gravity, and has the capacity to embrace the strong nuclear force, the weak nuclear force, the electromagnetic force, all the particles of matter in one coherent mathematical structure.

Q. What would you say is the biggest misconception people have about physics?

One significant difficulty people have is in understanding how mathematics gives rise to these strange ideas. You need to realize that when we physicists look out in the universe, we see patterns, we see repetitive phenomena, and math is the language of pattern. When you teach little kids to count by twos, and they can keep on going, they see the pattern. Just as the little kid can say, "Oh, after 10, it's 12," we can look at our mathematics and say, "Look, after that universe, there's another." We can see it in the pattern encapsulated in the mathematics.

Q. Can you provide examples of how string theory could be tested?

The full name of string theory is superstring theory. The "super" refers to something known as supersymmetry, a kind of mathematical pattern which implies there should be a whole class of particles, called supersymmetric particles, that we have not yet seen. The Large Hadron Collider may have enough energy in its collisions to conjure up those particles. If they're found, will it prove string theory? No, but it will be a strong piece of circumstantial evidence. Another way of testing string theory could be seeing if the collisions produce microscopic black holes. When people first heard about this possibility back in 2008, it generated some degree of public anxiety—the thought being that these black holes might swallow Geneva and then engulf the world—which is not a real worry at all. But string theory does suggest that in these collisions, little black holes might be formed. If they are, again you have a piece of circumstantial evidence. The missing energy experiments I mentioned before are also worth adding to the list—these experiments could test for the existence of extra dimensions and string theory's brane model of our universe.

Q. Are these theories applicable in the real world? If true, could they affect everyday life in some meaningful way?

What if I were to ask you, What is the concrete application of Beethoven's Fifth Symphony? Or the Mona Lisa? Or the works of James Joyce? It's a little hard to find concrete applications. But do they enrich life, are they part of what makes us excited to get up in the morning? Yes. I think these ideas in physics can paint a large view of reality that allows us to place our piece of it in a much grander context. And that's deeply enriching. Let me also note this: If, 80 years ago, you had asked Niels Bohr, "Niels, this quantum mechanics stuff that you guys are going on about, what's it good for?" he probably would have said, "Well, it's not really going to change everyday life. We're talking about atoms and subatomic particles." But now we've harnessed the understanding of quantum mechanics, and because of that, you have a cell phone and a personal computer and your life may be saved by an MRI machine.

Quantum physics gave rise to the integrated circuit, and the integrated circuit is in all of these devices, which is just to say that you don't know where basic research is going to lead. It may take 80 years, as with quantum mechanics; it may take 500 years; but when you deeply understand something, you can begin to manipulate the environment in ways that can revolutionize everyday life.

Q. How do you feel about the general attitude toward science?

In the broader public, there is significant resistance to engaging with science. This is largely due to the way that many have encountered science in the classroom, where there's a tendency to focus on details without an equal focus on the big, wondrous scientific ideas—the very ideas that can inspire passionate interest in learning those details. We need to embark on a radical cultural shift in which science takes its rightful place alongside music, art, theater and literature as an absolutely indispensible part of a full life. We need to make clear that science is not something that you can willfully ignore. All of the major decisions going forward, from stem cells to nuclear proliferation to nanotechnology to genetically modified food to alternative energy sources to climate change, have a scientific component. How can you be part of a democracy if you can't participate in the discussion about these ideas?

Provided by Columbia University

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