



The Observer

Interview

Physicist Brian Greene: 'Factual information is not the right yardstick for religion'

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Sat 8 Feb 2020 16:01 GMT

Brian Greene, 56, is director of Columbia University's centre for theoretical physics. His work on string theory has focused on the forms that extra dimensions may take. His latest book is *Until the End of Time: Mind, Matter and Our Search for Meaning in an Evolving Universe*.

What got you into physics?

As a kid I had the same kinds of questions that most kids struggle with at one time or another: why am I here, how did I come to be here, is there a purpose to it all? I remember thinking that if there was an answer I would know it, because everyone would know it. But no one did. So it struck me that seeking an answer to those questions was unlikely to yield anything deeply interesting. Instead, I got interested in the context: not why am I here, but how did I come to be here? Not why is there a universe, but how did it come to be? And those questions take you to the heart of physics.

When you were a student, a gas oven exploded in your face when you tried to cook a pizza. Did it have any impact on your life as a scientist?

It was the last experiment I ever did, and an unwitting experiment at that. I don't touch equipment. I'm a theorist through and through: pens, paper, pencils, computers. Even when I was in college, I somehow managed to slip through the requirement that students had to take a laboratory course. I found a way of getting out of it. No doubt, the exploding oven was looming in the background.

Expertise has come under attack in the US and the UK in recent years. Should we be worried?

There are questions that have right and wrong answers as opposed to opinions, and we've unfortunately come to a place where many people don't make that distinction. It's a vital one, especially when some of the questions are going to determine the fate of humankind and the fate of the planet. The solution has to be education. We need to impress upon kids at an early age that there are ways of investigating the world that can yield demonstrable truths. That's an exciting thing for a kid to learn. And it's essential.

Physicists are vying to build a new particle collider to supersede the Large Hadron Collider. Who should host it?

China is the likely place for it to be built, but it has to be a group of countries coming together. I'd like to think it doesn't matter in

Physicist Brian Greene: 'Factual information is not the right yardstick f... <https://www.theguardian.com/science/2020/feb/06/brian-greene-theoret..> which country it's built, because it'll be a machine for all humanity. Science is this beautiful place, perhaps the sole place, where the world comes together to work shoulder-to-shoulder on questions that transcend national borders, and that's a powerful thing. Is there a fifth force? Are there other particles? Is there an explanation for why matter particles have the properties they do? In other words, is there an explanation for why reality has the properties that it does? These are the kinds of universal questions the next machine can help us answer.

If you had a time machine, where and when would you go?

I would go forwards instead of backwards, which is a good thing because I don't think you can go backwards and I know for a fact that you can go forwards. Hanging out near the edge of a black hole is a popular technique. You spend a year near the edge and if you are close enough, you come back and it will be a billion years later. Or you go out on a rocket ship near the speed of light for six months, and turn around and come back, and depending on how close to the speed of light you travelled, when you return it'll be thousands or millions or billions of years into the future. So we know how to time travel in theory, we just don't know how to execute it in practice. I would go as far forward as the device allowed me to, because once I got there, I could always read about what happened beforehand. I would want to be in an era when there are still planets and stars. I would probably not go beyond a trillion years from now. It would be very lonely though. I would only do it if I could take my family.

In your book, you talk about the rising disorder - the increasing entropy - of the universe, and how that shapes its future. If the universe is becoming more and more disordered, why do stars, planets and people form?

This is absolutely fundamental. The beauty of the second law of thermodynamics is that while it stipulates that the overall amount of disorder has to increase, little pockets of order can form so long as, in the process, they create enough disorder in the surrounding environment to compensate. For stars and planets, we can establish that the formation process discards enough waste and disorder to the surrounding environment that the overall disorder goes up. Indeed, we humans are contraptions that squeeze out the disorder that is locked inside of matter. We eat things, we breathe, and when we metabolise all that we take in, we use it to create our internal order, to grow bigger, stronger and so forth, but in the process we release enough heat and waste so that the overall disorder balance sheet is totally in the direction of disorder.

// Life and mind are fleeting phenomena on the cosmic timeline... we have each been given a precious opportunity

What big problem would you like to see solved in your lifetime?

The nature of time. Where did time come from? Is there a realm of reality where there isn't any notion of time? Is time fundamental or does it only emerge in certain environments? These are the kinds of questions that, were we to gain insight before I move on to whatever realm awaits, which is probably nothing, would be deeply satisfying.

As someone who contemplates the origins and ends of the universe, how important is it to see the night sky?

These days in Manhattan, on the clearest of nights, you can see about three stars. It may sound naive, but it feels to me that if more people nightly experienced a brilliant sky full of stars, in some small way it would make the world a better place. It would make the world a place where we'd recognise we're part of a much grander whole. We are heading in a direction where fewer and fewer members of the species will have that experience.

In your book, you talk about the "majesty of religion". What do you mean by that?

There's a tendency, certainly among some scientists I know, to judge religion by whether or not it gives us factual information about an objective reality. That's not the right yardstick. There are many others who recognise that the value of religion is found in its capacity to provide a sense of community, to allow us to see our lives within a larger context, to connect us through ritual to our forebears, to alleviate anxiety in the face of mortality, among other thoroughly subjective benefits. When I'm looking to understand myself as a human, and how I fit in to the long chain of human culture that reaches back thousands of years, religion is a deeply valuable part of that story.

How big a part has music played in your life?

My dad was a composer and a singer. He dropped out of school early on to travel around the country as a singer-songwriter and later on as a vocal coach. That was a deep part of my upbringing. Music to me is the most direct route that we humans have to touching something that is powerfully beyond everyday experience. It allows the mind to move into a realm that's hard to get to, hard to reach, by any other means.

You mention in your book that we might be "Boltzmann brains" - fleeting aggregations of particles in space that happen to create the sense of being us. Does it keep you awake at night?

I don't worry in the sense of it giving me some kind of existential angst. I am confident that I am not a Boltzmann brain. However, we want our theories to similarly concur that we are not Boltzmann brains, but so far it has proved surprisingly difficult for them to do so. So, I see Boltzmann brains as a mathematical problem that we need to solve, as opposed to an existential affront. I believe it is a problem that we will one day overcome.

On a cosmic timescale, humanity will probably exist for the blink of an eye. If our species will one day die out, why should we strive to achieve?

As I discuss in the book, we have emerged from a vast sequence of quantum events stretching back to the big bang, every one of which could have turned out differently, resulting in a universe in which we did not exist. When you realise that, and when you realise too that life and mind are fleeting phenomena on the cosmic timeline, you realise that we should strive not in the service of leaving a lasting legacy, but rather because we have each been given an astoundingly unlikely, profoundly precious opportunity.

If people take away one thought from your book, what should it be?

That there is great value in understanding how we fit into the largest possible landscape, the longest possible timeline. Seeing how we and our species fit in between the big bang and the closest science can take us to the end of time is something that gives us deeply illuminating context. It allows us to see the human search for meaning and purpose in a different light, and with that to recognise that there is no ultimate answer hovering in the depths of space awaiting discovery. Instead, the context provided by the cosmological narrative frees us fully to develop our own, deeply and thoroughly subjective reasons for being.

Until the End of Time: Mind, Matter, and Our Search for Meaning in an Evolving Universe by Brian Greene is published by Penguin (£25). To order a copy go to guardianbookshop.com. Free UK p&p on all online books orders over £15.