3 Takeaways Podcast Transcript
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Ep 108: The Elegant Universe and Until The End of Time with Physicist Brian Greene

INTRO male voice: Welcome to the 3 Takeaways podcast, which features short memorable conversations with the world's best thinkers, business leaders, writers, politicians, scientists, and other newsmakers. Each episode ends with the three key takeaways that person has learned over their lives and their careers. And now your host and board member of schools at Harvard, Princeton and Columbia, Lynn Thoman.

Lynn Thoman: Hi everyone, it's Lynn Thoman, and welcome to another episode. Today, I'm excited to be with Brian Greene. Brian's a professor of physics and math at Columbia and co-founder of the World Science Festival. Brian is world-renowned for his discoveries in the field of string theory and also for his New York Times best-selling books, which include Until The End of Time and the Elegant Universe. He's pushed forward Einstein's ideas on space, time and our understanding of the universe. I'm excited to talk about the cutting edge with of science, including parallel universes, time travel, the Big Bang and riddles of reality, such as quantum entanglement. Welcome Brian, and thanks so much for our conversation today.

Brian Greene: Thank you. Pleasure pleased to be here.

LT: It is my pleasure. It's so interesting to me that our everyday experiences are so limited that they're not a good guide to how the world actually works, and that there's a tension between what we experience and the reality of the universe. Can you tell us about the hidden reality and how it differs from what we actually experience?

BG: Well, in differs in so many ways that it would actually take us probably longer than the duration of this entire conversation to fully canvas how our senses have misled us. But perhaps the deep point that's really worthy of emphasis is that we should have expected that our experiences would be a poor guide to the true nature of the world because our experiences are based on our senses, and our senses have been under evolutionary pressure not to understand the deep truth of reality, but rather to get us the next meal, to get us shelter that can protect us. So evolution has put pressure on our senses for one particular purpose, survival. And survival and the truth of reality are just two different things. And indeed, as we have been able to go beyond our senses, we've learned that space and time and matter and energy, they have qualities that are just different from what we would expect based upon our feeble perceptions, and that's really the story of science over the past 150 years.

LT: Can you give some specific examples?

BG: Quantum mechanics is probably the most dramatic break with what we would have anticipated, you look out into the world, and things travel along trajectories. In essence, what is reality from the standpoint of fundamental science, it's where things are and how they're moving. That's it really, that's the nuts and bolts of reality. Quantum mechanics has taught us, at least in the usual interpretation, that objects don't actually travel a long trajectories, there's a whole 'nother structure having to do with probabilities, where the best you can ever do according to quantum

mechanics is say there's a 10% chance of an object being in one location or another, or a 30% chance of it being in this location or that, that's completely counter to experience, we don't look out into the world and see a fuzzy haze of probabilities. We look out into the world and we see a definite reality where things occupy definite locations at different definite moments, and that we believe is an artifact of life at the particular scale that we humans inhabit. If we were to shrink our bodies down to a fraction of a millimeter, a tiny fraction, 10 to the minus 15 meters or something of that sort, we would recognize that the world is not what we thought it was based upon our experiences up here in the big world. The micro world is simply different from the macro world, and we don't experience that, and that's why it's so weird and unfamiliar.

LT: And you also believe that there are additional dimensions and parallel universes?

BG: Yeah, I certainly would not use the word believe in conjunction with those ideas. I would say that I find those ideas deeply intriguing, and I understand a mathematical set of ideas that takes us from what we have experimentally tested and observed through our most refined equipment, going from that through a series of mathematical links, does naturally take us to the possibility of say, other dimensions and other worlds. But it doesn't guarantee that those things exist, and I would consider those ideas to be deeply hypothetical among the most spectacular ideas that have emerged from modern science. So I'm hugely excited about these ideas, but there's a difference between being excited about something and saying it's true, or saying that you believe in it. And I think it's really important to draw the distinction between the two. I believe in things that are experimentally established, I believe in things that are observationally confirmed, and that's not the case with the either of those two wondrous ideas.

LT: How about the idea, or I should say the possibility that we are holograms?

BG: Yeah, it's another one of this his mind-boggling idea is that you'd say how in the world can science ever come to a potential conclusion like that? But when we studied esoteric objects, black holes in particular, we've found that to fully understand black holes where Nature led to the possibility that the three-dimensional world inside of a black hole is fully encapsulated by two-dimensional information that lives on the surface of the black hole.

BG: And then when we think about that deeply, we realize that there are resonances with the idea of a hologram. What's the hologram? It's a thin two-dimensional piece of plastic, which when you illuminate it correctly, yields a realistic three-dimensional image. So black holes may have this deep similarity with the holograms, and then the final step is, although we've come to this idea through studies of black holes, we recognize that the idea is naturally generalized to situations that don't involve a black hole at all. It could be that our three-dimensional world right now that we are experiencing in the way that we humans do may actually be completely equivalent to and perhaps more fundamentally described as information on a two-dimensional surface that bounds us perhaps at the edge of the observable universe, which would make us the holographic projection of that information living on that thin surface that surrounds us. And again, much as I mentioned before for extra dimensions and other universes, deeply intriguing idea at cutting edge of our mathematical investigations, but not yet at the level where we would say that we really think that this is true. Although as a footnote, it would say if the interview certain of my colleagues, I think they would be yet more bullish on this idea, and say, "Yeah, it's true." But I don't rise to that level because it hasn't in my mind received the necessary observational experimental support.

LT: There is another idea that is, that you can only predict the probability of an outcome, which you talked about, but the following ideas that every outcome happens, but they happen in distinct universes, and there is no certainty. Can you tell us about that?

BG: This does come from quantum mechanics, as I mentioned before, and it's a shocking idea because again, we grew up as a species in a world where things are definite, and there's a singular reality that we all experience, and basically the turn of the 20th century experimental results and theoretical developments began to pierce that view of the world. And at the end of that journey, frankly we're still developing it, but at the end of the first phase of that journey, which was a long time ago now, call it roughly 1930 or so. We realized that this quantum picture of the world is the one that nature abides by, and in this quantum world, you can only ever predict probabilities of things going one way or another, things turning out this way or that. And moreover, if you then go further and ask yourself, well, if there's a 50% chance that the electron is in my right hand and a 50% chance it's in my left hand, and let's say I do the observation and I find it in my right hand, what happened to the other possibility?

BG: And you might say, "Well, it just goes away." But the quantum math doesn't allow it to just go away, and so we've been struggling to figure out where it goes. And one possibility that comes to us from a brilliant physicist named Hugh Everett III, back in the 1950s, actually, he put forward the possibility that both outcomes do happen, but not in the same universe. One outcome, electron on my right hand happened, say in this universe, and another outcome, electron on my left hand takes place in another universe. And obviously an electron on my left or right hand is a pretty boring example, but now multiply that by every possibility allowed by the laws of physics. And understand he's saying that every possible outcome takes place, it just takes place in its own separate universe. So this incredible proliferation of realities that naturally emerges from this quantum world view. Now again, it's not the only way to interpret quantum mechanics. There will be folks you could talk to would say that is absolutely right, the many worlds interpretation is the right one, and there are others who will say, "No, no, we're not sold on that, we're still developing other ideas, other ideas have already been put forward." So again, intriguing, mind-blowing, but I would say not definitely correct.

LT: Okay. It used to be that we thought that what we see is the bulk of the universe, we now know that that's not the case, but how do you see space?

BG: We've learned that the familiar atoms and molecules that make up the familiar stuff in the world around us constitutes a tiny percentage of what the universe actually contains, and the bulk of what it contains, we've yet to identify, because we believe that it's dark, which means it doesn't give off light. If it's floating out there in space and it doesn't give off light, it's very hard to detect it, it's very hard to know what it is made of. And we have these names called dark matter and dark energy, which are in some sense euphemisms for those other stuff that we don't know what it is. And so we're struggling to figure out what that other stuff might be made of, there are a lot of ideas that have been put forward. There are a lot of experiments that are happening right now where people are trying to capture a particle of dark stuff so that we could examine it and figure out what exactly it is, this is a mystery that I think will be resolved one way or another, roughly in a decade or so. And it's just sobering to realize that however much we think we know by focusing upon electrons and quarks and atoms and molecules and the stuff that we have direct access to, we've only been dealing with a tiny part of a much larger reality. So it's deeply exciting regarding what that other stuff is, what we're going to find and what behavior that other stuff might be subject to.

LT: The images from the web telescope are gorgeous. How do you see them?

BG: Well, they're the beginnings of a new view of the cosmos. It's funny, I heard some NASA PR , which I felt, again, went over the top saying our view of the universe has been revolutionized today. When the first images came out, no, no, has not been revolutionized yet. This is the first step in a journey. And there's so these beautiful images, if you compare them to the old images by old, I mean, say those coming from the Hubble Space Telescope, they're so much sharper, they're so much clearer. And so we're going to be able to examine the universe with far greater precision, gaining far greater clarity than we have ever before. And so I look forward to the spectacular things that we're going to learn about things that we have studied so far, but even more exciting, we're going to learn about qualities of the world most likely that we haven't even yet imagined. And that's really where the excitement will happen in the next five, 10 years.

LT: What do we know about time? Does time exist everywhere?

BG: I don't know, it's hard to know if time is fundamental, which is how we've treated it for a long time, because it's hard to even think about reality without time. Reality is a sequence of events that occur within the timeline. But Einstein took the first sledge hammer to that idea by showing that different people moving relative to each other, they don't even have the same conception of time. The past of one person could be the future of another and vice versa, that was special relative. And then he had another sledge hammer, so to say, gravity affects the passage of time. So two individuals in different gravitational fields, one on earth, the other near a black hole, time for them will elapse at different rates. That's crazy. And then modern ideas in the last couple of decades have suggested that time itself might be not fundamental, but rather a kind of derived higher level notion that only comes into play in certain environments, so there might be environments of reality where there's no conception of time and so we're piecing it together. But my guess is that we're going to find that time is not part of the fundamental ingredients of reality, it's rather something that comes into being in certain circumstances such as the circumstance in which we live, but more fundamentally does not exist, at least in the way that we experience it.

LT: Is the universe expanding at an accelerating rate?

BG: So far, that's the way the data seems to be falling out, which is a shock. Prior to 1998, most people thought, yes, the universe is expanding, but it's slowing down in its expansion. Natural gravity tends to pull things back to each other, you drop something, it falls to the earth because the Earth and the object they pull on each other. So maybe the thought was the pull of every galaxy on every other would slow the cosmic exodus, so the expansion would slow down over time. But then 1998, two teams of astronomers measured the rate of cosmic slow down and found, hey, it's not even slowing down at all, it's speeding up. And that was a shock. And in fact, it's what gave rise to this idea of dark energy, because in Einstein's Math, it turns out if the universe is suffused uniformly with an energy that fills space, doesn't give off light, that's why we don't see it, but that energy can give rise to a repulsive version of gravity, an outward version of gravity that can push everything apart, and that's our best explanation for the data, which seems to show unequivocally that the expansion is speeding up, not slowing down.

LT: How do you think the world will end? Or will it end?

BG: Well, it depends what you mean by world and end. I don't know the time, at least if you're in a realm where time even comes into play. I don't think time will stop ticking, but the existence of structures, organized structures, planets, stars, galaxies, they will likely come to an end, their ingredients will disperse, fall apart and then waft through this ever quickening expansion of space. So the stable particles, the ones that don't fall apart into finer ingredients, they could in principle, persist indefinitely, but they wouldn't persist in organized structures. So in the far future, you'll have space dark with particles floating through it getting ever further apart, ever more dilute, and that might be how it goes for nearly an eternity. So many people would consider that the end, but it's not as though everything just sort of stopped. It's just organized structures. They're ephemeral. You and I and planets and stars, we come on the scene for a brief moment of time, and we're gone, and that's it.

LT: The universe is over 13 billion years old, and humans have existed, I believe, for less than a billion years. In an earlier a 3 Takeaways conversation with Harvard astronomer Avi Loeb, he said he believes that because the universe is so vast and because life could have existed for so many more billions of years than humans, that we are likely not the most sophisticated life form. In fact, he says we could be as common "as ants on a sidewalk." Do you think that there is life elsewhere that is more sophisticated than us?

BG: Yeah. So nobody can say, not Avi, not anybody, because again, it's up to observation experiment to confirm these hypothetical ideas. But I do agree with Avi that from what we know, we can speculate that it's not that hard for life to form, it seems as though if you have some fairly commonplace ingredients, if they come together in an environment that has a nice source of energy, like a star beating down on it, that those ingredients can coalesce into an orderly form that can generate life.

BG: It happened here pretty quickly, and so you imagine it could have happened other places pretty quickly too. In fact, even, maybe more quickly, could have begun sooner than it did here. And so given that, yeah. If I was a betting person, I would say sure, I would wager that there's life out there, but the thing that we don't know, and this is the one that Avi's speculating squared in some sense on, we really don't know what it takes for intelligent life to form. If you categorize intelligence to the level of cognitive sophistication to be able to build something like a radio telescope so you can communicate over vast distances, otherwise you'll be alone, and we'll never know about your existence.

BG: We don't know what it takes for intelligence to emerge, we don't know how common that is. Was it just a fluke of some asteroids slamming into the planet 65 million years ago, wiping out the dinosaurs, and without that, would the dinosaurs still be roaming the surface? Would the dinosaurs have built radio telescopes by now? I don't think so. So that to me is the big unknown. Life is certainly one, but intelligence, I just don't think we know enough about it to really say how likely or not it is that there are other examples in the cosmos.

LT: Jeff Bezos and Elon Musk have two very different views on space, as you know. Elon Musk wants people to be on multiple planets to assure the future of humanity, and Jeff Bezos has more of an earth-centric view, where he wants us to build space colonies on the Moon and near Earth, and eventually have people living and working in space around Earth. What do you think about their two views and what do you think our objectives should be?

BG: Well, I don't really see them in the long run as being intention. In the short run, sure, you've got to make plans, limited resources, how are you going to spend them and what are you going to do with the limited time and limited support that you were able to devote to this kind of activity? But in the long run, I do think that we're going to fan-out far and wide. In the short run, I think it's more likely that we're going to start more modestly and be closer to home, and I think that this is a valuable undertaking for the health not just of the species physically, but psychically. I think that it's deeply inspiring to people to still consider our species to be a species of explorers, the species that is willing to take risks to do the scary, terrifying thing and travel off into the unknown. So I think this will be part of our future, and it may well be that those with the greatest resources like the two gentlemen that you made reference to, they may be calling the shots for part of the time, because in some sense, they may be more visionary than governments.

BG: Ultimately though, I believe it will be governments that step in and push things to the next level. And my hope is that we get to a place where it's the world working together. How wonderful would that be if it's not Musk or Bezos or America, it's just the world reaching out into the wider cosmos. And so that may sound like naive, but that's how I would like this to unfold.

LT: No, it... Actually, it sounds quite wonderful that the world would come together on a scientific journey.

BG: Yeah, completely.

LT: What are some of the scientific ideas that you're most fascinated by?

BG: Some that we mentioned. I am fascinated by the nature of time, everything we do takes place in some duration of time, time is among the most precious things that we have, and yet we don't really know what it is. And so gaining a deeper insight into the nature of time, how flexible it is. It's much more flexible, our knowledge of it today suggests it's much more flexible than the knowledge that we had of it 100 years ago, a 100 years from now, will there be other revolutions where maybe we can even manipulate time, can we potentially have some version of time travel? These are again, the things of science fiction, but it would be remarkable and in keeping with previous developments, which basically follow the pattern of you're mystified by something, then you start to understand it, and once you start to understand it, you begin to manipulate it. Could we be in the stage of understanding and the era of manipulation is coming in our future, that to me is deeply exciting. And then the deep philosophical question that maybe science can weigh in on at some point, which is, why is there anything at all?

BG: Why is there something rather than nothing? As Leibniz once put it. Can science give us insight into a question like that, or is science limited to recognizing that there is something and then trying to understand that something? Can we push even further and understand why there's something at all?

LT: Before I ask for the three takeaways from our conversation, is there anything else you'd like to mention that you haven't already talked about?

BG: Nothing that really comes to mind beyond this wonderful discipline of science, which has allowed us to go beyond preconceived notions of the world, and I think that is the value of this activity. It pierces prejudice, it pierces the veil of certainty, and if you follow the approach that

science has provided, it reveals so far a remarkably strange and deeply inspiring reality.

LT: Brian, what are the three takeaways you'd like to leave the audience with today?

BG: Yes, so unfortunately, I'm deeply unprepared for the three takeaways, and I don't... You've probably never had a guest before who's like, I didn't do my homework, but the things that immediately come to mind for me is much in keeping with our conversation number one, don't trust your human perceptions of the world because they are so limited and allow yourself the freedom of thought and the freedom frame of mind to explore a much broader reality, so long as you use the methodology of science to determine what you have confidence and what you don't. So that would certainly be takeaway number one. Take away number two, perhaps more generally, is just in life itself, I find that the only undertakings that are ultimately worthwhile are the ones that you are emotionally tied to. As a scientist, we typically view scientists as those people who are cerebral, cognitive, using deductive reasoning to figure out the nature of the world, and certainly that's the approach that we use, but in the end of the day, if what you're doing doesn't fire you up emotionally, if it doesn't sort of get your heart pumping because of the excitement of it all, then I think you're probably not doing the thing that's really right for you, and all the ideas that we're talking about are exactly the ones that get me up in the morning, get me fired up, and that's why I find them so part of the life that I live.

BG: I can't live without these ideas. And I guess the final take away, what would it be? I would say, keep pushing the rock up the hill like Sisyphus. Fundamentally, I believe as the great existential thinkers believe that there's no fundamental meaning or fundamental value in the nature of reality, I think value and meaning are things that we construct in a fundamentally meaningless universe that has no objective criterion or notion of value. We make up the things that give us a sense of meaning, we make up the things that give us a sense of purpose. So we continue to push the boulder up the hill in a meaningless universe, and we kind of shake our fist at the cosmos and say, there isn't anything fundamental, I accept that, but I'm going to create my own re-add, I'm going to create my own value, my own meaning, my own purpose, and I'm going to pursue it with everything that I've got. And that to me is really the lesson that I've learned in terms of trying to make sense of this bizarre universe that we inhabit.

LT: Brian, this has been great. Thank you so much.

BG: My pleasure.

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