Preface

Dream or nightmare, we have to live our experience as it is, and we have to live it awake. We live in a world which is penetrated through and through by science and which is both whole and real. We cannot turn it into a game simply by taking sides.

—Jacob Bronowski

In the interests of full disclosure right at the outset I must admit that I am not sympathetic to the conviction that creation requires a creator, which is at the basis of all of the world's religions. Every day beautiful and miraculous objects suddenly appear, from snowflakes on a cold winter morning to vibrant rainbows after a late-afternoon summer shower. Yet no one but the most ardent fundamentalists would suggest that each and every such object is lovingly and painstakingly and, most important, purposefully created by a divine intelligence. In fact, many laypeople as well as scientists revel in our ability to explain how snowflakes and rainbows can spontaneously appear, based on simple, elegant laws of physics.

Of course, one can ask, and many do, "Where do the laws of physics come from?" as well as more suggestively, "Who created these laws?" Even if one can answer this first query, the petitioner will then often ask, "But where did that come from?" or "Who created that?" and so on.

Ultimately, many thoughtful people are driven to the apparent need for First Cause, as Plato, Aquinas, or the modern Roman Catholic Church might put it, and thereby to suppose some divine being: a creator of all that there is, and all that there ever will be, someone or something eternal and everywhere.

Nevertheless, the declaration of a First Cause still leaves open the question, "Who created the creator?" After all, what is the difference between arguing in favor of an eternally existing creator versus an eternally existing universe without one?

These arguments always remind me of the famous story of an expert giving a lecture on the origins of the universe (sometimes identified as Bertrand Russell and sometimes William James), who is challenged by a woman who believes that the world is held up by a gigantic turtle, who is then held up by another turtle, and then another . . . with further turtles "all the way down!" An infinite regress of some creative force that begets itself, even some imagined force that is greater than turtles, doesn't get us any closer to what it is that gives rise to the universe. Nonetheless, this metaphor of an infinite regression may actually be closer to the real process by which the universe came to be than a single creator would explain.

Defining away the question by arguing that the buck stops with God may seem to obviate the issue of infinite regression, but here I invoke my mantra: The universe is the way it is, whether we like it or not. The existence or nonexistence of a creator is independent of our desires. A world without God or purpose may seem harsh or pointless, but that alone doesn't require God to actually exist.

Similarly, our minds may not be able to easily comprehend infinities (although mathematics, a product of our minds, deals with them rather nicely), but that doesn't tell us that infinities don't exist. Our universe could be infinite in spatial or temporal extent. Or, as Richard Feynman once put it, the laws of physics could be like an infinitely layered onion, with new laws becoming operational as we probe new scales. *We simply don't know!*

For more than two thousand years, the question, "Why is there something rather than nothing?" has been presented as a challenge to the proposition that our universe—which contains the vast complex of stars, galaxies, humans, and who knows what else—might have arisen without design, intent, or purpose. While this is usually framed as a philosophical or religious question, it is first and foremost a question about the natural world, and so the appropriate place to try and resolve it, first and foremost, is with science.

The purpose of this book is simple. I want to show how modern science, in various guises, can address and *is* addressing the question of why there is something rather than nothing: The answers that have been obtained—from staggeringly beautiful experimental observations, as well as from the theories that underlie much of modern physics—all suggest that getting something from nothing is not a problem. Indeed, something from nothing may have been *required* for the universe to come into being. Moreover, all signs suggest that this is how our universe *could* have arisen.

I stress the word *could* here, because we may never have enough empirical information to resolve this question unambiguously. But the fact that a universe from nothing is even plausible is certainly significant, at least to me.

Before going further, I want to devote a few words to the notion of "nothing"—a topic that I will return to at some length later. For I have learned that, when discussing this question in public forums, nothing upsets the philosophers and theologians who disagree with me more than the notion that I, as a scientist, do not truly understand "nothing." (I am tempted to retort here that theologians are experts at nothing.)

"Nothing," they insist, is not any of the things I discuss. Nothing is "nonbeing," in some vague and ill-defined sense. This reminds me of my own efforts to define "intelligent design" when I first began debating with creationists, of which, it became clear, there is no clear definition, except to say what it isn't. "Intelligent design" is simply a unifying umbrella for opposing evolution. Similarly, some philosophers and many theologians define and redefine "nothing" as not being any of the versions of nothing that scientists currently describe.

But therein, in my opinion, lies the intellectual bankruptcy of much of theology and some of modern philosophy. For surely "nothing" is every bit as physical as "something," especially if it is to be defined as the "absence of something." It then behooves us to understand precisely the physical nature of both these quantities. And without science, any definition is just words.

A century ago, had one described "nothing" as referring to purely empty space, possessing no real material entity, this might

have received little argument. But the results of the past century have taught us that empty space is in fact far from the inviolate nothingness that we presupposed before we learned more about how nature works. Now, I am told by religious critics that I cannot refer to empty space as "nothing," but rather as a "quantum vacuum," to distinguish it from the philosopher's or theologian's idealized "nothing."

So be it. But what if we are then willing to describe "nothing" as the absence of space and time itself? Is this sufficient? Again, I suspect it would have been . . . at one time. But, as I shall describe, we have learned that space and time can themselves spontaneously appear, so now we are told that even this "nothing" is not really the nothing that matters. And we're told that the escape from the "real" nothing requires divinity, with "nothing" thus defined by fiat to be "that from which only God can create something."

It has also been suggested by various individuals with whom I have debated the issue that, if there is the "potential" to create something, then that is not a state of true nothingness. And surely having laws of nature that give such potential takes us away from the true realm of nonbeing. But then, if I argue that perhaps the laws themselves also arose spontaneously, as I shall describe might be the case, then that too is not good enough, because whatever system in which the laws may have arisen is not true nothingness.

Turtles all the way down? I don't believe so. But the turtles are appealing because science is changing the playing field in ways that make people uncomfortable. Of course, that is one of the purposes of science (one might have said "natural philosophy" in Socratic times). Lack of comfort means we are on the threshold of new insights. Surely, invoking "God" to avoid difficult questions of "how" is merely intellectually lazy. After all, if there were no potential for creation, then God couldn't have created anything. It would be semantic hocus-pocus to assert that the potentially infinite regression is avoided because God exists outside nature and, therefore, the "potential" for existence itself is not a part of the nothingness from which existence arose.

My real purpose here is to demonstrate that in fact science *has* changed the playing field, so that these abstract and useless debates about the nature of nothingness have been replaced by useful, operational efforts to describe how our universe might actually have originated. I will also explain the possible implications of this for our present and future.

This reflects a very important fact. When it comes to understanding how our universe evolves, religion and theology have been at best irrelevant. They often muddy the waters, for example, by focusing on questions of nothingness without providing any definition of the term based on empirical evidence. While we do not yet fully understand the origin of our universe, there is no reason to expect things to change in this regard. Moreover, I expect that ultimately the same will be true for our understanding of areas that religion now considers its own territory, such as human morality.

Science has been effective at furthering our understanding of nature because the scientific ethos is based on three key principles: (1) follow the evidence wherever it leads; (2) if one has a theory, one needs to be willing to try to prove it wrong as much as one tries to prove that it is right; (3) the ultimate arbiter of truth is experiment, not the comfort one derives from one's a priori beliefs, nor the beauty or elegance one ascribes to one's theoretical models.

The results of experiments that I will describe here are not only timely, they are also unexpected. The tapestry that science weaves in describing the evolution of our universe is far richer and far more fascinating than any revelatory images or imaginative stories that humans have concocted. Nature comes up with surprises that far exceed those that the human imagination can generate.

Over the past two decades, an exciting series of developments in cosmology, particle theory, and gravitation have completely changed the way we view the universe, with startling and profound implications for our understanding of its origins as well as its future. Nothing could therefore not be more interesting to write about, if you can forgive the pun.

The true inspiration for this book comes not so much from a desire to dispel myths or attack beliefs, as from my desire to

celebrate knowledge and, along with it, the absolutely surprising and fascinating universe that ours has turned out to be.

Our search will take us on a whirlwind tour to the farthest reaches of our expanding universe, from the earliest moments of the Big Bang to the far future, and will include perhaps the most surprising discovery in physics in the past century.

Indeed, the immediate motivation for writing this book now is a profound discovery about the universe that has driven my own scientific research for most of the past three decades and that has resulted in the startling conclusion that most of the energy in the universe resides in some mysterious, now inexplicable form permeating all of empty space. It is not an understatement to say that this discovery has changed the playing field of modern cosmology.

For one thing, this discovery has produced remarkable new support for the idea that our universe arose from precisely nothing. It has also provoked us to rethink both a host of assumptions about the processes that might govern its evolution and, ultimately, the question of whether the very laws of nature are truly fundamental. Each of these, in its own turn, now tends to make the question of why there is something rather than nothing appear less imposing, if not completely facile, as I hope to describe.

The direct genesis of this book hearkens back to October of 2009, when I delivered a lecture in Los Angeles with the same title. Much to my surprise, the YouTube video of the lecture, made available by the Richard Dawkins Foundation, has since become something of a sensation, with nearly a million viewings as of this writing, and numerous copies of parts of it being used by both the atheist and theist communities in their debates.

Because of the clear interest in this subject, and also as a result of some of the confusing commentary on the web and in various media following my lecture, I thought it worth producing a more complete rendition of the ideas that I had expressed there in this book. Here I can also take the opportunity to add to the arguments I presented at the time, which focused almost completely on the recent revolutions in cosmology that have changed our picture of

the universe, associated with the discovery of the energy and geometry of space, and which I discuss in the first two-thirds of this book.

In the intervening period, I have thought a lot more about the many antecedents and ideas constituting my argument; I've discussed it with others who reacted with a kind of enthusiasm that was infectious; and I've explored in more depth the impact of developments in particle physics, in particular, on the issue of the origin and nature of our universe. And finally, I have exposed some of my arguments to those who vehemently oppose them, and in so doing have gained some insights that have helped me develop my arguments further.

While fleshing out the ideas I have ultimately tried to describe here, I benefitted tremendously from discussions with some of my most thoughtful physics colleagues. In particular I wanted to thank Alan Guth and Frank Wilczek for taking the time to have extended discussions and correspondence with me, resolving some confusions in my own mind and in certain cases helping reinforce my own interpretations.

Emboldened by the interest of Leslie Meredith and Dominick Anfuso at Free Press, Simon & Schuster, in the possibility of a book on this subject, I then contacted my friend Christopher Hitchens, who, besides being one of the most literate and brilliant individuals I know, had himself been able to use some of the arguments from my lecture in his remarkable series of debates on science and religion. Christopher, in spite of his ill health, kindly, generously, and bravely agreed to write a foreword. For that act of friendship and trust, I will be eternally grateful. Unfortunately, Christopher's illness eventually overwhelmed him to the extent that completing the foreword became impossible, in spite of his best efforts. Nevertheless, in an embarrassment of riches, my eloquent, brilliant friend, the renowned scientist and writer Richard Dawkins, had earlier agreed to write an afterword. After my first draft was completed, he then proceeded to produce something in short order whose beauty and clarity was astounding, and at the same time humbling. I remain in awe. To Christopher, Richard, then, and all of those above, I issue my

thanks for their support and encouragement, and for motivating me to once again return to my computer and write.