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Book Review: Brief Answers to the Big Questions

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Stephen Hawking, *Brief Answers to the Big Questions* (New York: Bantam Books, 2018).

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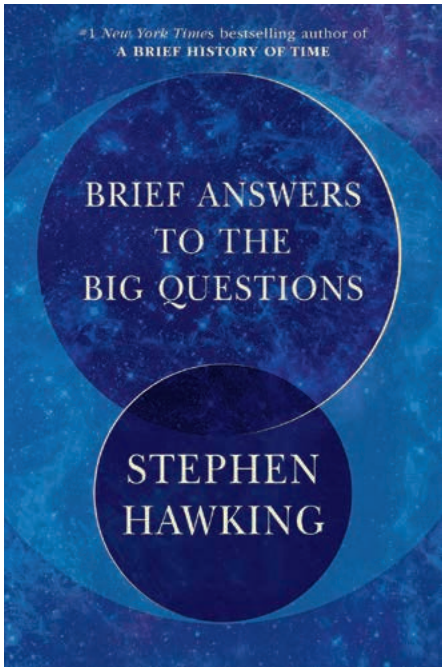
Brief Answers to the Big Questions is a compilation of the answers to the deep questions Hawking worked on and was often asked about as one of history's foremost thinkers. As a celebrated scientist in cosmology, Hawking was able to weave quantum mechanics and general relativity "boldly where no man or woman had gone before." His expertise in addressing these questions was not limited to physics; rather, his critical thinking, observational skills and humanity had no bounds. Here are the ten questions along with his answers that Hawking leads us through with his intellect, his smile and his all-consuming interest in the human condition (a theme that co-dominates Hawkins' physical and intellectual lifetime efforts and achievements): Is there a God? How did it all begin? Is there other intelligent life in the universe?

Can we predict the future? What is inside a black hole? Is time travel possible? Will we survive on Earth? Should we colonize space? Will artificial intelligence outsmart us? How do we shape the future? Make no mistake, this book and the answers it offers the reader as a rare gift are the voice of Stephen Hawking exuding science with every word and argument. The world needed him and desperately misses him already. We would all do well to follow his thoughts and words.

While subject, as we all are, to Earth's gravitational pull, Hawking was able to free himself to conquer gravity and physics at the cosmic scale with his travels to black holes. Hawking's vehicle (theoretical physics — science, math and modern physics) and results both play integral roles in how he came to arrive at his answers, so a bit of perspective may perhaps lend credibility — namely, black holes are a prediction of the theory of General Relativity and not a whim. In our recent lifetime, the evidence for black holes at the center of all galaxies, including our own, has become overwhelming. Everything is lost in the General Relativity black hole singularity including information. Such a singular state violates our notions of conservations and more familiar laws of thermodynamics and entropy. In one of his most lauded achievements that potentially resolves this contradiction, Hawking, for the first time, mixed the oil of quantum with the vinegarish landscape of the General Relativity black hole to predict that black holes radiate and therefore have a temperature and subsequently spectrum. This is a spectacular achievement. Not only then are symmetry and thermodynamics likely recovered, but the theory is also rife with predictions and new directions for all of theoretical physics awaiting experimental confirmation (or not) in the years to come with micro black holes in high-energy particle accelerators and through cosmological observations entering new eras and abilities of detection.



Hawking was more than an outside of the box thinker — he was a box redefiner (intellectually and academically a more difficult definition, I believe, of critical thinking for true knowledge, cultural and even economic advances). He stepped outside of the box only out of necessity, having exhausted all else that was ever known, ventured to where no one had ever gone before and then connected everything back to reality by predictions, mathematical consistency and experimental verification. This is science in practice. Hawking had the top-most credentials then to guide us to the answers to these scientific, cultural, philosophical and human questions — so his words and this book are well worth spending time to read and internalize.

In practice, I tend to read prose a bit laboriously, as my brain and eyes are trained to the flow and density of equations, not words. To my surprise, the 250 or so pages flew by. For most

people, this will be a train ride read. Even the typesetting is big. So too is it that a great short story or poem is, well, short, and may feel like a breeze to read, but the weight of the words and story may not necessarily hit you until much later. There may be cultural or experiential disconnects with the words, structure, and so many other intangibles that go into great writing, music, or art that can obscure, or delay meaning. I worry that both happen in places in a book and short answers like this without, in this case, math or the biggest ideas in physics over the last 100 years. Those ideas in physics are collectively defined as modern physics, encompassing relativity and quantum mechanics. Today, more than 100 years later, physics has moved well beyond this modern physics. None of this has been accepted into the mainstream of common knowledge or the standard education despite its impact on culture, medicine, and economy. It is like accepting that it is ok not to understand, say, history after 1900.

For example: It doesn't take long for Hawking to bring us to the result that time ceases to exist in a black hole. After your train ride and read on the way home, you probably settled in to think wow; time ceases to exist inside a Black hole. I was feeling great about what I had read and my pasta dinner until I began wondering if I really had any idea of what that actually means? Truthfully, and you can see this in the notes I scrawled in the margins of the book, I did what I always do. I wrote down equations. I started with what I know about time and wrote down the description of time, as it really is, as a space-time four-vector component, x^{μ}. This is derived from symmetry arguments (the group theory version of the idea that you can't tell if it is you moving or the people in the train next to you moving — both frames are equal) of Einstein's Special Relativity (1905) and on the side of the page I quickly derived time dilation, that time is not absolute to all. This gave me a better take on time and this time-ceasing business. With meatball clarity from my pasta dinner I uncovered an error in my thinking. I needed Einstein's General Relativity (1916) for the extreme space-time curvature and here I generalized the invariant interval in terms of the metric, $g_{\mu e}$, which is 'the' solution to the Einstein Field equations that describe how energy in all its forms (so mass, too, as energy, mc^2) tells space-time what to do (looks like $g_{\mu e}x^{e}x^{\mu}$). At this point, I think that I am finally starting to get the feel for what it means for time to cease to exist by taking the trip to a black hole mathematically and specifically in terms of a four by four metric tensor from Einstein's Field equation as did Hawking. Reading the book can be then, in places, like reading a travelogue — it's interesting, even captivating, but it's not the real thing — and thinking that by reading this book you can actually understand a black hole would be like thinking that you had tasted the café au lait of a Parisian breakfast when you had only read the Michelin guide. The math and physics implicit between each note might be required to fully absorb the meaning of what Hawking is telling us.

Hawking thought the equations were not necessary. You should side with him always. As for the quantum mechanics, that phenomenon of particle-antiparticle pairs popping out of the vacuum is the fundamental connection to how black holes radiate and have a temperature, and provides an additional space where language, culture, intuition and all human experience play little or no role or guide at all. Too many meatballs before bed.

So, maybe it is best then not to worry about the math and physics and take this book for its likely intended purpose which may follow something more like the lyrics from the Flaming Lips song "Sunship Balloons": *Now listen I don't know the dimensions of outer space. But if our ability to feel love turns out to be just a cosmic accident I'd like to think this means that the universe is on our side.*

Throughout each of the ten questions, Hawking democratically discards ideas that don't work, whether in science or religion (in terms of scientific questions) — his only metric for ideas is whether they get things right or redefine things, more than outside of the box, he demanded box redefinition to find a better answer. If getting better at medical diagnostics and treatment, using a cell phone, or building an economy are all based on the constant box redefinition of science and you live by this science, you cannot pick and choose at will when not to believe in science. You have to take what it gives you at each new turn. There you go: as best we know, time does cease to exist in black holes, deal with it. Quantum entanglement (non-local and non-definite — sorry Einstein) is the way it is. Human causes of global warming are significant and have to be addressed right now. Hawking is blunt about this, and he is allowed to be blunt because he understands the universe — of which the earth is just a small part — in a way that the rest (most) of us cannot hope to be able.

Though the landscape of Hawking's contributions and travels extended throughout the universe, he does not despair of humans and the human condition, but rather, hopes for a sustainable, hopeful future ahead. Implicitly and explicitly, he asks how we can be better for each other and do better for ourselves.

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