



Thoughts from Linda:
Brief Answers to the Big Questions

Stephen Hawking
2018

I well remember walking through Westminster Abbey with my husband in February of 2020 and seeing the final resting place of Stephen Hawking, so appropriately located between that of Sir Isaac Newton and Charles Darwin. I did not notice at the time, but now understand the significance of the script on his grave, which is the formula for what is called the 'Hawking temperature.' This book will describe what this and his other revolutionary formula, "Hawking Radiation," are all about.

They are perhaps the most radical theoretical physics discoveries in the second half of the twentieth century.

To read this book is like traveling to a different universe. It is the universe of the mind of Stephen Hawking, the most renowned scientist since Albert Einstein and the discoverer of many of the universe's greatest mysteries.

How did it all begin? Is there a God? 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?

These are the ten 'Big Questions' asked and answered by Hawking in this, his final book, taken from a collection of his responses in interviews and his comments in speeches, journals, and essays. It was in development at the time of his death, and a percentage of the royalties go to the Motor Neurone Disease Association and the Stephen Hawking Foundation.

The book consists of a chapter per question. Hawking's answers to six of these questions are deeply rooted in science, while his answers to the remaining four are not. However, as his colleague and friend, Kip Thorne, notes in the Introduction, "Stephen was always attracted to big questions, whether they were deeply rooted in his science or not. He did have the necessary skills, wisdom, and self-confidence to tackle them."

And he does just that in this most entertaining and stimulating book. I especially enjoyed the chapter, *'Is there other intelligent life in the universe?'* His wit is evident from the very first words, "I would like to speculate a little on the development of life in the universe, and in particular on the development of intelligent life. I shall take this to include the human race, even though much of its behavior throughout history has been pretty stupid and not calculated to aid the survival of the species." He asks and answers the questions: What is the probability of life existing somewhere else in the universe? And how may life develop in the future?

He defines 'life' as "an ordered system that can keep itself going against the tendency to disorder and can reproduce itself. That is, it can make similar, but independent ordered systems. To do these things, the system must convert energy in some ordered form—like food, sunlight, or electric power—into disordered energy, in the form of heat. A living being like you or me usually has two elements: a set of instructions that tell the system how to keep going and how to reproduce itself, and a mechanism to carry out the instructions. In biology these two parts are called genes and metabolism. But it is worth emphasizing that there need be nothing biological about them."

He takes us through a review of biology and chemistry as he sets up his thinking on the potential for other life in our universe. He introduces us to things like computer viruses as well as other types of viruses, which he does think count as 'life.' He takes us on a tour of chains of atoms, specifically carbon atoms, along with nitrogen and phosphorus, and indicates that he thinks these are the most promising for life due to their rich chemistry. He explains how the universe is so 'fine-tuned' and notes that there was no carbon when the universe began in the Big Bang, about 13.8 billion years ago. Hearing his explanation of the development of the universe itself is amazingly comprehensible, thanks to the simplicity of his writing (could have been his own spoken words) and the analogies he provides. He is a compelling storyteller.

He takes us on a tour of the cooling of the universe after the Big Bang and explains how protons and neutrons developed. As he notes, "one minute after the Big Bang, the temperature would have fallen to about a billion degrees, about a hundred times the temperature in the Sun." He follows with a vivid description of the formation of galaxies

and stars, starting some two billion years after the Big Bang, with our solar system emerging about 4.5 billion years ago, some nine billion years after the Big Bang. This chapter takes us through the development of DNA, including what we do and do not know at this time in our science.

He notes that the DNA in a human egg or sperm contains about three billion base pairs of nucleic acids. However, much of this information coded is redundant or inactive today. He goes on to say that "the total amount of useful information in our genes is probably something like a hundred million bits. One bit of information is the answer to a yes/no question. By contrast, a paperback novel might contain two million bits of information. Therefore, a human is equivalent to about fifty Harry Potter books!"

The development of language and particularly written language are major topics of relevance for him as he describes its impact on humanity and the considerations of life elsewhere. Unlike our DNA which can only pass on so much to the next generation, the knowledge that can be passed on thanks to the written word is "millions, if not billions, times higher than with our DNA."

In an insightful part of this chapter, he expresses the possibilities of homo sapiens extinguishing ourselves because of the limited evolution of our brains in contrast to the expansion of written knowledge that is being developed and transmitted at record speed. "We certainly cannot continue, for long, with the exponential growth rate of knowledge that we have had in the last 300 years. An even greater limitation and danger for future generations is that we still have aggressive instincts, and in particular, the aggressive impulses that we had in our caveman days. Aggression, in the form of subjugating or killing other men and taking their women and food, has had definite survival advantage up to the present time. But now it could destroy the entire human race and much of the rest of life on Earth. A nuclear war is still the most immediate danger, but there are others, such as the release of a genetically engineered virus...or the greenhouse effect becoming unstable."

He offers four possibilities about life in the universe, preferring the idea that there are other forms of intelligent life out there but that we, on Earth, have been 'overlooked.' He describes his thinking and his interaction with the Breakthrough Listen Initiatives. His advice is to "be wary of answering (any messages) until we have developed a bit further on Earth. Meeting a more advanced civilization, at our present stage, might be a bit like the original inhabitants of America meeting Columbus—and I don't think they thought they were better off for it."

His treatment of artificial intelligence and how we can shape the future are masterful, full of wisdom and insights. He concludes this book with these words: "We stand at a threshold of important discoveries in all areas of science. Without doubt, our world will change enormously in the next 50 years. We will find out what happened at the Big Bang. We will come to understand how life began on Earth. We may even discover whether life exists elsewhere in the universe. While the chances of communicating with an intelligent extra-terrestrial species may be slim, the importance of such a discovery means we must not give up trying.

We will continue to explore our cosmic habitat, sending robots and humans into space. We cannot continue to look inwards at ourselves on a small and increasingly polluted and overcrowded planet. Through scientific endeavor and technological innovation, we must look outwards to the wider universe while also striving to fix the problems on Earth. And I am optimistic that we will ultimately create viable habitats for the human race on other planets. We will transcend the Earth and learn to exist in space. This is not the end of the story, but just the beginning of what I hope will be billions of years of life flourishing in the cosmos."

The book concludes with a lovely tribute by Lucy Hawking, the daughter of Stephen and his wife, Jane. She speaks of her father's basic humanity and humility and notes his advice to her in his last words: "...he told me that I had been a lovely daughter and that I should be unafraid." She said, "I will never be as brave as him—I'm not by nature a particularly courageous person—but he showed me that I could try. And that trying might turn out to be the most important part of courage."

Stephen Hawking's life was the epitome of a courageous and brilliant man. This book uses his own voice, and I encourage you to read the book and hear him speak. It is a wonderful adventure and a most educational experience.