

A BRIEF HISTORY OF TIME

STEPHEN HAWKING

<u>Chapter 1 - Our Picture of the Universe</u>
<u>Chapter 2 - Space and Time</u>
<u>Chapter 3 - The Expanding Universe</u>
<u>Chapter 4 - The Uncertainty Principle</u>
<u>Chapter 5 - Elementary Particles and the Forces of Nature</u>
<u>Chapter 6 - Black Holes</u>
<u>Chapter 7 - Black Holes Ain't So Black</u>
<u>Chapter 8 - The Origin and Fate of the Universe</u>
<u>Chapter 9 - The Arrow of Time</u>
<u>Chapter 10 - Wormholes and Time Travel</u>
<u>Chapter 11 - The Unification of Physics</u>
<u>Chapter 12 - Conclusion</u>
<u>Glossary</u>
<u>Acknowledgments & About The Author</u>

FOREWARD

I didn't write a foreword to the original edition of *A Brief History of Time*. That was done by Carl Sagan. Instead, I wrote a short piece titled "Acknowledgments" in which I was advised to thank everyone. Some of the foundations that had given me support weren't too pleased to have been mentioned, however, because it led to a great increase in applications.

I don't think anyone, my publishers, my agent, or myself, expected the book to do anything like as well as it did. It was in the London *Sunday Times* best-seller list for 237 weeks, longer than any other book (apparently, the Bible and Shakespeare aren't counted). It has been translated into something like forty languages and has sold about one copy for every 750 men, women, and children in the world. As Nathan Myhrvold of Microsoft (a former post-doc of mine) remarked: I have sold more books on physics than Madonna has on sex.

The success of *A Brief History* indicates that there is widespread interest in the big questions like: Where did we come from? And why is the universe the way it is?

I have taken the opportunity to update the book and include new theoretical and observational results obtained since the book was first published (on April Fools' Day, 1988). I have included a new chapter on wormholes and time travel. Einstein's General Theory of Relativity seems to offer the possibility that we could create and maintain wormholes, little tubes that connect different regions of space-time. If so, we might be able to use them for rapid travel around the galaxy or travel back in time. Of course, we have not seen anyone from the

future (or have we?) but I discuss a possible explanation for this.

I also describe the progress that has been made recently in finding “dualities” or correspondences between apparently different theories of physics. These correspondences are a strong indication that there is a complete unified theory of physics, but they also suggest that it may not be possible to express this theory in a single fundamental formulation. Instead, we may have to use different reflections of the underlying theory in different situations. It might be like our being unable to represent the surface of the earth on a single map and having to use different maps in different regions. This would be a revolution in our view of the unification of the laws of science but it would not change the most important point: that the universe is governed by a set of rational laws that we can discover and understand.

On the observational side, by far the most important development has been the measurement of fluctuations in the cosmic microwave background radiation by COBE (the Cosmic Background Explorer satellite) and other collaborations. These fluctuations are the finger-prints of creation, tiny initial irregularities in the otherwise smooth and uniform early universe that later grew into galaxies, stars, and all the structures we see around us. Their form agrees with the predictions of the proposal that the universe has no boundaries or edges in the imaginary time direction; but further observations will be necessary to distinguish this proposal from other possible explanations for the fluctuations in the background. However, within a few years we should know whether we can believe that we live in a universe that is completely self-contained and without beginning or end.

Stephen Hawking