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STEPHEN HAWKING

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BLACK HOLES AND BABY UNIVERSES

AND OTHER ESSAYS

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Stephen Hawking

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PREFACE

THIS VOLUME CONTAINS a collection of pieces that I wrote over the period 1976 to 1992. They range from autobiographical sketches through the philosophy of science to attempts to explain the excitement I feel about science and the universe. The volume concludes with the transcript of a *Desert Island Discs* program on which I appeared. This is a peculiarly British institution in which the guest is asked to imagine himself or herself cast away on a desert island and is invited to choose eight records with which to while away the time until rescued. Fortunately, I didn't have too long to wait before returning to civilization.

Because these pieces were written over a period of sixteen years, they reflect the state of my knowledge at the time, which I hope has increased over the years. I have therefore given the date and occasion for which each was composed. As each was meant to be self-contained, there is inevitably a certain amount of repetition. I have tried to reduce it, but some remains.

A number of the pieces in this volume were designed to be spoken. My voice used to be so slurred that I had to give lectures and seminars through another person, usually one of my research students who could understand me or who read a text I had written. However, in 1985 I had an operation that removed my powers of speech altogether. For a time I was without any means of communication. Eventually I was equipped with a computer system and a remarkably

good speech synthesizer. To my surprise, I found I could be a successful public speaker, addressing large audiences. I enjoy explaining science and answering questions. I'm sure I have a lot to learn about how to do it better, but I hope I'm improving. You can judge for yourselves whether I am by reading these pages.

I do not agree with the view that the universe is a mystery, something that one can have intuition about but never fully analyze or comprehend. I feel that this view does not do justice to the scientific revolution that was started almost four hundred years ago by Galileo and carried on by Newton. They showed that at least some areas of the universe do not behave in an arbitrary manner but are governed by precise mathematical laws. Over the years since then, we have extended the work of Galileo and Newton to almost every area of the universe. We now have mathematical laws that govern everything we normally experience. It is a measure of our success that we now have to spend billions of dollars to build giant machines to accelerate particles to such high energy that we don't yet know what will happen when they collide. These very high particle energies don't occur in normal situations on earth, so it might seem academic and unnecessary to spend large sums on studying them. But they would have occurred in the early universe, so we must find out what happens at these energies if we are to understand how we and the universe began.

There is still a great deal that we don't know or understand about the universe. But the remarkable progress we have made, particularly in the last hundred years, should encourage us to believe that a complete understanding may not be beyond our powers. We may not be forever doomed to grope in the dark. We may break through to a complete theory of the universe. In that case, we would indeed be Masters of the Universe.

The scientific articles in this volume were written in the belief that the universe is governed by an order that we can perceive partially now and that we may understand fully in the not-too-distant future. It may be that this hope is just a mirage; there may be no ultimate theory, and even if there is, we may not find it. But it is surely better

to strive for a complete understanding than to despair of the human mind.

STEPHEN HAWKING
31st March 1993

One

CHILDHOOD*

I WAS BORN ON January 8, 1942, exactly three hundred years after the death of Galileo. However, I estimate that about two hundred thousand other babies were also born that day. I don't know whether any of them were later interested in astronomy. I was born in Oxford, even though my parents were living in London. This was because Oxford was a good place to be born during World War II: The Germans had an agreement that they would not bomb Oxford and Cambridge, in return for the British not bombing Heidelberg and Göttingen. It is a pity that this civilized sort of arrangement couldn't have been extended to more cities.

My father came from Yorkshire. His grandfather my great-grandfather, had been a wealthy farmer. He had bought too many farms and had gone bankrupt in the agricultural depression at the beginning of this century. This left my father's parents badly off, but they managed to send him to Oxford, where he studied medicine. He then went into research in tropical medicine. He went out to East Africa in 1937. When the war began, he made an overland journey across Africa to get a ship back to England, where he volunteered for military service. He was told, however, that he was more valuable in medical research.

My mother was born in Glasgow, Scotland, the second child of seven of a family doctor. The family moved south to Devon when she was twelve. Like my father's family, hers was not well off. Nevertheless, they managed to send my mother to Oxford. After Oxford, she had various jobs, including that of inspector of taxes, which she did not like. She gave that up to become a secretary. That

was how she met my father in the early years of the war.

We lived in Highgate, north London. My sister Mary was born eighteen months after me. I'm told I did not welcome her arrival. All through our childhood there was a certain tension between us, fed by the narrow difference in our ages. In our adult life, however, this tension has disappeared, as we have gone different ways. She became a doctor, which pleased my father. My younger sister, Philippa, was born when I was nearly five and was able to understand what was happening. I can remember looking forward to her arrival so that there would be three of us to play games. She was a very intense and perceptive child. I always respected her judgment and opinions. My brother Edward came much later, when I was fourteen, so he hardly entered my childhood at all. He was very different from the other three children, being completely nonacademic and nonintellectual. It was probably good for us. He was a rather difficult child, but one couldn't help liking him.

My earliest memory is of standing in the nursery of Byron House in Highgate and crying my head off. All around me, children were playing with what seemed like wonderful toys. I wanted to join in, but I was only two and a half, and this was the first time I had been left with people I didn't know. I think my parents were rather surprised at my reaction, because I was their first child and they had been following child development textbooks that said that children ought to start making social relationships at two. But they took me away after that awful morning and didn't send me back to Byron House for another year and a half.

At that time, during and just after the war, Highgate was an area in which a number of scientific and academic people lived. In another country they would have been called intellectuals, but the English have never admitted to having any intellectuals. All these parents sent their children to Byron House school, which was a very progressive school for those times. I remember complaining to my parents that they weren't teaching me anything. They didn't believe in what was then the accepted way of drilling things into you. Instead, you were supposed to learn to read without realizing you were being taught. In

the end, I did learn to read, but not until the fairly late age of eight. My sister Philippa was taught to read by more conventional methods and could read by the age of four. But then, she was definitely brighter than me.

We lived in a tall, narrow Victorian house, which my parents had bought very cheaply during the war, when everyone thought London was going to be bombed flat. In fact, a V-2 rocket landed a few houses away from ours. I was away with my mother and sister at the time, but my father was in the house. Fortunately, he was not hurt, and the house was not badly damaged. But for years there was a large bomb site down the road, on which I used to play with my friend Howard, who lived three doors the other way. Howard was a revelation to me because his parents weren't intellectuals like the parents of all the other children I knew. He went to the council school, not Byron House, and he knew about football and boxing, sports that my parents wouldn't have dreamed of following.

Another early memory was getting my first train set. Toys were not manufactured during the war, at least not for the home market. But I had a passionate interest in model trains. My father tried making me a wooden train, but that didn't satisfy me, as I wanted something that worked. So my father got a secondhand clockwork train, repaired it with a soldering iron, and gave it to me for Christmas when I was nearly three. That train didn't work very well. But my father went to America just after the war, and when he came back on the *Queen Mary*, he brought my mother some nylons, which were not obtainable in Britain at that time. He brought my sister Mary a doll that closed its eyes when you laid it down. And he brought me an American train, complete with a cowcatcher and a figure-eight track. I can still remember my excitement as I opened the box.

Clockwork trains were all very well, but what I really wanted were electric trains. I used to spend hours watching a model railway club layout in Crouch End, near Highgate I dreamed about electric trains. Finally, when both my parents were away somewhere, I took the opportunity to draw out of the Post Office bank all the very modest amount of money that people had given me on special occasions like