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Edited by Michael Hoskin
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Astronomy is one of the oldest sciences, and one which has repeatedly led to fundamental changes in our view of the world. This book covers the history of our study of the cosmos from prehistory through to a survey of modern astronomy and astrophysics, itself sure to be of interest to future historians of twentieth-century astronomy!

It does not attempt to cover everything in depth, but deliberately concentrates on the important themes and topics. These include the Copernican revolution, which led to the challenge of ancient authorities in many areas, not just astronomy, and seventeenth- and eighteenth-century stellar astronomy, at the time subordinated to the study of the solar system, but the source of many important concepts in modern astronomy.

Based on the widely acclaimed *Cambridge Illustrated History of Astronomy*, this book is beautifully illustrated throughout, and follows a similar structure and style. However, it is focused to meet the needs of final year undergraduates or beginning postgraduates. This is an essential text for students of the history of science and for students of astronomy who require a historical background to their studies.

Michael Hoskin taught the history of astronomy at Cambridge University for thirty years, and is editor of *The Journal for the History of Astronomy*.

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Preface

University teachers believe that in order to learn a subject, you have first to teach it. The thread running through this book is the history of astronomy as I learned it in three decades of lecturing to Cambridge undergraduates.

All teachers eventually convince themselves that they have seen the wood for the trees. I am no exception, and so I have elected to discuss at length, sometimes at considerable length, those few issues I believe to be of fundamental importance. To make room, questions that other historians might consider important, as well as innumerable lesser topics, are mentioned in passing, if at all.

We concentrate on the development, in the Near East and Europe, of the science of astronomy as the whole world knows it today. Other traditions, such as astronomy in China, and the sophisticated astronomies developed in the New World before the arrival of the *conquistadores*, occupy the attentions of respected historians of astronomy; but here they are described only briefly.

Readers sometimes come to the history of astronomy expecting the discussion to focus on 'who first got it right'. In the present work these expectations will be fulfilled very imperfectly, and this for two reasons.

First, 'getting it right' assumes that science is an onward and uninterrupted accumulation of truth, with theory approximating ever closer to reality. At the factual level, there is something in this. It is difficult to imagine that the claim, dating from Antiquity, that the Earth is roughly spherical will ever be abandoned, or that we shall one day discover that Venus is in fact closer to the Sun than is Mercury. But at a deeper, theoretical level, the development of science is immensely more complex. What has been termed 'normal science' often consists in the gradual clarification and elaboration of what is at first confused, with contributions from many hands. But there are sometimes dramatic and disturbing developments. A century after Isaac Newton's death it was generally believed that he

alone of the whole human race had been privileged to announce the fundamental truths of the physical universe – that this announcement had been made once, in 1687, and that the feat could never be repeated. But this complacent view was destroyed by Einstein's root-and-branch reform of the most fundamental Newtonian concepts of space, time, gravitation, and so forth. Yet it would be a poor historian who declared Newton simply to have been 'wrong' and his work therefore unworthy of attention.

Second, today's historians of astronomy see it their duty not to award medals to past astronomers whose opinions coincided with those of their modern counterparts, but to take their readers on an exciting journey. This journey introduces them to lands that are conceptually foreign – to past cultures, that sought as we do to make sense of the heavens, but did so by asking questions often very different from those that we take for granted, and who looked for answers strange to our way of thinking. Historians invite their readers to venture with them into these alien ideas, leaving behind modern assumptions as to the nature and purpose of astronomy, and putting much of our modern knowledge of the heavens onto 'hold'.

For example, Plato's contemporaries observed that the heavens were rotating night after night with constant speed. They saw that there were myriads of 'fixed' stars which, while sharing in this rotation, preserved their positions relative to each other without change; but they also saw, moving among the fixed stars in puzzling fashion, seven 'wanderers' or 'planets': the Sun, the Moon, Mercury and so forth. If, therefore, we are to understand astronomy in the nineteen centuries between Plato and Copernicus, we must put on one side the modern concept of 'planet', and accept the Sun and the Moon as planets. More important still, we must put on one side what we nowadays think of as the job of astronomers, for we are studying cultures in which their job was to contrive, for each of the seven wanderers, a geometrical model from which accurate tables of its future positions could be calculated.

This meant that for nearly two millennia, astronomy was applied geometry. The culmination of this Greek program came with the publication in 1543 of Copernicus's *De revolutionibus*, in which the otherwise-conservative author found himself compelled to make the Earth into a planet in orbit about the Sun. In the early decades of the seventeenth century, Kepler explored the physical implications of this claim – the *forces* at work in the solar system – and he thereby transformed astronomy, moving it from

kinematics to dynamics. Not surprisingly, the new concepts developed by Kepler, Galileo, Descartes and their contemporaries were at first vague and confused, and clarification came only in 1687, with the publication of Newton's *Principia*, in which the author claimed that the law of gravitational attraction was the key to understanding the physical universe.

The test of this claim was whether or not the law, when applied to the dauntingly complex solar system, could account for the observed motions of the planets and their satellites, and of the comets. During the eighteenth century and beyond this question occupied the attentions of a tiny band of mathematicians of outstanding genius; and how to deal with their work is a problem for the historian of astronomy. But while their conclusions were of the keenest interest to astronomers, they were not themselves astronomers but mathematicians working in the service of astronomy, and so we can disregard the details of their calculations with a clear conscience.

These 'celestial mechanicians', like their ancient and medieval precursors, were preoccupied with the solar system. The stars were still little more than an unchanging – and therefore uninteresting – backdrop to the movements of the planets, and there was little to be done about them beyond the cataloguing of their positions and brightnesses. Even as late as 1833, the leading authority on the stars and nebulae, John Herschel, published *A Treatise on Astronomy* in which he dealt with these bodies in a single chapter. With rare exceptions, his contemporaries, professionals and amateurs alike, were preoccupied with just one star – namely the Sun – and its satellites.

But since then the balance has tilted sharply in the opposite direction, and today's historian sees that the pioneering eighteenth- and nineteenth-century investigations into stars, nebulae, and 'the construction of the heavens' were to have a profound influence on future astronomical thinking. This book therefore gives more space to early explorations beyond the confines of the solar system than would have seemed proper to astronomers alive at the time.

One issue recurs throughout our account of astronomy in recent centuries: distances. The observer sees the celestial bodies as spread out on the surface of the heavenly sphere; the evidence, that is, is two-dimensional. To theorize about the three-dimensional universe, observers must investigate the third co-ordinate, that of distance.

The story of this investigation is an exciting one, for the successful measurement of the distances of unimaginably

remote objects is one of the astonishing achievements of astronomy – even the nearest stars are so far away that their light takes years to reach us. But this remoteness of celestial bodies brings an unexpected bonus, for we see them, not as they are now, but as they were when their light set out on its journey through space. This enables the astronomer to do the seemingly impossible, and look back in time. The more distant the object, the further back in time its light takes us; and today the distances studied are sometimes so great that the objects involved are cited in evidence, for and against cosmological theories of how the universe appeared in its infancy.

When does history end and science begin? Historians are themselves too close to contemporary astronomy to be able to offer a considered perspective. But although it is too soon to see 'Astronomy Today' with historical eyes, astronomy has clearly been transformed in recent decades, and the changes are too dramatic and too exciting for the historian simply to ignore. We therefore end our historical journey by looking around us, at how things stand today in the quest we share with our ancestors both ancient and modern: to understand the universe in which we find ourselves.

The present text is based on that of *The Cambridge Illustrated History of Astronomy*. But whereas the *Illustrated History* was intended for 'the general reader' with a minimal grasp of mathematics and physics, the present text includes certain materials more suitable for those who have studied these subjects at school.