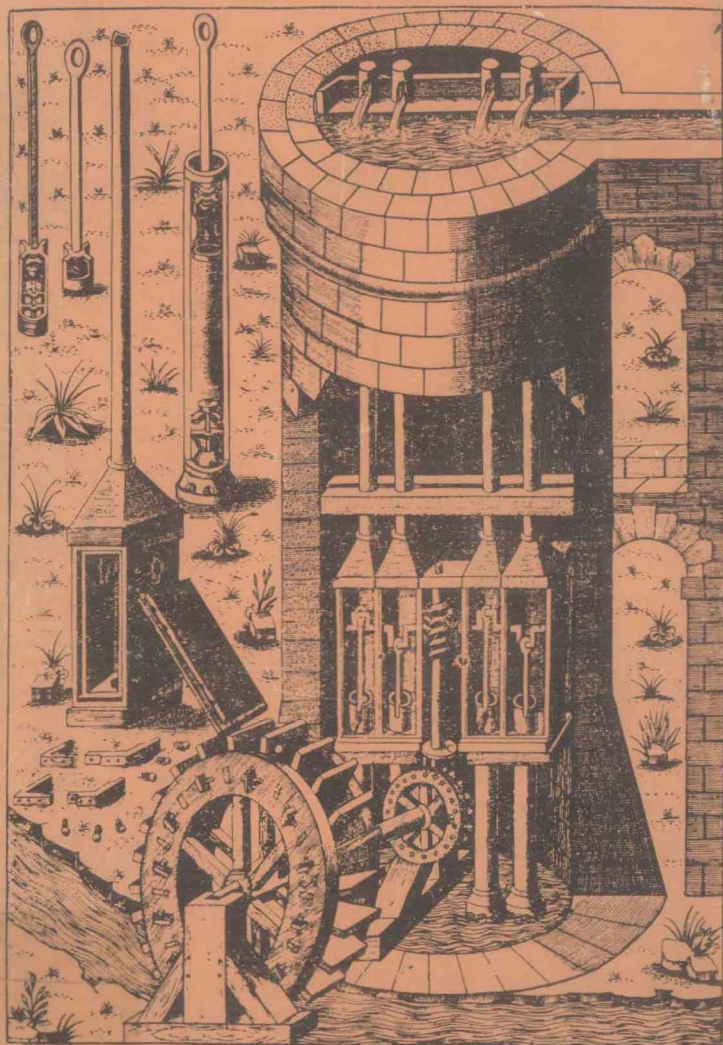


A SHORT HISTORY OF SCIENTIFIC IDEAS TO 1900



CHARLES SINGER

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BY
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PREFACE

THESE pages were written to give an elementary idea of how science came to occupy its distinctive position in the life of our own time. For this it is necessary to have some knowledge also of the Civilizations within which the science of the past has several times waxed and waned. To portray the different settings of science during the ages would be an immense task but I have tried, here and there, to indicate some of those factors in this complex story which seem less widely familiar. Of these a ready general example is the influence of the Arabic-speaking world; a specific case is the importance of the astrolabe.

It is evident that, in the last two generations, there has been a basic change in the status of science. This has affected the whole spiritual climate in which we live. Until the twentieth century the main inner life of civilized societies had been supported, for thousands of years, by activities quite outside the realm of scientific ideas. It is true that for the last few hundred years, and notably since the mid-eighteenth century, science has sometimes come to the aid of industry or agriculture by raising production or otherwise bettering the human lot. But on the spiritual side, save among isolated groups, science did little to exercise the intellect or satisfy the hunger for knowledge, and even less to appeal to the sense of beauty.

In England, until the later nineteenth century, science hardly penetrated the educational system and is still not integrated with it. Science seldom attracted general public interest until the beginning of the twentieth century. The place of science in the older universities remained at best secondary, at worst precarious. Since then the immense and accelerating increase in scientific activity and the resulting mass of real and applicable knowledge has changed every side of life. Having come to control and direct industry, it is now rapidly and manifestly transforming the very face of the earth and the lot of its living inhabitants, whether human, animal, or plant. A true history of science should end by discussing these latter-day metamorphoses. That last chapter must be a very long one and difficult to write. I am incapable of dealing with it and must perforce leave it to others.

I take this occasion to call to mind that science, the great aim of which is to make the world intelligible, or at least describable, has by its very success been riven into many departments. That this is so is due to the sheer accumulation of knowledge and thus ultimately to

human limitations. However distressing and artificial these divisions may appear to the philosopher, it must be remembered that they are, after all, merely formal and their frontiers movable at will and according to circumstances. There remain, however, three real gaps which are of a more fundamental kind. One divides the biological from the physico-mathematical sciences. A second divides the psychological sciences from the *Naturwissenschaften*—for which we have no shorter English term. A third separates the sociological sciences from the others. There is evidence that these hiatuses are now occasionally being crossed. When such journeys become more frequent and more secure, it may be possible to bring a history of science 'up to date'. It is these gaps, and not the mere bulk of knowledge, that makes this consummation so difficult. It must, however, be remembered that this achievement would not change the basic difficulty of forming a mental picture of the scheme of nature as a whole. It seems that the substratum of reality, even if expressible in mathematical terms, can never be reduced to the conceptual. The idea contained in that statement is the real bar between the nineteenth and the twentieth centuries.

This book is based on one bearing the title *A Short History of Science*, drafted first in 1929 and published in 1941. It underwent several revisions but the present form is much more than a revision and rather more than a new edition. I have therefore thought best to give it a modified title. It is one-quarter longer than its predecessor, more fully illustrated, brought with fair uniformity to the end of the nineteenth century, stresses ideas more than formerly, pays more attention to simple philosophical implications, and refers more frequently to the historical and economic setting of science. It has been kept firmly on an elementary level and demands no more than the basic information included in a secondary education.

I have to thank several colleagues for generous help. Professor H. Dingle has written the section from p. 418 to p. 460 and has saved the text from some errors elsewhere. Dr. Angus Armitage has written the opening section on Mesopotamia and Egypt (pp. 6–12). Dr. Derek de Solla Price has provided the account of Ptolemy's *Almagest* (pp. 90–95) and of the astrolabe (pp. 149–51). Many helpful suggestions have been made by Dr. E. J. Holmyard, Professor Douglas McKie, and Professor E. G. R. Taylor. As with the earlier work I have had the constant help of Mrs. Singer.

The origins of the figures are given in the list of illustrations. Special thanks are due to the directors of Imperial Chemical Industries for permission to use a number of figures from volumes of *A History of Technology*, the publication of which was completed

in 1958. A share in the editing of that work has taught me much which has been used here and for that I have to thank that public-spirited and far-sighted corporation. *A History of Technology* has afforded me a belated apprenticeship which remains among the most intellectually rewarding experiences of my not very short life.

The Library of the Wellcome Historical Medical Museum has been of great assistance. Its librarian, Dr. F. N. L. Poynter, has courteously done some searching for me and provided several useful figures. Those numbered 146 to 154 were kindly lent by Dr. Dorothy Feyer.

Only the traditional anonymity of the staff of the Clarendon Press prevents personal acknowledgment of assistance by several of its members. My affection and respect for the great institution which they serve is co-temporary with my association with it for well over forty years.

The general sources of the book will be evident to any with first-hand knowledge of the history of science. In view of the aim of the book its bulk has necessarily been severely restricted. On this account, and especially because of its elementary character, references seem out of place but none of them is obscure or inaccessible.

A word of general advice to the reader. The book cannot be understood unless the plan be grasped. To do this not only should a beginning be made by examining the *Table of Contents*, but constant reference to it is needed if the narrative is to be followed. In essence the book is a series of about sixty short and elementary essays on aspects of the history and philosophy of science, but neither the titles, nor the sequence, nor the interconnexion of these essays is haphazard. They follow a plan matured over a number of years. Therefore I beg the reader to keep on consulting the *Table of Contents* if he wishes to understand what I have to say.

C. S.

'Kilmarth', Par, Cornwall

1 January 1959

An Ancient Picture of the Universe

'Thou hast ordered all things by measure, number, and weight.'

Wisdom of Solomon. An apocryphal work of c. 100 B.C.

The Hope of the Determinist

'I wish I could derive all phenomena of nature, by some kind of reasoning, from mechanical principles: for I have many reasons to suspect that they all depend upon certain forces by which the particles of bodies are either mutually attracted and cohere in regular figures or are repelled and recede from each other.'

NEWTON, 1687

A Classical Statement of Classical Physics

'We should regard the present state of the universe as the effect of its antecedent state and the cause of its subsequent state. An intelligence acquainted with all the forces of nature, and with the positions at any given instant of all the parts thereof, would include in one and the same formula the movements of the largest bodies and those of the lightest atoms.'

LAPLACE, 1814

Modern Physics and Mental Images

'The classical tradition had been to consider the world to be an association of observable objects moving according to definite laws of force, so that one could form a mental picture of the whole scheme. . . . It has become increasingly evident, however, that nature works on a different plan. Her fundamental laws do not govern the world as it appears in our picture in any direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies.'

P. A. M. DIRAC, 1933

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PLATE

Louis XIV and Colbert visit the *Académie des Sciences* in 1671 *frontispiece*

The original was drawn and engraved by Sebastien Le Clerc (1637-1714), who was himself a trained and experienced man of science, as well as an artist and scientific draughtsman. This is the earliest representation of a meeting of a learned society. It first appeared in the *Mémoires pour servir à l'Histoire Naturelle des Animaux*, Paris 1671.

The place is a room attached to the King's Library at Paris in the Rue Vivienne, near where the Bibliothèque Nationale now stands. The occasion is a visit to the Académie in 1671 of Louis XIV who stands in front. On his left is his minister, Jean Baptiste Colbert (1619-83), who always showed a personal interest in science, both pure and applied. On the King's right is Louis de Bourbon, Prince de Condé (1621-86) and the King's brother, Philip, Duc d'Orleans (1640-1701).

Behind these four stand the members, all portraits. Claude Perrault (1613-88, p. 301), the moving spirit of the Académie, is just behind and between the King and Colbert. G. D. Cassini (1625-1712, p. 304) stands just behind the other two royal personages and is speaking over his shoulder. To the extreme right of the picture, Jean Picard (1620-82, p. 301) holds open his *Mésure de la Terre* (p. 319).

In the forefront of the picture is an armillary sphere, behind and to its right a gigantic concave burning mirror, while by its side is a telescope. Further to the right is a terrestrial globe. Behind these a large framed map and another rolled up indicate the Académie's interest in cartography. Behind the framed map is a drawing of a gazelle and its dissected parts. In the right forecorner is a stuffed civet or some such animal. In the front to the left on a table is the air-pump and compound microscope of Christian Huygens (1629-95, p. 302). On the back wall is the skeleton of a lion together with complex stills and other chemical apparatus. Below the open window is a model, perhaps of the water works at Versailles.

Through the open window is seen the garden where the Académie's astronomical work began. There stands the Académie's large quadrant. In the further distance is the Paris Observatory still under construction (begun 1667, completed 1672, p. 301). The artist's licence has brought this building some two miles nearer than its actual site.