# A History of Natural Philosophy

Natural philosophy encompassed all natural phenomena of the physical world. It sought to discover the physical causes of all natural effects and was little concerned with mathematics. By contrast, the exact mathematical sciences – such as astronomy, optics, and mechanics – were narrowly confined to various computations that did not involve physical causes. Natural philosophy and the exact sciences functioned independently of each other. Although this began slowly to change in the late Middle Ages, a much more thoroughgoing union of natural philosophy and mathematics occurred in the seventeenth century and thereby made the Scientific Revolution possible. The title of Isaac Newton's great work, *The Mathematical Principles of Natural Philosophy*, perfectly reflects the new relationship. Natural philosophy became the "Great Mother of the Sciences," which by the nineteenth century had nourished the manifold chemical, physical, and biological sciences to maturity, thus enabling them to leave the "Great Mother" and emerge as the multiplicity of independent sciences we know today.

Edward Grant is Distinguished Professor Emeritus of the History and Philosophy of Science at Indiana University, Bloomington. He is the author or editor of twelve books, one of which has been translated into eleven languages and one into three languages. He is also the author of approximately ninety articles on the history of science and natural philosophy. He was Vice President and President of the History of Science Society and was awarded the prestigious George Sarton Medal of that society.

# A History of Natural Philosophy

## From the Ancient World to the Nineteenth Century

EDWARD GRANT
*Indiana University, Bloomington*

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
32 Avenue of the Americas, New York, NY 10013-2473, USA

www.cambridge.org
Information on this title: www.cambridge.org/9780521869317



First published 2007

Printed in the United States of America

*A catalog record for this publication is available from the British Library.*

*Library of Congress Cataloging in Publication Data*

Grant, Edward, 1926–
A history of natural philosophy : from the ancient world to the nineteenth century /
Edward Grant.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-521-86931-7
ISBN-10: 0-521-86931-5
ISBN-13: 978-0-521-68957-1 (pbk.)
ISBN-10: 0-521-68957-0 (pbk.)
1. Physics – History. 2. Science – History. I. Title.
QC7.G73 2007
509–dc22 2006012920

ISBN 978-0-521-86931-7 hardback
ISBN 978-0-521-68957-1 paperback

*In Remembrance of*
*Marshall Clagett (1916–2005)*
*Teacher and Dear Friend*

# Contents

# Preface

Most of my publications over many years have in one way or another been about, or concerned with, natural philosophy. In all those years, however, neither I nor anyone else has seen fit to write a history of that discipline. Although numerous histories of science have been published, and will undoubtedly continue to appear, I am unaware of any history of natural philosophy. It occurred to me that an account of the historical evolution of natural philosophy should prove helpful to a better understanding of the development of the history of science itself. Indeed, as readers will discover, the historical relationship between natural philosophy and science is by no means straightforward. Opinions about their association and interconnections have often been controversial and sometimes quite elusive.

Once I determined to write a history of natural philosophy, I had to decide whether that history should be all encompassing – from its origins to its general replacement by modern science – or whether it should be confined to one or two historical periods. Because my area of specialization has been the late Middle Ages, it seemed plausible to begin with the origins of natural philosophy in the ancient world and conclude at about 1500, when medieval natural philosophy reached the height of its development. Around 1998 I became aware of an opinion that claimed that natural philosophy was always about God, even when God is not discussed or mentioned; and, consequently, that natural philosophy could not be science, because the latter was never about God. Although Dr. Andrew Cunningham, the scholar who proposed this interpretation (see Chapters 9 and 10), focused on Isaac Newton and the seventeenth century, his claims applied to all of natural philosophy, including the Middle Ages. This view of natural philosophy was so utterly contrary to my own understanding of that ancient discipline that I decided to extend my historical range, not only to the seventeenth century but also to the nineteenth century by the end of which natural philosophy had largely passed from the scene, although, in many older universities and colleges, some academic scientists continue to the present to hold the title "Professor of Natural Philosophy."

My study is not intended as a highly detailed description of all aspects of the history of natural philosophy. That would be a very formidable task.

For example, I have said almost nothing about natural philosophy in the fifteenth and eighteenth centuries, largely because I do not believe any dramatic changes occurred in those periods. Nor have I included discussions about nineteenth-century *Naturphilosophie*, associated with the names of Schelling, Fichte, Hegel, and others. My objective, rather, has been to describe the general characteristics of natural philosophy in the different historical periods and to trace the major transformations that occurred over the centuries. As readers will observe, the most profound change in natural philosophy occurred in the seventeenth century. It involved a union of the exact sciences and natural philosophy, a phenomenon that has received relatively little attention in the vast literature about the meaning and causes of the Scientific Revolution. Without that fusion, however, it is doubtful that the Scientific Revolution could have occurred in the seventeenth century. One major result of this coming-together was that natural philosophy, once regarded as largely independent and isolated from mathematics and the exact sciences, became significantly mathematized. In this mathematized form, natural philosophy became synonymous with the term science, which came into use in the nineteenth century. As the reader will see, it was because of natural philosophy's capacity for absorbing sciences and expanding their horizons that, in the seventeenth century, Sir Francis Bacon, with great insight and vision, designated natural philosophy as the "Great Mother of the Sciences."

By virtue of the enormous role Aristotle's works have played in the history of natural philosophy, there are many quotations from, and references to, his treatises. In my numerous references to his works, I have followed the usual conventions. Citations of passages in Aristotle's works almost always follow the page numbering of his Greek texts, which were edited in the nineteenth century by Immanuel Bekker and published by the Berlin Academy (1831–1870). Every reference to a passage in Aristotle's works consists minimally of a page number, a column letter, and a line number. There is no confusion about page numbers, because the pagination of the Bekker edition is completely sequential from volume to volume. For example, *Physics* 184a.10–15 is a reference to page 184, column a, lines 10–15 of Aristotle's *Physics* in the Bekker edition; or *Metaphysics* 1067b.25–30, which refers to page 1067, column b, lines 25–30 of the Bekker edition. Vernacular translations of Aristotle's works have adopted Bekker's page, column, and line numbering, so that when one cites a passage from the Oxford English translation (which is used throughout this volume), the reference is equally valid for both the Greek edition and the English translation. This is evident from the fact that the beginning of every page in the Greek (Bekker) edition is printed in the margin alongside the corresponding line in the English translation. The lines are then numbered in multiples of five until the end of that column (*a* or *b*) is reached, at which point the next page and column number are printed, and

so on through every page. The first treatise in the revised Oxford English translation is the *Categories*, which has 1a1 (actually $1^a1$, but I shall not use superscripts for columns *a* and *b*) alongside the first line of the treatise, signifying page 1, column a, line 1; some 30 lines below, we find 1b1 in the margin, and 30 lines later, we have 2a1 in the margin, and so on until we reach 1462b1, or page 1462, column b, line 1, which coincides with the last page of Aristotle's *Poetics* in the Greek edition.

One also can broaden a reference by adding book and chapter numbers. For example, *On the Heavens* 2.14.296b.12–23, indicates a reference to book 2, chapter 14 in the English translation of *On the Heavens*, and, more specifically to that part of the English translation that corresponds to page 296, column b, lines 12–23 of the Greek text.

I wish to express a considerable debt of gratitude to the librarians and staff of the Herman B. Wells Library at Indiana University, who, as always, facilitated my work in countless ways. I am also grateful to Indiana University for research funds that enabled me to obtain essential equipment and supplies. Once again, I wish to express my deep gratitude to my weekly luncheon companions, colleagues, and longtime friends – Frederick Churchill, H. Scott Gordon, Noretta Koertge, Jack Moore, and John Walbridge – who responded to my numerous queries with their usual insight and concern. I was fortunate to have had two diligent and intelligent anonymous readers of my manuscript who offered many helpful suggestions to improve its quality. To each of them I wish to express sincere and grateful thanks. Finally, as so often in the past, I thank my wife, Sydelle, for her patience in listening to numerous problems relevant to my books and for always responding with helpful, intelligent suggestions.

My book is dedicated to the memory of a great scholar and dear friend, Professor Marshall Clagett, who passed away on October 21, 2005, at the age of eighty-nine. Since 1964, Marshall Clagett was a Professor of the History of Science in the School of Historical Studies of the Institute for Advanced Study, Princeton, New Jersey. I had the great good fortune to have him as my major professor in the Department of the History of Science at the University of Wisconsin–Madison, in the years 1951–1957. His textual scholarship was extraordinary and the range of his publications awesome. He published extensively on ancient Greek science; medieval Latin physics, which included *Archimedes in the Middle Ages*, a five volume work in ten parts published between 1964 and 1984; and, finally, a few years before his retirement from the Institute in 1986, he came to focus his research talents exclusively on ancient Egyptian science, for which purpose he traveled to Egypt many times and learned to read Egyptian hieroglyphics. The result of these extraordinary activities occurred between 1989 and 1999 when Marshall Clagett published three volumes (in four tomes) on Egyptian science. These volumes ranged over cosmology, astronomy, and mathematics

and were largely comprised of source documents, many of which Clagett translated. A fourth volume on medicine was in process at the time of his death.

There can be little doubt that Marshall Clagett was one of the greatest and most unusual scholars of the twentieth century. His like will not soon come again.