

## PREFACE

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The concepts and ideas of elementary particle physics are abstract, and they are typically expressed in the language of mathematics. However, the goal of elementary particle physics is very simple, and all the efforts of elementary particle physicists are directed toward that simple goal: to identify the basic building blocks of matter and to understand how they interact to produce the material world we observe.

This encyclopedia contains articles intended for a broad audience of general readers and is designed to edify and give readers an appreciation for one of the most active and productive areas of physics throughout the twentieth century and to the present time. On the one hand, most of the articles have been written in ordinary language and provide a solid base in particle physics concepts and history for those who are new to the field. On the other hand, some topics in particle physics are difficult to express in everyday words, and in the articles on such topics, symbols appear and even an occasional equation. Even these articles, however, are written so that the reader with little physics background can capture a general sense of the topic covered.

Several features of the encyclopedia are designed to help the general reader navigate the language of physics and mathematics included in the articles on the more complex topics. A glossary in the back of the book provides definitions for terms

that may be unknown to the reader, both in the field of physics and in related sciences. A list of common abbreviations and acronyms at the beginning of the book is included to aid readers unfamiliar with those used in the book. Numerous tables, figures, illustrations, and photographs supplement the information contained within the articles and provide visual tools to better understand the material presented.

Entries are arranged alphabetically and include extensive cross-references to refer the reader to additional discussions of related topics. In each article, a bibliography directs the reader to books, articles, and Web sites that provide additional sources of information. The articles themselves focus on particular topics that, taken together, make up the intellectual framework called elementary particle physics. Articles such as those on accelerators, quarks, leptons, antimatter, and particle identification provide a working base for the study of particle physics. Articles such as those on quantum chromodynamics, neutrino oscillations, electroweak symmetry breaking, and string theory bring readers to subjects that fill the conversations of contemporary particle physicists. Finally, articles such as those on the cosmological constant and dark energy, supersymmetry, and unified theories discuss the key topics replete with many exciting questions left to be answered.

Articles also detail the history of particle physics, including the discovery of specific particles, such as the antiproton and the electron. In addition to the historical articles, a time line is included to provide an overview of the development of the field of particle physics. This time line of research and development in what is now called particle physics extends back almost three millennia. The time line demonstrates the commanding grip that the desire to identify the basic building blocks of matter has had on the minds of past and present scientists. Biographical articles of physicists who have made seminal contributions to our understanding of the material world complete the encyclopedia's coverage of the history of particle physics. The selection of physicists for the biographies was based on the desire to provide a historical background for the topics presented in this encyclopedia, and so no living physicist was included.

Since experimentation is a vital part of particle physics, detailed articles discuss the technologies used to discover particles, including current accelerator types and subsystems. Articles also profile the international laboratories that house these accelerators, describing experiments, both historic and current, conducted at these labs. Articles on case studies are included to provide the reader with more in-depth information as to how these technologies contribute to the past and continuing search for particles.

Particle physics both affects and is affected by other sciences as well as by the political and philosophical environment. Articles discuss the interac-

tion of particle physics and cosmology, astrophysics, philosophy, culture, and metaphysics. Also included are articles describing the spin-off technologies created in the search for particles as well as the funding of this research.

A reader's guide in the beginning of the encyclopedia arranges the topics into broad categories and thereby helps organize the array of individual entries into a comprehensive field of study. Additionally, the article on elementary particle physics provides an overview of the field and its current questions.

The authors of the articles contained in this encyclopedia work in the top particle physics laboratories and are professors at renowned colleges and universities. Not only does this encyclopedia provide a comprehensive coverage of the field of particle physics, but it also brings together articles from the top members of the physics and scientific community.

This collection of articles would not have been possible without the effort of those who contributed, and I thank each of the authors. Jonathan Rosner, University of Chicago, has responded to personal requests I made of him, and I thank him. Also, I am grateful to both editors, Jonathan Bagger, Johns Hopkins University, and Roger H. Stuewer, University of Minnesota, for their work and advice. Lastly, the Macmillan editor, Deirdre Graves, has been devoted in her assistance throughout the project. We, the editors, thank her.

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