Centennial History of the Carnegie Institution of Washington
Volume II The Department of Terrestrial Magnetism

In 1902, Andrew Carnegie founded the Carnegie Institution of Washington, to support innovative science research. Since its creation two years later, the Department of Terrestrial Magnetism has undertaken a broad range of research from terrestrial magnetism, ionospheric physics and geochemistry to biophysics, radio astronomy and planetary science. This second volume in a series of five histories of the Carnegie Institution describes the people and events, the challenges and successes that the Department has witnessed over the last century. Contemporary photographs illustrate some of the remarkable expeditions and instruments developed in pursuit of scientific understanding, from sailing ships to nuclear particle accelerators and radio telescopes to mass spectrometers. These photographs show an evolution of scientific progress through the century, often done under trying, even exciting circumstances.

LOUIS BROWN'S first scientific position was at the University of Basel where he helped construct the first source of polarized ions. He arrived at the Department of Terrestrial Magnetism (DTM) in 1961 to begin a fifteen-year research program in nuclear physics. However, his interests have always been broad and he has also pursued research in optical and X-ray spectroscopy, and designed numerous instruments used in astronomy and mass spectrometry. He served as Acting Director of DTM from 1991 to 1992, and continued to work in mass spectrometry as an Emeritus Staff Member until 2004.

CENTENNIAL HISTORY OF THE
CARNEGIE INSTITUTION OF WASHINGTON

Volume II

THE DEPARTMENT OF TERRESTRIAL MAGNETISM

LOUIS BROWN
Carnegie Institution of Washington

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FOREWORD

In 1902 Andrew Carnegie, a steel magnate turned philanthropist, had a brilliant idea. Carnegie was prescient in recognizing the important role that science could play in the advancement of humankind. He also believed that the best science came by providing "exceptional" individuals with the resources they need in an environment that is free of needless constraints. He created the Carnegie Institution as a means to realize these understandings, directing the Institution to undertake "projects of broad scope that may lead to the discovery and utilization of new forces for the benefit of man." Carnegie was confident that this unusual formula would succeed. And he was right.

For over a century, the Carnegie Institution has sponsored creative and often high-risk science. Some of the luminaries who were supported by the Institution over the years are well known. For example, Edwin Hubble, who made the astonishing discoveries that the universe is larger than just our galaxy and that it is expanding, was a Carnegie astronomer. Barbara McClintock, who discovered the existence of transposable genes, and Alfred Hershey, who proved that DNA holds the genetic code, both won Nobel Prizes for their work as Carnegie scientists. But many other innovative Carnegie researchers who are perhaps not so well known outside their fields of work have made significant advances.

Thus, as part of its centennial celebration, the Institution enlisted the help of many individuals who have contributed to the Institution's history to chronicle the achievements of the Institution's five major departments. (Our newest department, the Department of Global Ecology, was started in 2002 and its contributions will largely lie ahead.) The result is five illustrated volumes, which describe the people and events, and the challenges and controversies behind some of the Institution's significant accomplishments. The result is a rich and fascinating history not only of the Institution, but also of the progress of science through a remarkable period of scientific discovery.

Andrew Carnegie could not have imagined what his Institution would accomplish in the century after its founding. But I believe that he would be very proud. His idea has been validated by the scientific excellence of the

exceptional men and women who have carried out his mission. Their work has placed the Institution in a unique position in the world of science, which is just what Andrew Carnegie set out to do.

Richard A. Meserve
President, Carnegie Institution of Washington

PREFACE

When human activities are evaluated two things have permanence: science and history. Science is the knowledge of how the physical and biological worlds function and of their histories. It is the consequence of our learning to use instruments to read the book nature presents to us and to use our minds to form explanations out of what would otherwise be a discordant multitude of facts. It does not address why things are what we find. History is the story of how we obtained science and must tell the whole story of civilization. When the Carnegie Institution of Washington has passed from the scene, it will have left the history of a small but solid contribution.

The Institution's history can, as with other scientific organizations, be extracted from its publications, but this material lacks historical focus, and even Carnegie staff members would have difficulty obtaining a balanced picture without a significant amount of study, regardless of their familiarity with the literature of the various fields. It is the purpose of this book to perform this (very enjoyable) labor for the Department of Terrestrial Magnetism, known far and wide as DTM. It is a history intended for scientists and the scientifically literate public. The goal of the Department has been the production of science, and I construe its history to be descriptions of the advances in the sciences studied. These advances were made by individuals or small groups, and their stories are intimately bound to their work, indeed form the glue that holds the story together. In the background lie administrative matters that have influenced the course of research over the years. It is the glory of the Institution that those decisions have been enlightened, allowing one to write a history that is decidedly upbeat. Finally, the story includes bits and pieces of the effects of conditions in the "real world," and it has been a strength of the Institution to have been able to shield its staff from many of these, at times, highly disturbing influences.

In reading a number of books and articles by historians of science I can see that this book differs from their norm. As a rule they do not follow the science closely, sometimes not at all, preferring to concentrate on how decisions to proceed in certain endeavors came about and the consequences of them. Their scholarship frequently tends toward sociology. They make much of the examination of the correspondence between senior participants and of the records of meetings. Such sources are not excluded from this study

but do not carry much weight. Here the emphasis is on what was the science, how was it done and who did it.

Anyone connected with the Department during the past century will be appalled at what is missing: many experiments and observations not even alluded to, many important individuals not mentioned. This is a serious flaw, but one that I justify by noting how large the activities of DTM have been during its century and how many, many persons have contributed – and few of those employed or associated have had trivial parts. The purpose of this history is to gather the important facts in a readable form, which places severe constraints on the length and the manner of telling the story. To the persons slighted, either from the absence of their names or of the experiments or observations they held dear or the valuable support they supplied, my sincere apologies. This is especially true of the many whom I knew and whose work I valued. In discussing this problem with my colleagues I contrived a plan to list all the scientific and support staff members, associates, fellows, visitors, postdocs and the like. What seemed on the surface to be a useful and fair way of handling this great omission proved to be quite unworkable, owing to the magnitude and heterogeneity of the records.

The overwhelming sources for this study lie in Carnegie publications, especially the *Year Books*. Information from the *Year Books* is provided in citation only very rarely because to do so in the usual scholarly manner would burden the reader with a mass of references that he does not require; it is not difficult to make the connection between the text and the *Year Books*. Other Carnegie publications are cited, as is material gathered from other locations. Discreet use of the Department's personnel files has allowed the characters of the story to take on more human form.

For the first 50 years the *Year Books* are very useful for an historian. They had the format of the Director describing the activities of his unit to the President and the Trustees as well as any others who might care to learn what the Department had been doing. The scientific accomplishments were described briefly, with non-specialists in mind; the significance of the work was explained and credit for its accomplishment given; publications were listed; administrative matters reported; and in some years lists of seminar speakers provided. Unfortunately, personnel were listed sporadically during the first years, with little about the support staff. Not until *Year Book 21* was there a complete listing, and this was followed by a hiatus until *Year Book 26* after which they became standard except during the war years, when it was omitted evidently to hide secret activities. It is highly concentrated and magnificent material.

In the 1950s a change began that made it significantly harder in some cases for the historian. The *Year Book* began to be composed of a series of individually or group authored papers, generally, although not always, written for other scientists in the field and quite obviously not for many

of the Trustees. The number of pages grew from 54 in 1946 to 122 in 1966 for a staff of comparable size, and reading the annual reports changed from pleasure to tedious work. This style spread throughout the Institution, and *Year Book 73* reached 1197 pages. With *Year Book 82* there was a critical evaluation of its value and of the cost and the effort expended by the staff in preparing it, which was judged greater than the benefit achieved and resulted in a radically new and much shorter volume.

The new version had the virtue of addressing non-specialist readers, however until *Year Book 87* the material was not organized according to department. The shortened format included only those matters that had come to some kind of fruition and were ready for public display, so chronology became confused and the steps preceding important science omitted. With time they became unduly abridged, and it was necessary in preparing this history to cite papers from archive journals. The present format copies much from reports to the stockholders of corporations, and one suspects the intended readers have changed from those desiring to learn what the Institution has done to prospective donors.

In addition to the *Year Books* the Department has a wealth of archival material of use to the historian. Its library and archives are filled with material relevant to past activities. In addition to books about the diverse science accomplished, there is a collection of nearly 19 000 photographs of land magnetic expeditions, 3700 of the cruises of the *Galilee* and the *Carnegie*, and 14 000 documenting instruments, buildings, personnel, attendance at meetings, even moments of great discovery. The library holds an unparalleled collection of scientific literature on geomagnetism and related fields, such as auroras, cosmic rays, terrestrial and atmospheric electricity, including more than 10 000 catalogued books, observatory and expedition reports, conference proceedings, theses and offprints in addition to long runs of the leading geophysical journals. This substantial base was initiated and fashioned by Harry Durward Harradon, who served as librarian, archivist, editor and translator from 1912 until 1949. Unless otherwise indicated, all images in this book come from the DTM archives.

One source for this history is conspicuously absent: Bauer's personal papers. He had an extensive correspondence, which has been frequently sought by historians of science but which has disappeared. It was known to have been in the custody of his daughter, but his granddaughter, Lucy Pirtle, did not find it on settling her mother's household. Bauer was an avid collector of books, all donated to the Department library. Fleming's papers are also missing with no clue as to their fate.

In telling the story of the Department one must record the principal science accomplished in sufficient detail for its significance to be appreciated. Unfortunately, the story requires some degree of understanding of scientific detail by the reader, and because of the wide variety of the subjects studied

at the Broad Branch Road location many well-informed readers will find their backgrounds inadequate for smooth reading, making some chapters difficult. The reader should apply the skills in selective skipping that he/she has acquired for just such occasions and wait until the troublesome paragraphs are past. As the Contents shows, there is variety ahead.

The preparation of this history has drawn on the generously provided help of many persons. Foremost has been Shaun Hardy, librarian and archivist of the combined DTM and Geophysical Laboratories collections. His knowledge of the material available and of the Department's history has proved invaluable, and his careful reading of the manuscript caused the removal of factual errors, flawed interpretations and an array of typos and clumsy sentences.

The staff has always shown a serious interest in DTM's history and many have read and commented on portions of the manuscript with improved copy the result. Current staff members who have performed this function are Alan Boss, Rick Carlson, John Graham, David James, Alan Linde, Timothy Mock, Vera Rubin, Selwyn Sacks, Sean Solomon, Fouad Tera and George Wetherill. Retired staff who have done the same are Philip Abelson, Thomas Aldrich, Roy Britten, Kent Ford and Paul Johnson. To them all my sincere thanks. For a careful reading of the manuscript by an outsider I am indebted to F. A. Kingsley.

Figure 1 Louis A. Bauer. Director 1904–31.

Figure 2 John Fleming. Assistant Director 1922–29, Acting Director 1930–34, Director 1935–46.

Figure 3 Merle A. Tuve. Director 1946–66. *Circa* 1963.

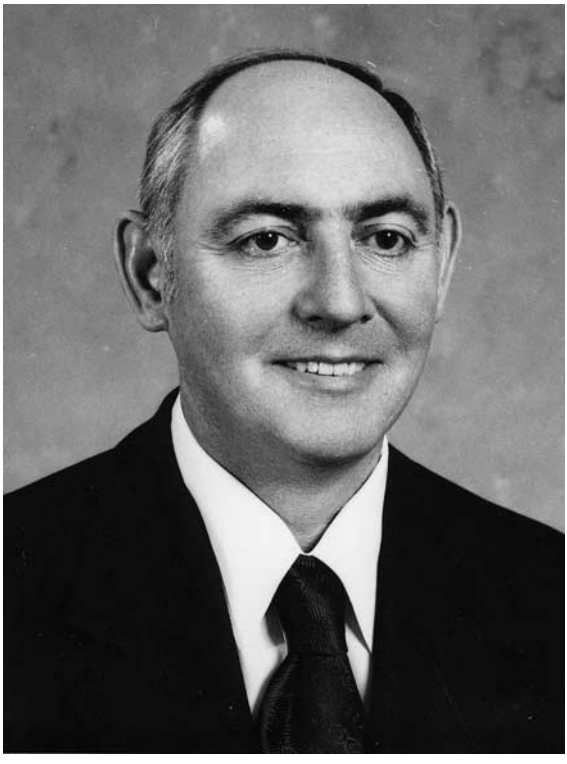

Figure 4 Ellis T. Bolton. Director 1966–74.

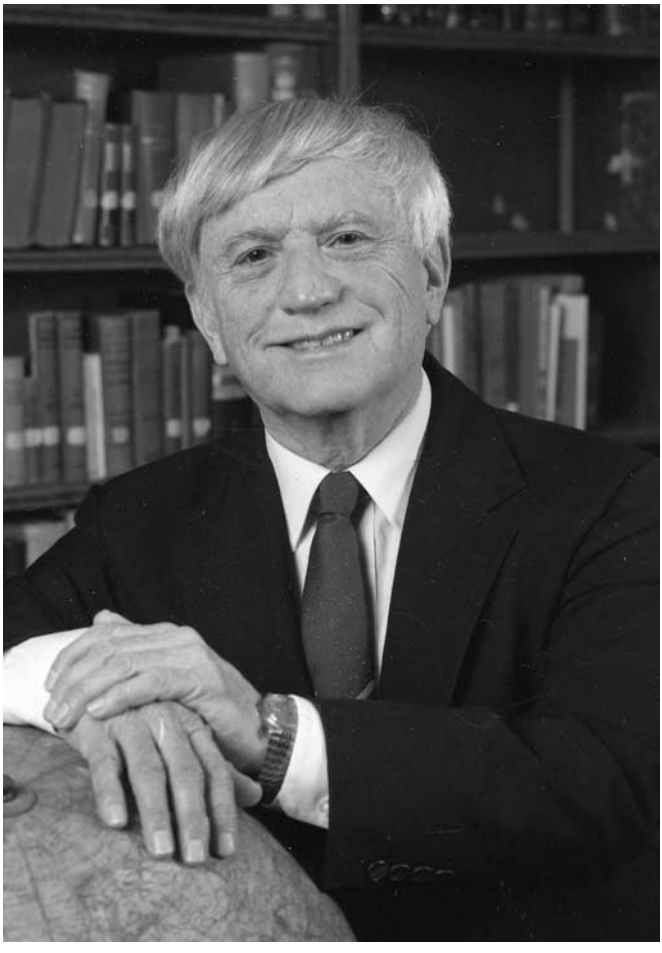

Figure 5 George W. Wetherill. Director 1974–91. *Circa* 1990.

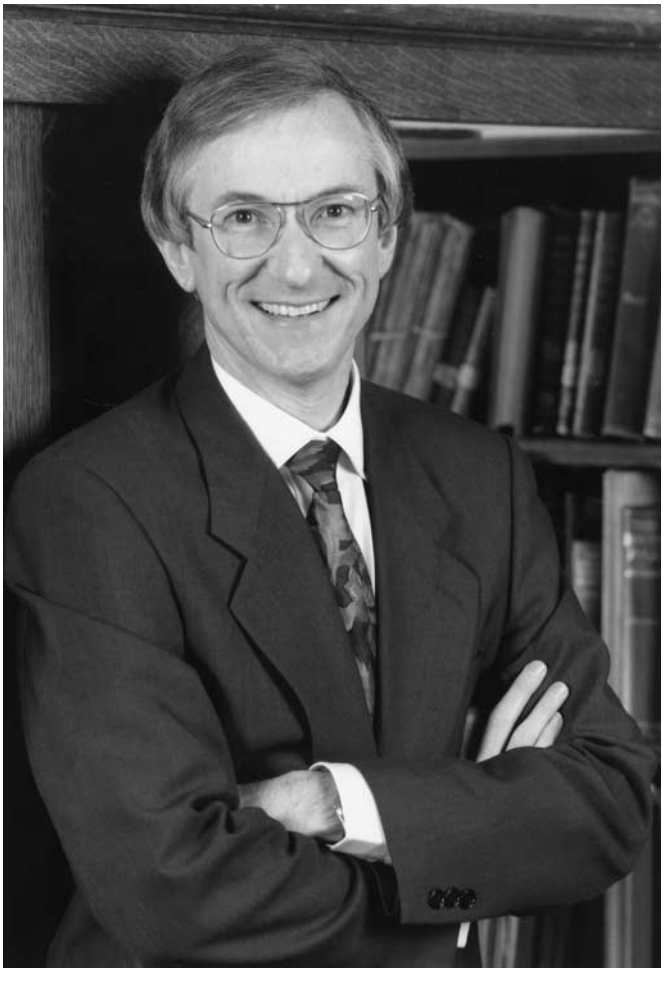

Figure 6 Sean C. Solomon. Director 1992–present.