Centennial History of the Carnegie Institution of Washington
Volume I The Mount Wilson Observatory

Since its foundation in 1904, the Mount Wilson Observatory has been at the center of the development of astrophysics. Perched atop a mountain wilderness, two mammoth solar tower telescopes and the 60- and 100-inch behemoth night-time reflectors were all the largest in the world. Research has centered around two main themes – the evolution of stars, and the development of the universe. This first volume in a series of five histories of the Carnegie Institution describes the people and events, the challenges and successes that the Observatory has witnessed. It includes biographical sketches of forty of the most famous Mount Wilson pioneer astronomers working during the first half of the twentieth century. Contemporary photographs illustrate the development and use of some of the innovative instruments that filled the observatory during this time. This story brings together the elements that formed modern theories of stellar evolution and cosmology.

ALLAN SANDAGE started as an observing assistant to Edwin Hubble in 1949 and then was appointed to the scientific staff of the Carnegie Observatories in 1952. He stayed to become a major player in the history of astronomy. For half a century, he has been a leader in the observational quest to understand stars, galaxies, and the universe. As such, Sandage is uniquely qualified to recount the history of the central themes of astronomy at the Mount Wilson Observatory.

CENTENNIAL HISTORY OF THE
CARNEGIE INSTITUTION OF WASHINGTON

Volume I

THE MOUNT WILSON OBSERVATORY

Breaking the Code of Cosmic Evolution

ALLAN SANDAGE
Observatories of the Carnegie Institution of Washington

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To the memory of the observatory on Mount Wilson, where a group of people were determined to understand the stars

CONTENTS

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

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A book of this type could not have been completed without inordinate help from others in the narrative, the preparation of the diagrams and photographs, and in many details of preparing the citations for the endnotes and the bibliography.

Nor could it have been written without the continuous use of the library of what was the Mount Wilson Observatory, now called The Observatories of the Carnegie Institution of Washington. This library, still one of the best in astronomy in its archival holdings, is complete in the bound volumes of the Mount Wilson Contribution series (MWC). Nearly every paper published from the Observatory in *the Astrophysical Journal* from 1904 to 1946 is in this series. The backbone of the science in the book rests on this complete record.

Interrogation could also be made of the older archive literature from individual observatory publications around the world and in the early runs of the standard international journals. The library's collection is particularly complete here. John Grula, librarian, has been helpful in many ways in locating obscure references, birth and death dates of the principal characters, and in the detailed task of gaining permissions to publish diagrams and photographs that did not originate at Mount Wilson. Grula's daily help was invaluable.

Several astronomers read parts of early drafts of some chapters. I am grateful to Guido Munch, Donald Osterbrock, Gibson Reaves, François Schweizer, and Gustav Tammann for their comments and suggestions. Larry Webster, senior observer on the Mount Wilson solar program of the University of California Los Angeles has been invaluable in supplying and checking important details of the early Mount Wilson solar telèscopes and their auxiliary instruments. Webster was the senior night assistant at the 60- and 100-inch reflectors when the mountain was still operated by the Carnegie Institution.

Steven Padilla, head of the observatory's photo lab following the legendary John Bedke, who left that post at Mount Wilson to assume a similar role as chief photographer at the Space Telescope Science Institute in Baltimore, was keeper of the archival photographs (organized by Bedke) that trace the history beginning in 1904. He provided photographic prints of many of the original images shown here. John Grula undertook the enormous task

of digitizing the 180 diagrams, many from the observatory's photographic archive, and making the electronic files necessary to publication.

The portraits of Pieter Zeeman in Chapter 7 and of Harlow Shapley in Chapter 17 were kindly supplied by Spencer Weart, director of the Center for History of Physics of the American Institute of Physics, from their Niels Bohr Library.

The portrait of Bertil Lindblad at work in Chapter 18 is from his son Per Olof Lindblad, to whom I am grateful.

The portrait of Guido Munch in Chapter 24 is from Guido himself, to whom I am grateful.

The Dudley Observatory kindly supplied the photographs for Chapter 19 showing various aspects of the Carnegie Department of Meridian Astrometry when it was at Dudley from 1906 to 1938.

Tina McDowell, director of editorial operations at the Carnegie Institution's home office in Washington, was the tough taskmaster but very capable liaison officer between our efforts in Pasadena and the Cambridge University Press.

My first thanks concerning the management of the manuscript itself go to Leona Kershaw, who transcribed multiple early electronic drafts (executed in a powerful but obscure early word-processing program), into an updated form so that my editor, Allan Fallow, could line-edit the manuscript. Fallow untangled my syntax, then suggested how we could reassemble the manuscript from the shreds. His editing weeded out redundancies and Proustian exhaustions that sometimes obscured the original. He is a genius at what he does, and I am most grateful for what he has rendered. Any infelicities of language that remain are my own.

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Becky Lynn, head of the mailroom and of the astronomers on the first and second floors in Pasadena, kept the transportation of the parts of the work going to the right places.

Finally, the incomparable Silvia Hutchison, the principal factotum of all factoti, kept the project on course. She channeled communications through her email address because none exists for me, and she saw to it that successive iterations of each chapter got shuttled back and forth week after week, again and again, as the project progressed.

Great gratitudes to all.

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