BOOK REVIEWS

Applications of a Beneficence

The Earth, the Heavens, and the Carnegie Institution of Washington. GREGORY A. GOOD, Ed. American Geophysical Union, Washington, DC, 1994. xiv, 252 pp., illus. $42; to AGU members, $29.40. History of Geophysics, vol. 5. Based on a conference, Washington, DC, June 1992.

But for the stubbornness of Andrew Carnegie and the influence of John S. Billings, the Carnegie Institution of Washington (CIW), founded in 1902 with a gift of $10 million from Carnegie, might have been a national university rather than a private institution for the patronage and conduct of scientific research. This book deals mainly with the CIW's support of geomagnetic research, astronomy, and ionospheric studies. Biology under the CIW's umbrella, some of it studied recently by Sharon Kingsland and Joel Hagen, and oceanography are left to others.

In its early days, the second president of the institution, Robert S. Woodward, its executive council, and its board struggled with the conflict between supporting "the exceptional man" (the phrase was Carnegie's) and support for disciplinary research or research groups. Initially aloof from universities, the CIW inadvertently found itself supporting the research stables of eminent academics. The debate was lengthy, but within a few years the CIW was the mainstay of a number of prominent scientists working in established and developing disciplines, among them Vilhelm Bjerknes, Raphael Pumpelly, F. A. Vening Meinesz, George Ellery Hale, and T. C. Chamberlin. It also established a number of research departments, among them its Department of Terrestrial Magnetism (1904) and its Geophysical Laboratory (1906–1907), both still in existence after nine decades of distinguished work.

In contrast to earlier studies of the CIW by Nathan Reingold and Robert Kohler, which mainly dealt with the founding of the CIW and its conduct of patronage in science, this book deals with the science itself, centering on geophysics but ranging from archeology to meteorology. Its sections are focused on the foundation of the institution and the evolution of geophysics in the early 20th century; fieldwork and expeditions; astronomy, notably the Mount Wilson Observatory; ionospheric studies; the CIW's research in other countries and at sea; geophysics after the Second World War, with emphasis on the influence of Merle Tuve; and bibliographic sources and resources relating to the CIW and to geophysics in general.

Inevitably, a book that ranges from hardcore history of science by recognized practitioners (among them Gregory Good, Ralph Jewell, Naomi Oreskes, Ronald Doel, R. S. Brashear, David DeVorkin, N. S. Hetherington, John Lankford, Owen Gingerich, C. Stewart Gillmor, Bruce Hevly, R. W. Home, H. E. LeGrand, and Thomas Cornell) to recollections by participants in the research will be uneven in style, format, and quality. Such is the case here. But the historical essays are of uniformly high quality and the recollections and interpretations of the participants add immediacy to this first concentrated account of the CIW's work in earth sciences.

Historians of geophysics will return to this volume frequently, partly because of its attention to sources: nearly every essay outlines the location and contents of its sources. The concluding section, Resources for Historical Research, outlines the strategy of archival collecting, describes the collections available at the CIW and elsewhere (the Huntington Library and the American Institute of Physics), and presents an album of photographs of CIW activities in the field and laboratory, all of high quality and historical interest.

I was intrigued especially by several of the essays. Good describes the uncertain status of geophysics in the early 20th century, its transition from data collection to topical and regional studies, and its struggle to win professional recognition separate from geodesy. Jewell will annoy social constructivists by his attention to Bjerknes's motives in providing a "grounding theory" of atmospheric motions. The CIW provided the justification of Bjerknes's attempt to give his theoretical work practical expression and the means by which it could be accomplished. Out of this came a series of unexpected advances in atmospheric and oceanic dynamics—and the Bergen school of meteorology.

Vening Meinesz's use of his new multipendulum gravimeters in submarines at sea during the 1920s came at a time when the figure of the Earth and isostasy were under intense study and when Alfred Wegener's mobilism threatened to upset geological applecarts. Oreskes makes the case that Vening Meinesz's work was an important step in linking an applied science, geodesy, with theoretical geology; out of this and later developments came the new discipline of geophysics.

Doel examines expeditions, particularly those supported by CIW money, as "transient institutions," asking how expeditions are related to or may result in the permanent institutions of science. He asks interesting questions about the origins of expeditions, their results, their relation to laboratory science, their dependence on vehicles, and their use of imagery as artifact and as promotional device.

Big science such as astronomy required collaborative work as well as big bucks. Theoreticians and observational astronomers rubbed shoulders, often with distrust, and women edged into science as "computers" of the masses of data emanating from observatories such as Mount Wilson, which was established by Hale in 1904. A series of papers paints a picture of the complexity of activity at Mount Wilson, the establishment of a physics laboratory in the observatory, and the development of theoretical astrophysics.

Neither Mount Wilson nor the CIW's other departments could be independent of outside links. Hevly shows the complexity of research cooperation between the CIW's Department of Terrestrial Magnetism (DTM) and a government agency, the Naval Research Laboratory, in ionospheric studies. Rather than arriving at a common view of what was important, the two maintained their own approaches and independence despite exchanges of ideas, money, and instruments. The DTM had scientific enterprises in far-off places as well, undertaking surveys of geomagnetism in unstudied areas, including the oceans. Home's paper describes the colonial approach of the DTM to the establishment of a magnetic observatory in a remote part of Western Australia and how local initiative led to the evolution of the observatory from an outpost of a foreign power to a component of burgeoning Australian science 30 years later.

Merle Tuve, director of the DTM from 1946 into the 1960s, had a powerful influence on CIW science and was not afraid to swing his colleagues' work into areas he considered important. Tuve warmed at first to paleomagnetic research. Then as it grew confusing he redirected the attention of his department to isotopic dating, as LeGrand

discusses, and thus away from one linchpin of the revolution in geology that occurred in the 1960s. Tuve's individuality and force of personality resulted in successful deep seismic studies of the continental United States. Cornell ranges beyond this to analyze Tuve's style of science and his passionate support of pure research; "he viewed research as a sport that emphasized personal participation and the progressive development of technique."

It is unlikely that we will see again a scientific world like that envisioned and experienced by CIW researchers between 1902 and the 1950s, in which pure and applied research could be funded by a wealthy private institution without much consideration of social or financial consequences. Good and his co-authors give us a view of what may come to be considered the early Golden Age of research in the Earth sciences. They are likely to provoke new, even more wide-ranging studies of geophysics, the Sleeping Beauty engendered by physics and geology, then transformed by the princely kisses of patronage, wartime needs, and the development of new instruments and techniques.

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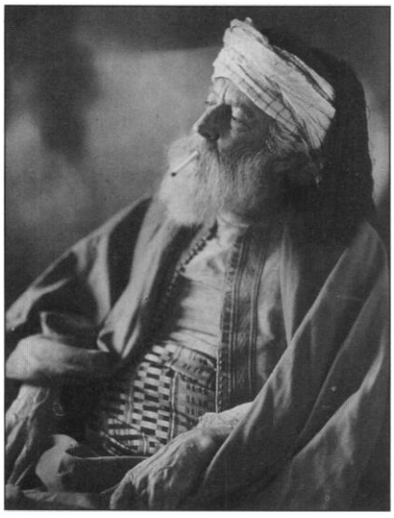
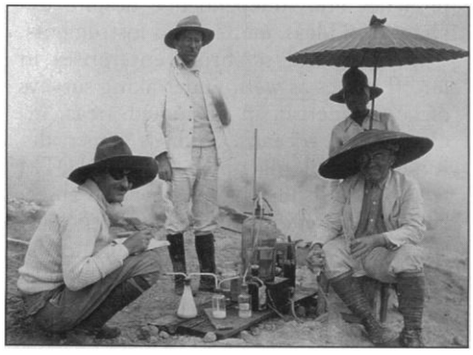


"Undated portrait of petrologist H. S. Washington in Greek costume (1920s?). Washington's interest in volcanic rocks evolved through his archaeological 'tours' of the Mediterranean Region. His monumental compilation of 30 years of data, *Chemical Analyses of Igneous Rocks* (1917), was based on an original system of classification ('CIPW')." [From *The Earth, the Heavens, and the Carnegie Institution of Washington*]

"Crossing Australia by camel train with E. Kidson's expedition, 1914. Kidson's magnetic survey followed less than a decade after survey teams blazed the 'Canning Stock Route' through often hostile parts of Western Australia. His exploratory work is reflected today in the names of several natural features in the region." [From *The Earth, the Heavens, and the Carnegie Institution of Washington*]



"Members of an expedition from the Geophysical Laboratory and the Volcanological Survey of the Netherlands East Indies, collecting volcanic gases at Papandayan volcano, Java, 1928. . . . Kilauea, Lassen Peak, the Valley of Ten Thousand Smokes and Yellowstone were among the sites of volcanism and hydrothermal activity studied actively in the pre-World War II era." [From *The Earth, the Heavens, and the Carnegie Institution of Washington*]

Scientific party on the bridge of the research vessel *Carnegie*, with the after observatory in the foreground, August 1909. [From *The Earth, the Heavens, and the Carnegie Institution of Washington*]

Lines of Defense

Primordial Immunity. Foundations for the Vertebrate Immune System. GREGORY BECK, EDWIN L. COOPER, GAIL S. HABICHT, and JOHN J. MARCHALONIS, Eds. New York Academy of Sciences, New York, 1994. xii, 376 pp., illus. Paper, $100 or £69.50. Annals of the New York Academy of Sciences, vol. 712. From a conference, Woods Hole, MA, May 1993.

In these times of antibiotic resistance it is critical that we uncover all of the strategies that have evolved to combat pathogens. The adaptive (also referred to as acquired or anticipatory) immune system is so called because of its capacity to respond to a virtually infinite variety of antigens as they are presented to it. T and B lymphocytes with clonally distributed receptors (T-cell receptor and immunoglobulin, respectively) are the major players of the adaptive immune system. While this adaptive system is apparently present only in the vertebrates, so-called nonadaptive immune functions have existed in one form or another since life began. There are many innate cellular and humoral immune mechanisms, which can be sophisticated; often such mechanisms have been maintained in vertebrates either as a primary means of attack or for interactions with the adaptive immune system. The use of invertebrate models to examine such processes as phagocytosis, cytotoxicity, and inflammation permits an unclouded view of primitive defense systems in the absence of overwhelming adaptive responses.

This book offers one gemlet after another describing the various mediators and phenomena found in invertebrate and lower-vertebrate immune systems. The three-page preface provides a concise and informative introduction to immune strategies present in invertebrates and relates how many of these systems have been exploited by vertebrates. There is also a clear description of what can be gained in clinical medicine and basic science by understanding "primordial immunity."

Several chapters speculate on the evolu-