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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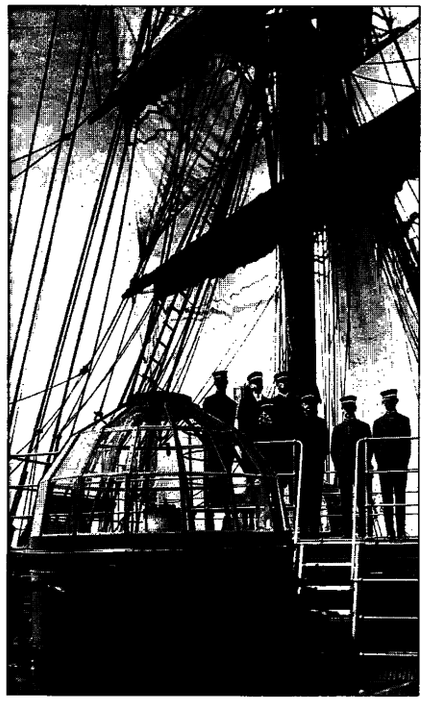
"Undated portrait of petrologist H. S. Washington in Greek costume (1920s?). Washington's interest in volcanic rocks evolved through his archaeological 'tours' of the Mediterranean Region. His monumental compilation of 30 years of data, *Chemical Analyses of Igneous Rocks* (1917), was based on an original 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-

tion of the adaptive immune system, of which there is definitive evidence, both at the functional and at the molecular level, in the cartilaginous fish (sharks, skates, and rays). The lamprey and the hagfish are the only two living representatives of the earliest vertebrate class to arise in evolution, and they have failed to yield any indication of an adaptive system built around T and B lymphocytes. Taking into consideration all of the data from the vertebrate and protovertebrate taxa, Smith and Davidson argue that it is unlikely that the adaptive immune system arose *in toto* early in the vertebrate line; they suggest that, like most other physiological systems, the immune system was built bit by bit, with innovations being maintained and subjected to selection as vertebrates became more complex. Whether this supposition is correct or not, it provides a framework for comparative immunologists to position new findings. I personally believe that most of the fundamental signatures of the adaptive immune system emerged in concert, since shark antigen receptor genes undergo rearrangement and somatic mutation and polymorphic major histocompatibility antigens are expressed in a fashion similar to that of mammals.

Those sections of the book that combine the theoretical with the experimental are the most engaging. Chapters on the evolution of the thiol-ester bond, phagocytosis and opsonization, and invertebrate cytokines are particularly informative, especially when comparisons with similar mechanisms in vertebrates are made. One gets the impression that most of the background players that interact with the adaptive immune system arose early in evolution, that is, the Pips, representing an assortment of nonadaptive immune mechanisms, antedated Gladys Knight, symbolizing lymphocytes expressing immunoglobulins and T-cell receptors; the collaboration that ensued is arguably as successful for the immune system as "Midnight Train to Georgia" was for G. K. and the Pips.

What are the origins of the adaptive cellular immune system? Until recently the best model in invertebrates has been a polymorphic histocompatibility system in tunicates that regulates the rejection of genetically disparate colonies. However, vertebrate histocompatibility molecules apparently did not evolve their high level of polymorphism for direct recognition by receptors on lymphocytes but rather for the intracellular acquisition of peptides with diverse sequences; that is, rejection of allogeneic grafts in vertebrates is non-physiological and apparently covergent with the tunicate rejection process. However, a nonadaptive cell-mediated response in vertebrates is performed by natural killer (NK) cells that seemingly scan the body for the *absence* of self-histocompatibility markers. Such a mechanism is suggested in this volume for the colonial tunicates and sponges. Further, the molecules on vertebrate NK cells mediating the recognition process may be C-type lectins, a phylogenetically old and diverse family that is reviewed in detail here. Identification of the receptor-ligand pairs involved in the histocompatibility reactions of invertebrates is needed to judge whether they indeed are forerunners of those used by the vertebrate recognition system.

The book is subtitled "Foundations for the Vertebrate Immune System." Those mechanisms that have been preserved and modified in vertebrates are well portrayed. However, when and how the adaptive immune system arose with its hallmarks of gene rearrangement, epigenetic tolerance induction, and memory sustained by somatic mutation of antigen receptor genes remains obscure. This book does not (and cannot) provide the answers to this last question, but it certainly presents a wealth of information useful for anyone who is curious about the evolution of immunity.

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Vignettes: Electronic Transformations

The mysteries of religious dogma have throughout history been managed by various tightly knit priesthoods of custodians, regardless of time, culture, or place. What [the availability of the] computer-aided analysis [of the Dead Sea Scrolls] has done . . . is to strike a blow for accessibility and freedom of access to religious information. The silent electronic servant may be as potent a religious force as the Protestant reformer Martin Luther, who posted his 95 Theses "for the purpose of eliciting truth" on the door of All Saints Church in Wittenberg on October 31, 1517.

—*Anne Wells Branscomb*, in *Who Owns Information? From Privacy to Public Access* (BasicBooks)

Similar to the way previous media dissolved social boundaries related to time and space, the latest computer-mediated communications media seem to dissolve boundaries of *identity* as well. One of the things that we "McLuhan's children" around the world who grew up with television and direct-dialing seem to be doing with our time, via Minitel in Paris and commercial computer chat services in Japan, England, and the United States, as well as intercontinental Internet zones like [Multi-User Dungeons], is *pretending to be somebody else*, or even pretending to be several different people at the same time.

—*Howard Rheingold*, in *The Virtual Community: Homesteading on the Electronic Frontier* (Addison-Wesley)

The Second Sociality

Queen Number and Sociality in Insects. LAURENT KELLER, Ed. Oxford University Press, New York, 1993. xii, 439 pp., illus. $75 or £50.

It probably appears an annoying distraction to many that many social insects have many queens per colony and that these may all be fertile. The textbook picture of single-queen colonies enables one to understand the evolution of eusociality, namely that form of sociality characterized by reproductive self-sacrifice, castes, and relatively greater longevity of the reproducing females. But we should be ready to take on new complexities now that we understand that kin selection is indeed the engine that, without exception, drives all models for the evolution of eusociality and that male haploidy (the genetic system in which males arise from unfertilized eggs and are haploid), through its effects on sex allocation, indeed promotes the evolution of eusociality.

The occurrence of many queens per nest has been called (originally by Rosengren and Pamilo) the "second sociality" and poses its own problems. After all, given that kin selection drove the evolution of eusociality in the first place, how can selection of any kind favor the addition of further queens to a colony, which dilutes the relat-