excellent portraits of such scientists as Lillie or Loeb, plus glimpses of numerous others. It reveals much about the nature of funding for science and about institutions such as the Marine Biological Laboratory. Only in the presentation of Just's scientific background and in the assessment of his particular contributions does the book falter at all. Even here the greatest problem is that Manning leads the reader to want more. Manning obviously understands Just and his work; he presents Just's ideas clearly and accurately. Yet when he steps outside Just's work to assess it within its context, the result lacks some of the depth that the rest of the study offers. Perhaps it is unfair to expect more. As it is, Manning's volume establishes beyond doubt that Just was an important and fascinating scientist, and in doing so it marvelously exemplifies what a superior scholarly history can be.

JANE MAIENSCHEIN
*Department of Philosophy,
Arizona State University,
Tempe 85287*

Mathematics and Reform

Neohumanism and the Persistence of Pure Mathematics in Wilhelmian Germany. LEWIS PYENSON. American Philosophical Society, Philadelphia, 1983. xii, 136 pp. Paper, $10.

Most studies in the history of science concern either the evolution of scientific ideas or the context in which those ideas evolved, or both. Pyenson's learned monograph concerns neither; instead, his subject is the relationship between an ideology ("neohumanism") that became entrenched in 19th-century German academic life and the attempts to reform mathematics education in the secondary schools of Germany between 1890 and 1914. His treatment of this esoteric and complex subject should be of interest to students of the history of science, mathematics, education, and culture.

To help us understand his subject, Pyenson recapitulates the meaning and function of the neohumanist ideology. Neohumanism, we are reminded, was a revival of the values and ideals of life as presented in ancient Greek literature and culture. The emphasis was strictly on the ideal in life, not on the practical or the real. The study of mathematics and the Greek and Latin languages and literatures formed the backbone of the neohumanist secondary-school curriculum. Between the early 19th and the early 20th centuries neohumanism functioned as the "ideological basis" of the elitist secondary schools—the Gymnasien—and the universities in Germany. Virtually all of Germany's 19th-century political and professional leaders were educated on this basis.

After 1870, however, academic specialization and Germany's rapid industrialization led to criticism of the neohumanist ideology. Reformist mathematicians and scientists, along with engineers and modern language teachers, challenged the content and distribution of subject matter taught in the classical Gymnasium. Between 1890 and 1914 the reformers, Pyenson shows, sought to emphasize applied—as opposed to pure—mathematics, to expand the scant amount of experimental science instruction offered in the secondary schools, and, in general, to increase the opportunities of graduates of other types of secondary schools to study at the German universities.

Pyenson's most original contribution is his discussion of the role of mathematicians and natural scientists—including, among others, the chemist Friedrich August Kekulé, the polymaths Hermann von Helmholtz and Ernst Mach, and the mathematician Felix Klein—in the debates about curriculum reform. He has skillfully used his knowledge of the history of physics and mathematics in Germany to highlight the central role of Klein and his acolytes within the reform movement. Mathematics, he argues, played a two-faced role in the secondary-school curriculum. On the one hand, its emphasis on abstraction and purity made it an integral part of the traditional neohumanist curriculum; on the other, its potential applications in the physical sciences and engineering made it important to the reformers. Pyenson stresses the pure mathematicians' claim that pure mathematics could also solve scientific problems in the real world; they thereby preserved, he says, pure mathematics. Klein and other mathematicians sought to reform secondary-school mathematics in order "to maintain the power of vested interests in the mathematical disciplines" (p. 57).

My only criticism of Pyenson's study emerges from his enigmatic title. For in one sense, a cognitive rather than social-institutional one, how could pure mathematics have *failed* to persist? In my opinion, by the middle of the 19th century mathematics' own internal logic guaranteed its continual development irrespective of the existence of neohumanism or the reformist activities concerning mathematics education in the secondary schools. Moreover, Pyenson says relatively little about the state and development of mathematics at the university level. This criticism notwithstanding, there is much to learn from Pyenson's fine account of neohumanism and the attempts to reform secondary-school mathematics instruction in Wilhelmian Germany.

DAVID CAHAN
*Department of History,
University of Nebraska,
Lincoln 68588*

The Philosophy of Space-Time

Foundations of Space-Time Theories. Relativistic Physics and Philosophy of Science. MICHAEL FRIEDMAN. Princeton University Press, Princeton, N.J., 1983. xvi, 386 pp., illus. $35.

Over the last decade or so, a new standard of rigor has emerged in scholarly writing on the philosophy of space and time. This has come concurrently with the carrying over from mathematical physics of the "intrinsic" or coordinate-free method of formulating space-time theories. Friedman's new book will provide the philosophically oriented reader a palatable introduction to these new standards and methods, which are used exclusively throughout the book.

The essence of the new method is to treat the entities of space-time theories in a way that is independent of any coordinate system. For example, vectors are no longer thought of in terms of quadruples of numbers in a given coordinate system. Rather they are defined as a certain type of mapping of scalar fields on the space-time manifold, which turns out miraculously to have all the required properties. For this, coordinate systems just need not be mentioned. Friedman takes care to introduce these new ideas with "motivation" in the body of the text and to give a more rigorous development in a brief but in my case much-thumbed appendix.

The value of this new approach can be illustrated in brief by Friedman's discussion of the derivation of the Lorentz transformation (pp. 138–142). Traditionally, the linearity of the transformation is justified by an appeal to the homogeneity of space. Friedman's insistence that we clearly specify the structures that constitute this "space" shows just how ambiguous and incomplete this appeal is. It is satisfied, for example, by any space of constant non-vanishing curvature, in which the desired linearity condition does not obtain.

Friedman uses the new methods to give a thorough comparison of Newton's and Einstein's theories of space and time. He starts with a simple Newtonian theory of absolute space and, working Tinker-Toy style, adds and subtracts objects from it, progressing through various versions of Newtonian gravitation theory, classical electrodynamics, and special relativity and finally arriving at general relativity. Friedman carefully weighs the methodological criteria used to guide each step. Later in the book, this enables him to develop what he calls a picture of scientific method, based on the notion of theoretical unification.

In contrast with more traditional treatments, each theory is written in the same formalism, so that the exact differences between them become especially clear. We find a now traditional objection well justified: Einstein cannot claim that his theory is a true general theory of relativity just because its equations are generally covariant. For the equations of *all* the theories Friedman considers are presented in generally covariant forms. But Friedman does not allow this to settle the question. Following an approach best known from J. L. Anderson's 1967 *Principles of Relativity Physics*, he introduces the concept of "absolute objects." These are objects that act upon other objects of the theory without in turn being affected. Examples are the Minkowski metric of special relativity and the vector field defining absolute rest in some versions of Newtonian theory. Einstein's general theory of relativity is distinguished as being the only theory considered that is entirely free of these objects. It is essentially through this feature that the theory answers the epistemological objections that Einstein tells us guided him to his theory.

Unfortunately Friedman does not seem to have made any further serious attempts to understand the motivations that guided Einstein. Rather, in a way that is now all too familiar, he characterizes them as based on confusions compounded to the point of irresistibility (p. 209) and all but ignores Einstein's later reassessments and reformulations. If Einstein was really so fundamentally confused, then surely it is more than astonishing that he achieved all he did. I prefer to locate much of the confusion in *our* understanding of Einstein's motivations.

The remainder of the book deals with the questions of relationism and conventionalism in space-time theories. Friedman argues for a realist approach to space-time, rather than what he calls the Leibnizean relationist view, in which physical reality is accorded only to *occupied* points in space-time, that is to physical events. The argument is based on the methodological criteria, which began to emerge in earlier chapters, concerning whether we should ascribe physical reality to a given theoretical entity. Space-time passes the test because it has definite unifying power in Friedman's reconstructed development of space-time theories. In particular, Friedman concludes, adopting the realist attitude means that our space-time theories are better confirmed by the relevant evidence.

I was disappointed that Friedman should allow his arguments against relationism to focus on such general methodological issues, when developments in relativity theory have blurred the fundamental distinction upon which that view depends: the distinction between space-time the container and matter the contained. For, at least on a theoretical level, general relativity has fused space-time with the gravitational field and the energy-momentum that it carries. Friedman treats this thorny but crucial issue only briefly and in passing (pp. 222–223).

Following the work of Reichenbach and others, it has become widely accepted that the ascription of a geometry to space or a distant simultaneity relation to events in special relativity is conventional in large measure. In each case, the argument rests on the possibility of producing a range of theoretically distinct but empirically equivalent versions of the appropriate theories. To choose between them in any more than a conventional way, it is said, is to introduce an arbitrary, empirically superfluous structure into the theory. Here the intrinsic approach has a dazzling impact. From its point of view, as Friedman demonstrates, the situation is exactly reversed, and it is the conventionalists who are guilty of introducing arbitrary structures. For one can only produce these empirically equivalent formulations by introducing what are now seen to be empirically superfluous objects, such as a universal force field or one that generates an anisotropy of space.

Friedman's book is a timely addition to the literature on the philosophy of space and time. It is distinguished by the care and clarity of its exposition and will surely become compulsory reading for anyone seriously interested in keeping abreast of recent developments in the field.

JOHN NORTON
Center for Philosophy of Science, University of Pittsburgh, Pittsburgh, Pennsylvania 15260

Hominids from Iraq

The Shanidar Neandertals. ERIK TRINKAUS. Academic Press, New York, 1983. xxvi, 502 pp., illus. $47.50.

Most of the scientific community now accepts the fact that the characteristics of modern human anatomy evolved from predecessors of distinctly less than modern appearance between 30 and 40 thousand years ago. The first of these predecessors to be recognized as such was found in the Neander Valley, the Neanderthal as it then was, in western Germany in the middle part of the last century. Many have subsequently used the term "Neanderthal" to stand for that grade in human evolution where modern brain size had been reached but before those reductions occurred that transformed Middle Pleistocene levels of skeletal robustness and muscularity into modern form.

What is not generally realized is that this view of Late Pleistocene human evolution has traditionally been rejected by the very specialists whose efforts have produced the evidence on which it is based. Consequently, analyses of major discoveries aided by modern techniques and perspectives, such as Trinkaus's report *The Shanidar Neandertals*, are of especially great interest.

Shanidar Cave in Iraqi Kurdistan near the borders with Iran and Turkey was excavated between 1951 and 1960. Seven adult and two infant human skeletons were found in varying degrees of completeness and in datable stratigraphic context. For the first time it was possible to use modern sedimentological, palynological, and radiometric techniques to assess the life and times of the inhabitants of a site of such age and importance. However, it is a mystery why it took a whole generation to produce a final description of the seven fragmentary human skeletons when time, money, and the best of skilled professionals were available from the beginning.

The delay was certainly not the fault of Trinkaus, who only took on the project in 1976. When he first got to the Iraq Museum in Baghdad, he found that one of the most important crania had not yet been unpacked since its excavation 16 years earlier. He got right to work, and, in an ambitious series of reports culminating in the book under review, he has produced the definitive description of the Neanderthal skeletons from Shanidar Cave. It is a careful and methodical, bone-by-bone descriptive account. Further, Trinkaus compares the Shanidar material with other Neanderthal and