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.

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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.

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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.