education in 1969. The latter finding bolsters the authors' conclusion that there has been an overinvestment in education; before-tax returns on physical capital are 13 to 15 percent and thus greatly exceed the usual social rate of return to education. Since the rate of return declines with additional years of study (except for the study of law and medicine), the overinvestment is particularly marked in the case of the master's and Ph.D. degrees.

Following F. Thomas Juster's *Education, Income, and Human Behavior*, this second volume from the National Bureau of Economic Research provides a detailed analysis of the determinants of earnings. The data set is unique: a longitudinal sample of 5000 men who, having volunteered for the Army Air Corps, were surveyed in 1943, again in 1955, and a third time in 1969. Having at least a high school diploma and with test scores at the college sophomore level, this cohort of males was more intelligent (and less averse to risk) than the average. The authors are careful to warn that some of the results, drawn from a sample of a special population, may not be generally applicable.

But the more important caveats, as John Meyer points out in a foreword, have to do with what is being measured. Can research identify the nonpecuniary returns to education? The bureau's studies will continue to probe the relationship between education and other, often nonfinancial factors such as health, demographic behavior, and the taste for leisure, and between preschool environment and school performance. Taubman and Wales, too, raise broader questions for research. What types of abilities influence earnings, and how are these abilities to be measured? Can we determine what cognitive or affective skills education improves, and how?

Looking further into the black box called education, as the authors propose, may reassure educators. For the moment, however, we are confronted with some sobering conclusions: personal characteristics and mental abilities contribute as much to earnings as education; the real rate of return on a college degree is only about 8 percent; approximately half of that return is due to the screening effect of education.

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Aspirations for the Mechanic Arts

Philadelphia's Philosopher Mechanics. A History of the Franklin Institute, 1824–1865. BRUCE SINCLAIR. Johns Hopkins University Press, Baltimore, 1974. xiv, 354 pp. $15. History of Technology.

Studies of institutions are often dull, because the data fit temptingly into chronological or discrete topical patterns. Rarely does such research combine readable, thoughtful analysis with extensive detail and scholarly apparatus. In this history of the Franklin Institute in the mid-19th century Sinclair has produced a volume that is integrative, combining contemporary presuppositions about egalitarianism and the nature of learning into what might otherwise have been a narrow study of a meritorious institution.

The Franklin Institute, founded in 1824, was intended to promote industrial advancement and technological research. Through a careful comparison of it with similar institutions, Sinclair justifies his claim that Philadelphia's mechanics' institute (appropriately named in honor of that city's most illustrious experimentalist) was the prominent technical organization in pre-Civil-War America. Its early leadership proved flexible in adapting ideas from similar British institutions and in trying various schemes—popular lectures, industrial fairs, and educational programs—for promoting the mechanical arts. Experimentalists at heart, the leadership was not inhibited by false starts and continued to test not only mechanical but also institutional alternatives. As the title of this volume indicates, the intention of the Institute was never simply to produce technical (or mechanical) expertise but to offer sufficient background that students acquired a philosophical (or scientific) foundation as well.

Interested in providing national leadership, certain members of the Institute challenged the Patent Office to establish the principle of open access to approved patents and worked for clearer guidelines on procedures. Although the Institute's resolutions were not immediately acted upon, a statute passed in 1836 incorporated several of its proposals. Probably the most famous project of the Institute was an investigation, under grant from Congress, into the cause of steam boiler explosions on riverboats. A tightly cast report, written by an ambitious young scientist, Alexander Dallas Bache, outlined the experimental techniques used to analyze the design, materials, and constructions of steam boilers, various safety devices available, and procedures for safety checks of equipment in service.

A fortuitous combination of aspiring young scientists located in or near Philadelphia in the 1830's pulled the Institute toward professionalism. Its *Journal* was transformed from an eclectic and reportorial newsletter to an organ for new research; expert opinion was solicited on articles submitted, and the editor was relegated to the routine tasks of circulating material and checking proof and copy. The young leaders insisted that more emphasis be placed on investigation than on exhibit, on exploring for the future than on lauding the past. Not surprisingly, there was a growing tension between persons interested in popular programs and those concerned with research.

Some of the popular and educational schemes were old-fashioned (though of a sort in current usage), as for example the competitive exhibits for producers of textiles or machinery and gala fairs to demonstrate local enterprise. Sinclair might have assessed such programs more carefully. Although they attracted attention, it is not clear that they fulfilled the initial intention of providing incentive for new invention.

The Institute's stated goal was to elevate the mechanic and enhance the quality of American technology. Sinclair never comes to terms with the class bias evident in the leadership of the organization, nor does he spend much time on the individuals who participated in short-term educational programs.

The enthusiasm of the young Institute, which fit so well into the optimistic, progressive outlook of a new nation, was contagious. Sinclair concentrates on the formative years during which the Institute's activities brought it international recognition, paying less attention to subsequent programs whose successes were more limited. For the most part he is objective, but he is clearly attracted to the goals of the scientific leadership and occasionally dominated by their enthusiasms and by their later disenchantment. Toward the end of the study detail overrides analysis, perhaps because the problem of decline is difficult to discuss.

Years of research are evident in Sinclair's familiarity with the persons in his study, and he generally confines his fascination with tangential data to footnotes. The documentation is thorough, the bibliography excellent, and the annotated index helpful. An added bonus is four pictorial essays illustrating the persons and apparatus common to Philadelphia's technological effort. More discussion of the equipment shown and the relationship between selections in each section would

Cover advertisement from the *Journal of the Franklin Institute*, July 1846. "Building fire engines was one of [Philadelphia's] mechanical specialties. . . . The talents required . . . rather naturally led Philadelphia mechanics in two related directions—the production of steam engines and of machine tools." Thomas P. Jones, the editor of the *Journal*, "had also once engaged in the manufacture of fire engines [and] carried advertisements in his *Journal* which called attention to their increasing versatility." [From *Philadelphia's Philosopher Mechanics*]

have made the presentation informative as well as engaging.

Overall, this book is an exceptionally good one. It demonstrates that an institutional study can provide a fresh perspective on a long-standing issue. During the Institute's early years, the relationship between science and technology was under continuous scrutiny by practitioners and by the public. Briefly the philosopher mechanics seemed to link the two. Then the coordination fell apart. Were the assumptions of a relationship false? Was the approach of the Institute inadequate? Sinclair raises and works with such problems, but the problems are larger than the Institute, whose experience remains a provocative anomaly. This study of Institute personnel and practice underscores the point that engineers, educational leaders, scientists, and industrialists had much in common and could work constructively together during the first half of the 19th century. Backgrounds and goals were less diverse than they would be among such groups in later generations.

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Meanings of Reductionism

Studies in the Philosophy of Biology. Reduction and Related Problems. Proceedings of a conference, Bellagio, Italy, Sept. 1972. FRANCISCO JOSÉ AYALA and THEODOSIUS DOBZHANSKY, Eds. University of California Press, Berkeley, 1975. xx, 390 pp., illus. $22.50.

There has been a philosophy of science ever since there has been science. Only in the present century, however, and increasingly in recent years, has the philosophy of science been formally recognized as a professional and pedagogical specialty. Early in this movement it was generally assumed that an acceptable philosophy of science was, or would be, derived from the physical sciences. Biologists soon began to object to that exclusive approach, and the question arose whether and in what way a philosophy including the life sciences would differ from or add to one based exclusively on the physical sciences. It is particularly interesting that a number of physical scientists who began to consider living organisms some 30 years ago did so in the expectation or hope of discovering either new physical principles or nonphysical ones. Witness, for example, Schrödinger (*1*) and Delbrück (*2*). On the other hand increasing emphasis in biology on its physical and chemical or specifically molecular aspects led many biologists to look toward strictly physicochemical explanations of biological phenomena. Thus in more recent years we have had an eminent molecular biologist, Crick (*3*), adopting an uncompromising physicochemical approach to the properties (but not necessarily the history) of organisms, while an also eminent physical chemist, Polanyi (*4*), maintained that organismal phenomena are not reducible in that way.

In pursuit of such problems in the last ten years or so there have been a number of conferences bringing together physical scientists, life scientists, and philosophers of science. At some of them the meeting of minds has been almost minimal because the vocabularies, premises, and prejudices in the three fields are so different. At others, however, there has been progress in overcoming those handicaps.

The basic problem between the physical and the life sciences on which a philosophy to encompass both must focus involves reductionism, in some sense of that word. One of the most extensive of the relevant interdisciplinary efforts was a series of three conferences at the Villa Serbelloni, Bellagio, Italy, in 1966, 1967, and 1968, arranged by C. H. Waddington, who also edited the three resulting volumes (*5*). The subject of reductionism underlay many of the discussions at those conferences and occasionally surfaced, for instance in a remark by Waddington (a footnote in volume 1 of the publications) that "even the most doctrinaire reductionist cannot tell the biologists just what they have to reduce their systems to." Nevertheless, and rather surprisingly, there was no special focus on reductionism and that was not among the designated topics of any of the conferences.

It is thus particularly welcome that a conference specifically directed to the subject of reductionism was held, also at the Villa Serbelloni, in 1972 and that its content has now been published. It was arranged and the resulting book is edited by Francisco Ayala and Theodosius Dobzhansky, geneticists of successive generations, both specialists on *Drosophila* and both with exceptionally broad biological and philosophical interests. The participants and authors include a wide spectrum of similarly philosophically minded biologists and a few who are more specifically philosophers of science, but no physical scientists strictly speaking. The latter omission, obviously deliberate, is justified by having kept the discussion largely in terms mutually comprehensible. There are still differences in points of view, in interests, and in vocabulary, as is inevitable in a group with such diverse specialties and