laboratories designed to develop new products for commercialization), Riken grew by the early 1940s into an unwieldy melange of small and medium-sized companies employing some 40,000 workers in a wide variety of industries.

Riken's founding genius, Masatoshi Okochi (1878–1952), was trained as an engineer at Tokyo Imperial University. He then became not only a scientific entrepreneur but also a prolific and remarkably prophetic writer. Noting Japan's lack of natural resources, Okochi stressed the need for an indigenous, science-based, perpetually innovative industrial system organized so as to take advantage of the nation's highly educated and energetic work force. During and after the Pacific War, Okochi was denounced in some quarters as a fascist, partly because his companies had helped produce munitions. Cusumano here sees him as a visionary, an important writer comparable to such Americans as Frederick W. Taylor and Thorstein Veblen. Certainly some of Okochi's writings have an uncannily modern ring. More than two generations ago, contemplating the rise and decline of nations, he wrote that although Great Britain was continuing to produce an ample number of first-rate basic scientists, British engineers were falling behind. Worse still, British business firms were typically taking a short-term view. They were emphasizing finance and profit-taking more than market share and process technology and were lagging in the design and engineering of new, science-based products. Okochi argued that this was the fundamental reason why Germany surpassed Britain in modern industrial enterprise.

Does this indictment sound familiar?

THOMAS K. MCCRAW
Graduate School of Business Administration, Harvard University, Boston, MA 02163

Organizations and Careers

The Bureaucratic Labor Market. The Case of the Federal Civil Service. THOMAS A. DIPRETE. Plenum, New York, 1989. xvi, 341 pp. $39.50. Plenum Studies in Work and Industry.

This is a book about how an organization's decisions affect the careers of its employees. Since the organization at issue is the Federal Civil Service (which has about the same share of the nation's workforce—3%—as New York City has of the nation's population), the findings are of more than academic interest. What makes this book appealing is that its conclusions have both academic and practical importance—or, more accurately, that its theoretical analysis contributes to our understanding of the real-world predicaments of federal civil servants.

The basic conceptual apparatus DiPrete employs is derived from the theory of internal labor markets. This perspective stipulates that career mobility within organizations is more strongly influenced by rules, that is, the rules that identify promotion sequences or job ladders, than by the more chaotic and free-wheeling forces of supply and demand. DiPrete breaks new ground, however, because he does not take the shape, length, and strength of job ladders as given but as factors to be explained and examined empirically. Of central importance to employees' careers are the barriers that separate various jobs in white-collar hierarchies, as well as the ladders that link them.

Thus in the late 20th century large organizations of all kinds recognize separate tiers of clerical and administrative work. This is a distinction of considerable stability, held in place by the framework of social status and moral sentiment. It is also, as DiPrete exhaustively demonstrates here, a relatively recent construction. As late as 1927, he tells us, "the State Department had only an undersecretary and three assistant secretaries above the chief *clerk*" (p. 65, my emphasis). How the line between managers and clerks was drawn in the federal service and what it has done to the careers of civil servants become the central themes of this monograph—themes that are developed with demographic and with historical data.

The historical narrative has the flavor of a detective story. Blame (or credit) for the segregation of clerical and administrative careers could be plausibly allocated to any number of social forces. The British civil service, which reserved superior positions for the university-educated, was a ready model throughout the late 19th and early 20th centuries. The Progressive movement often pushed in the same direction—better government meant more efficient government staffed by the college-trained and the technically competent. Taylorism (scientific management) contributed through its development of systematic job description, job classification, and organizational centralization. There were also diverse forces of resistance. A persistent American ideology of egalitarian democracy, federal employee unions that wanted to protect promotion rights of existing members, and political efforts of veterans each slowed down the imposition of a clerical-administrative barrier.

This stalemate was not broken decisively, DiPrete informs us, until after the end of World War II. What finally turned the tide in favor of separate administrative and clerical job ladders appears to have been developments outside more than inside the federal government. At this point, the story gets rather murky, but the key factors can be positively identified. One was the changing job market for college graduates in the 1940s and '50s—a market in which the federal civil service was competing poorly. To enhance its market position, the Civil Service Commission implemented a hiring strategy that linked formal testing (the Federal Service Entrance Exam) and college recruiting. A second contingency was the increasing identification of lower level white-collar work with women. Although this was certainly occurring outside of the federal government, DiPrete tends to focus on feminization of clerical work within the civil service.

The historical evidence provided here reveals some interesting truths and raises some interesting questions. For example, the emergence of separate governmental career paths for the college-educated was not a simple result of the inexorable march of "credentialism." But it is not completely clear how the other relevant social forces actually brought about the change that occurred. How did the establishment of a career track for baccalaureate managers enhance the government's market standing? Did candidates for administrative jobs demand protection against competition from lower-level employees? Were they assured of this protection in private sector markets? Which mattered more, the external market or the government's response?

Having described and accounted for this "structure," DiPrete then proceeds to assess its vitality. Through a painstaking, and occasionally pains-giving, statistical analysis of mobility records, he demonstrates that job ladders constrain but do not fully determine individuals' paths through the bureaucratic system. Considerable attention is also devoted to understanding how the differential opportunities embedded in job ladders explain the relative mobility chances of women and minorities in the federal government. A separate chapter examines the impact of affirmative action and Equal Employment Opportunity provisions on the mobility system (which was left largely intact) and the mobility chances of protected employees (which were, nevertheless, enhanced). Throughout these analyses, DiPrete sustains an interesting comparison between the clerical-administrative boundary and the technical-professional line. Although all the statistical findings are presented with technical rigor, some could have been communicated with greater substantive clarity.

In general, this is an ambitious and suc-

cessful book. Despite the presence of a few problems—an arid first chapter that is rather disconnected from the rest of the volume is the biggest one—there is a lot offered here for both the specialist and the general reader. The book elevates the methodology of the case study to a level that has been previously seen only in such organizational classics such as *Union Democracy*. Most important, it reminds us of a basic truth of organizational and social life: the natural and rigid distinctions that frame our most important decisions are not necessarily either.

WILLIAM P. BRIDGES
Department of Sociology, University of Illinois, Chicago, IL 60680

A Cooperative Innovation

The American Synthetic Rubber Research Program. PETER J. T. MORRIS. University of Pennsylvania Press, Philadelphia, 1989. xii, 191 pp., illus. $34.95. The Chemical Sciences in Society.

Evaluating the effectiveness of research programs has been a problem that has plagued every industrial research director since Willis Whitney joined General Electric's new and pioneering laboratory in 1900. Because technological innovation is a process that encompasses a much larger sphere than the immediate laboratory environment, the relationship between a research program and any innovation is a complex one. At opposite ends of a spectrum, researchers can provide a host environment into which outside developments can be implanted, or they can invent and innovate radically new technologies. In this small book Peter Morris attempts to say some big things about research and innovation. Through the example of the research arm of the American synthetic rubber program, Morris asserts that cooperative research is less productive than proprietary research between competing firms, the reason being that companies undertake research to develop patented products or processes that will give them a competitive advantage. In making this assertion, Morris assumes that major developments score the most points in the research contest; but before accepting the final tally on his scorecard, it is necessary to put the research program in a broader perspective.

In late 1941 as the Japanese Empire spread into Malaya and the Dutch East Indies, the United States found itself cut off from its supply of natural rubber. To remedy this situation, the wartime government managed a massive effort to create a synthetic rubber industry based on a butadiene-styrene copolymer developed in Germany in the 1930s. American rubber companies had done some work in this area, but low prices of natural rubber had kept the work in the laboratory stage. Not only were there economic problems but technological ones as well; the rubber companies knew how to make tires, but their knowledge of petrochemicals and polymerization was limited. The wartime program overcame these obstacles—production went from virtually nothing in 1943 to 850,000 tons in 1945—because the technical capabilities of the chemical, oil, and rubber companies were combined in a cooperative effort that probably could not have happened in peacetime. Overall, synthetic rubber was a successful innovation.

In this book, Morris focuses more narrowly on the official "research" arm of the project. Founded in October 1942, this effort was initially headed by Robert R. Williams, an experienced Bell Telephone Laboratories chemist and an expert on natural rubber. Over the next year Williams enlisted 12 universities to join the program, the key figures being Carl Marvel at Illinois, Piet Kolthoff at Minnesota, and William Harkins and Morris Kharasch at the University of Chicago. Other participants were the major rubber companies, Bell Laboratories, and the National Bureau of Standards. During the war when the large-scale production of a standardized product was the goal, the researchers' role was troubleshooting and doing fundamental studies of the process and polymer. Even Morris agrees that this research was largely successful, even though it failed to develop an all-synthetic-rubber truck tire. That problem would not be solved until the mid-1950s when it became possible to make synthetic natural rubber.

After the war the government did not turn over the synthetic rubber plants to the private sector immediately because there was considerable uncertainty about the ability of synthetic rubber to compete against its natural counterpart. For strategic reasons the military wanted America to have the capability to be self-sufficient with regard to this critical material. In addition to the military concerns, the government had invested $677 million, which it hoped could be partly recouped by auctioning the plants to private industry. For these reasons, the government-funded research program continued after the war with the general goal of improving synthetic rubber until it was comparable in price and properties to natural rubber. This goal was accomplished in the late 1940s and early 1950s, but the major innovations—cold polymerized butadiene-styrene rubber, oil-extended rubber, and synthesized natural rubber—all came from outside the program. Major new innovations that come from outside established industries are commonplace in the history of technology. Very often the rewards of invention do not go to those who make the breakthrough but to those who innovate making maximum use of the new technology. This appears to have been the case in the postwar rubber industry.

With synthetic rubber on a sound economic and technological footing, the government auctioned the plants to industry in 1955, raising over $260 million. At this point the government research program was disbanded after having spent $56 million over 13 years. After 1956, funding of new synthetic rubbers fell to the military. Although a number of commentators, including Morris, have lamented the alleged waste of money by the civilian program, no one has cast a critical eye at the military programs. Industrial and academic scientists who had benefitted from the government program probably were happy to see the funding shifted to the military, where outside criticism would be muted by the exigency of the Cold War.

JOHN K. SMITH
Department of History, Lehigh University, Bethlehem, PA 18015

Words About Invention

Inventing for Fun and Profit. JACOB RABINOW. San Francisco Press, San Francisco, CA, 1990. x, 278 pp., illus. $18.75. History of Technology Monographs.

Engineers are notoriously nonverbal, preferring to think and work in the media of drawings and numbers. When they put pencil to paper, it is more than likely to sketch a new idea or to calculate a new arrangement of materials and things. But engineering drawings and calculations are not ends in themselves, for they serve mainly to communicate the artifact to other engineers, to machinists, and to technicians. When the artifact is realized in tangible form, the drawings and calculations are often forgot-