

and others began to emphasize empirical facts and experimental tests could modern science begin.

Historians have conventionally identified Copernicus as a seminal early figure for his intellectual leap of putting the Sun at the center of our planetary system. But as Crump explains, ingrained philosophical prejudice led Copernicus to stick with perfectly circular orbits, which caused him no end of difficulty. It was Johannes Kepler, building on the massive compilation of observations by Tycho Brahe, who proved that the planets follow elliptical orbits. This apparently small geometrical innovation was an epochal development: It placed mathematical analysis of hard-won data above abstract reason in the forming of scientific theories.

Crump makes a worthy effort to explain the importance of devising reliable, standardized ways to measure things—distances, masses, times, electric currents, and so on. Such mundane matters are usually relegated to footnotes, but Crump provides anecdotes that illustrate how much ingenuity was required to solve these forgotten problems. Unfortunately, highlights such as these are buried in a generally rambling text in which the author is at pains to mention every experiment and invention he can think of and leave the reader to figure out their importance. As much as Crump wants to concentrate on observations and experiments, it takes theory to cohere apparently contradictory or inconsistent empirical findings into a comprehensible whole. His reluctance to provide clear summations of the bits and pieces of evidence is tantamount to writing a murder mystery and leaving out the final chapter.

—DAVID LINDLEY

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**SCIENTISTS, BUSINESS, AND THE STATE, 1890–1960.**

By Patrick J. McGrath. Univ. of North Carolina Press. 248 pp. \$39.95

McGrath has written an extremely important intellectual history of American science in the 20th century. While delving into such familiar episodes as the Manhattan Project, the debate over the hydrogen bomb, the security hearing of J. Robert Oppenheimer, and various arms control issues, McGrath concentrates on

the larger question of how scientists changed American political culture. His insights are sure to stir controversy.

An independent historian trained at New York University, McGrath argues that beginning in the 1890s, an elite group of American scientists forged a profitable alliance with the country's corporate, political, and military elites. Initially, this alliance elevated the status of scientists in the public-policy arena. As expert technicians, these corporate scientists—such men as Frank Jewett, Karl Compton, David Lilienthal, Vannevar Bush, and James Conant—believed that science could transform America and inaugurate an era of economic progress, social stability, and national security. Inspired by that “Great Engineer,” Herbert Hoover, they thought of themselves as progressives who could construct a “harmonious, classless meritocracy.” In 1890, America had only four industrial research laboratories; by 1930, there were more than a thousand.

The meritocratic dream, together with Hoover's presidency, collapsed in the Great Depression. During World War II and then the Cold War, McGrath argues, a different vision of American science prevailed. The relatively moderate progressive vision of Lilienthal, Bush, and Conant was supplanted by a scientific militarism. “Scientists and administrators such as Edward Teller, Lewis Strauss, and Ernest Lawrence, with their full-throated militarism and anti-communism, pushed American scientists and their institutions toward a nearly complete and subservient devotion to American military interests.”

Even President Dwight D. Eisenhower felt compelled to protest. When an official committee in 1957 advocated expanding the nation's nuclear arsenal, Eisenhower said: “You can't have this kind of war. There just aren't enough bulldozers to scrape the bodies off the street.” Yet Bush, Conant, and the other moderates mostly stayed silent. “I kept in channels rather religiously, perhaps too much so,” Bush once reflected. By the 1960s, this once idealistic class of corporate scientists had made so many compromises that they had become mere technicians serving military masters. These experts, as McGrath puts it, “did not openly challenge the policies of their allies and benefactors. They were simply good soldiers.”

—KAI BIRD