whether scientists themselves understand "the nature of science" very well. Indeed, ours is only the first generation of philosophers to embrace Locke's underlaborer role so openly.

Many of Callebaut's interlocutors seem to think that, in following Locke's lead, they are also continuing the project of the logical positivists and their Popperian cousins. The positivists are credited with good intentions in wanting to model philosophical practices on scientific ones. But they are faulted for their failure to master the details of particular sciences, with the partial exception of physics. Yet Callebaut's interlocutors are at a loss to explain how it was that the positivists, for all their technical deficiencies, managed to exert so much influence over scientific methodology and the public image of science.

One hypothesis is that the positivists were not trying to be underlaborers at all but were in fact using science to promote certain philosophical ends of greater societal import. From this angle, we may be able to see the point of Latour's perplexity. Consider the symbolic function of the natural sciences in the project of "Enlightenment" promoted in our own time by Karl Popper. The idea here is not one of philosophers paving the way for a mounting body of esoteric knowledge. Rather, it is one of extending to all spheres of life the critical attitude that had motivated scientists to challenge traditional beliefs in the first place.

As science becomes more expensive and more technical, it is increasingly difficult to sustain the spirit of criticism. Some followers of Popper, such as Paul Feyerabend, have gone so far as to suggest that scientific research programs need to be cut down to a size that enables criticism to flourish. Thus, when Feyerabend argues—against Kitcher and Ruse—that creationism should be taught alongside evolutionary theory in the public schools, he is not offering an opinion on the probative value of creationism *per se* but rather an opinion on the social contexts in which its probative value should be determined. This distinction is subtle but crucial for understanding the politics of science implied by the underlaborer model and why such politics might puzzle Latour and disturb Callebaut.

For his part, Feyerabend intervened in the creationist controversy as someone who wanted to square the imperatives of science and democracy. This is a classically philosophical interest that requires sustained thinking about science, but without being beholden to particular scientific research programs. In contrast, as he recalls to Callebaut, Kitcher became involved in the controversy as a partisan for the evolutionary cause. His first impulse was to forge a "new consensus" in the philosophy of science, one whose united front would keep the creationists out of the classroom. Philosophers have always been known to slip into ideology as their political ends overtake their intellectual means. However, today's philosopher-underlaborers come dangerously close to being apologists for the masters whose houses they so dutifully clean.

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Pipers and Tunes in Science

Prometheus Bound. Science in a Dynamic Steady State. JOHN ZIMAN. Cambridge University Press, New York, 1994. x, 289 pp. $24.95 or £16.95.

Across the industrialized world, strategic planning for basic science is the rage. From Tokyo to Brussels and Washington, the common purpose is to use scarcer funds more productively in order to serve national economic goals. But there's a catch: no one knows confidently how to plan science more reliably now than in the past. In the United States we can see this in the consternation elicited by recent calls for the National Science Foundation and the National Institutes of Health to chart "strategic goals." And in the European community, governments are stewing about the rationale for and expectations from university-based research funding.

Prometheus Bound is a masterly contribution to our thinking on these issues. In an elegantly woven appraisal, John Ziman speaks about and for the research community, proud of its past while finding its aspirations and resources under siege. Ziman substantiates the "radical, pervasive, and permanent structural change" in the institutions of the scientific enterprise. And he asks, "Can the research system be reshaped without losing many features that have made science so productive?" His prognosis is guarded. If Ziman were to pen in advance an epitaph for our spectacularly successful 20th-century science, my hunch is that he would write, "Died of extreme accountability."

Beginning ruefully by documenting the evident limits on growth in funding for all of research and development—an asymptote of 2 to 3 percent of national income in the most advanced nations—the book moves relentlessly to explore the consequences of this new "steady state" for basic science. What are the effects, asks Ziman, of "knowledge creation, the acme of individual enterprise, being collectivized" in the interest of national prosperity? The prose is clear and the tone consistently realistic ("nostalgia is a fruitless sentiment"). Ziman does not indulge in any superficial advocacy of addressing science's problems by applying merely a bit of money, here and there, just this year, nor does he toy with the possibility of science's returning to a period of double-digit growth.

In the heyday of the 1960s, a few perceptive leaders in science mapped the trends and estimated the consequences now emerging. After 30 years of policy analysis, we know a great deal about the linkages of education and fundamental research with the enormous range of activities essential to higher economic productivity. Yet past experiments with "targeting" science have yielded mixed results, and some long-range research driven only by curiosity has yielded unexpected economic benefits. Thus hopes for better research planning are undercut by the fear (as of a hex) that any fix will be worse than the present pattern. This concern is familiar to everyone immersed in public policy: "you want results and you get consequences."

Put another way, if science were managed more tightly, would the system leave enough freedom for investigators to follow their intuitions in ways that are not immediately "relevant" to explicit goals but might produce results widely applicable in meeting public needs and enhancing markets? To illustrate the point, Ziman reminds us of Faraday's legendary reply to a parliamentarian skeptical about the uses of electricity—"Someday you will tax it." Accordingly, science policy-makers are stuck with the problem of how to balance features of a bottom-up, pluralistic system in which investigators compete on criteria of quality measured against goals charted broadly with features of a top-down system in which allocations are made to scientists among subfields for quite specific purposes. Each nation employs some features of both models.

Ziman, a distinguished British physicist, demonstrates how well he knows the inner

Vignettes: Writing and Reading

There are three ways of writing books: bad, good and excellent.
—*A. Kondrashov*, in *Trends in Ecology and Evolution*, March 1994, p. 111

A book is like a mirror. If a monkey looks into it no apostle looks out.
—*Georg Christoph Lichtenberg* as quoted by Alan L. Mackay in *A Dictionary of Scientific Quotations* (Institute of Physics)

workings of distinguished laboratories and corridors of power. He empathizes with the current unease of working scientists, and he understands the rising demands imposed on corporate executives, university leaders, government bureaucrats, and politicians. Ziman presents these tensions with the eye and ear of a fine novelist. He tellingly characterizes a selection panel's agony about the final decisions on funding grants. He gets under the skin of a senior investigator juggling the financial and administrative tasks of managing a laboratory, and he portrays sensitively a young scientist working through conflicts and obstacles in building a career. Shrewdly exploiting an ample supply of such observations, Ziman unerringly exposes the causes of the current distress in the system.

In large measure, the distress stems directly from the new economic situation. As many analysts have noted—a well-chosen cross-section of pertinent works is given in Ziman's superb "armature" (bibliography) for this book—the tendency toward level funding inevitably leads to qualitative changes in institutions accustomed to open-ended growth. Furthermore, the costs of frontier research keep rising. Gone, accordingly, are the leisure and freedom to seize unforeseen opportunities, and gone is the margin of funds that enable risk-taking and speculation. Will widespread public optimism about the likely benefits of research go next? Will young people enter science and engineering when every dollar is tight, every moment scheduled, every funding renewal in doubt, every research achievement weighed by the press or the public for possible adverse consequences?

Ziman integrates his tale of the workings of science with the social context that affects the enterprise. As the weather for funding has changed, research also has become clouded by sternly utilitarian expectations. Voters, shareholders, planners, and cabinet officers issue slogans about wealth creation, job creation, technology policies, and university-industry-government partnerships. Journalists repeat these slogans and ask about milestones, priorities, and benefits. The system churns and whirls with little patience for inevitable research failures and delays. The life sciences were long protected from these stresses, partly because of the universal appeal of "health advances." Today, however, they too face new limits on funding, and their future is complicated by an array of conflicting views flowing from animal rights activists, ethical critics of genetic engineering, managers controlling costs of health care, and entrepreneurs and government planners who bank on biotechnology to build economic growth.

In Ziman's consideration of where these trends may lead there are a few deficiencies. One major omission is consideration of the 80 percent of the world's population who currently have only 15 percent of the world's scientists and engineers with only 5 percent of the R&D funding and who aim to build their research capacity for accelerated economic development. In China and India, and across the rapidly industrializing Asian and Latin American regions, scientific institutions may set a different course for the 21st century from the one set 200 years ago in Europe and the United States. With the quickening pace of new global partnerships in, say, environmental research and of technology-led private alliances for economic development, governments and firms might make more, or less, room for basic science. Growing systems in other regions may develop hybrid styles, evolving novel arrangements for research.

Ziman also gives short shrift to two other key subjects. One is the issue of developing career possibilities for women in science and engineering. Although Ziman appreciates the rising importance of talented women, just a few paragraphs touch on this moral and pragmatic imperative for every country. A second gap has to do with the military's role in research and development. Defense "conversion" affects tens of thousands of professionals and vast sums of money. Not only will total global research funding probably be reduced, substantial human resources will be underemployed. Ziman scarcely scratches this subject.

On the other hand, Ziman's British perspective on "the regime of science" brings welcome fresh air to the debates on this side of the Atlantic. In describing the "new ball game . . . in its own terms, according to its own rationale," he makes astute use of examples from Britain, where "the transition to level funding was peculiarly disheartening and disruptive." In the United States, the research community is only now learning, as has long been recognized in the United Kingdom and Europe, that talk of a "national science base" is unrealistic, as witness the internationalization of research in high-energy physics.

On balance, then, Ziman lays bare and probes deeply the current concerns of science and those faced with making policy decisions affecting it. His sensible and subtle approach to how the research system actually works will complement historical accounts given by, for example, Nathan Rosenberg and L. E. Birdzell Jr. in *How the West Grew Rich*. Most will agree with Ziman that it is no longer enough to assert that science runs best when running free. The roughly $160 billion spent for research and development (including $25 billion for "basic" research) in the United States is just too much funding to be treated lightly; and governmental missions (agriculture, health, defense, and space, to name only a few) have always dominated public investments in research and development. Yet it is unreasonable to ask science alone to be responsible for assuring prosperity.

Like the Carnegie Commission on Science, Technology, and Government in its reports on goal-setting and other topics, Ziman underscores the point that science's accountability to its sponsors is at once more crucial and more fraught with risks than is often realized. The classical distinctions between policy-for-science (how much for chemistry?) and science-in-policy (what are wise uses of chemical analysis in environmental regulation?) must not be confused in the urgency to anticipate results and delimit frontiers. Ziman reveals such distinctions and nails the errors of those who fail to see them.

Let every minister and legislator, every journalist and citizen, and, yes, scientists and engineers too, go to Ziman's inspiring seminar. An antidote to facile judgments, his essay is also a wonderful read. With wit, grace, and light touches of erudition, Ziman clarifies the challenges of managing the enterprise of discovery. The horizonless enterprise may be in danger, says Ziman, because of new requirements and practices "so ill-judged that they could do lasting damage to the health of science and its efficacy as a social institution."

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