There has indeed been a huge growth in the number of Ph.D. scientists during the past half-century. In 1940, there were 320 doctoral scientists and engineers for every one million Americans over the age of 22; by 1966, the total had reached 778, and now it stands at 2,000. This vast increase in quantity, Stephan maintains, has resulted in a discernible decrease in quality.

"The average quality of people going into science in the '70s and early '80s," Stephan claims, "was not as high as in the '50s and '60s in terms of motivation, ability, and interest in science." In the 1970s, according to studies by Stephan and Sharon G. Levin of the University of Missouri, recent Ph.D.'s in particle physics were producing, over a two-year period, an average of nine fewer articles than their predecessors in the 1950s did.

The quality of an individual scientist's work suffers when he does not have adequate resources, stimulating colleagues, and due recognition, she argues. These are available at top-level research institutions and national laboratories, but most new science positions have been created elsewhere. A physicist's chance of being at one of those "right places" plummeted from 50 percent in 1963 to 17 percent in 1973.

The large number of scientists, asserts Stephan, also has encouraged intense competition among them, with the result being not only an inordinate amount of time spent chasing research grants but a general avoidance of research that could be important but may well not pan out.

Further contributing to the putative decline in the quality of scientists, Stephan contends, has been the shift by increasing numbers of very bright students, starting in the early 1970s, away from scientific careers and toward the more lucrative fields of business, law, and medicine.

Critics of Stephan's argument are not in short supply, Holden found. "The young assistant professors I've seen are more capable and more brilliant than ever in the past," asserts Richard Atkinson, chancellor of the University of California, San Diego. Critics say that more Ph.D. scientists are required to sustain the U.S. economy's technological edge. Unless "we're just going to change the whole society we're living in," Atkinson says, we need to have more scientists.

## RESOURCES & ENVIRONMENT

### *Going To Market For Cleaner Air?*

"Incentive-Based Regulation: A New Era from an Old Idea?" by Robert W. Hahn and Robert N. Stavins, in *Ecology Law Quarterly* (Vol. 18, No. 1, 1991), Boalt Hall School of Law, Univ. of Calif., Berkeley, Calif. 94720.

For more than two decades, economists have been pushing the idea of market-based environmental regulation. In recent years, Congress and others involved in making policy have started to listen. When the Clean Air Act was overhauled last year, for example, Congress and the Bush administration included a "tradeable permit" system for controlling acid rain. Under this scheme, companies are permitted to generate certain levels of sulfur dioxide; if they keep their emissions below those levels, they can then sell their surplus permits to other firms. This gives companies economic incentives to keep their emissions down.

In the past, Congress and the Environmental Protection Agency (EPA) have favored the "command-and-control" approach to environmental protection, compelling firms to use certain pollution-control equipment or to meet certain emission standards.

That sort of regulatory approach may work to control pollution, say Hahn, a resident scholar at the American Enterprise Institute, and Stavins, a Harvard professor of public policy, but the method is inef-

ficient (because the costs vary greatly among firms) and expensive to society. Since 1984, the cost of compliance with U.S. environmental regulations has increased nearly 40 percent and now stands at about $90 billion a year. Set against a backdrop of fiscal austerity and concern about improving U.S. firms' productivity and competitiveness, the high cost of command-and-control environmental protection has made political leaders and environmentalists much more receptive to market-oriented ways of pursuing the same goal. The Environmental Defense Fund, for example, has become "an enthusiastic proponent" of such approaches, the authors say, and the Sierra Club and the National Audubon Society now back "selective use" of them.

Economic-incentive methods have been employed in the past on a limited basis. In 1982–87, the EPA, in its successful drive to reduce use of lead in gasoline, used a permit system that let fuel refiners "bank" and "trade" their lead-content savings. Other market-oriented devices have been put into use here and abroad. Nine states, for example, seeking to reduce litter, have mandatory deposit laws in effect for bottles and cans. France, the Netherlands, and Germany curb water pollution by means of fees or taxes.

Hahn and Stavins say they are "bullish" on the use of economic incentives but still think they will remain limited. EPA bureaucrats, environmentalists, and others have a great deal invested in the status quo. Even industry lobbyists in Washington display a "curious resistance" to market-oriented reforms. Like their opponents, their stock-in-trade is manipulation of the existing system; new rules for playing the game are a threat (and might, at least at first, cost some industries more). But despite all the resistance, the authors say, economic-incentive proposals are going to get "a warmer reception" from policymakers in the years ahead.

## *Too Hot To Handle*

"Risk Perception, Trust, and Nuclear Waste: Lessons from Yucca Mountain" by Paul Slovic, Mark Layman, and James H. Flynn, in *Environment* (Apr. 1991), Heldref Publications, 4000 Albemarle St. N.W., Washington, D.C. 20016.

When it comes to the disposal of highly radioactive nuclear waste, expert appraisal and public opinion could not be more opposed. Government and industry scientists say that spent fuel from the nation's 111 commercial nuclear reactors—each one generating about 30 tons of high-level nuclear waste every year—can be safely stored in deep, underground repositories for tens of thousands of years. The risks involved are negligible, most specialists say. Yet the public regards those risks as immense and unacceptable. In Nevada, intense opposition from both state officials and residents has stymied the U.S. Energy Department's efforts to evaluate Yucca Mountain as a potential site for a permanent nuclear waste storage facility.

Surveys that psychologist Slovic, president of Decision Research, and his colleagues conducted in 1988–90 asked people to reveal the thoughts or images that came to mind in response to the term *underground nuclear waste repository*. More than half the 10,000 responses were negative, and the words most often expressed were *dangerous, danger, death,* and *pollution*. Positive images were rare.

The public's fears, the authors say, represent "a profound breakdown of public trust in the scientific, governmental, and industrial managers of nuclear technologies." Restoring this trust will not be easy, they observe, especially in light of past Energy Department "mismanagement" of the Yucca Mountain project.

The only feasible course, they conclude, "is to delay the siting of a permanent repository for several decades and to store the wastes wherever they are produced in the interim in dry-cask storage." According to the National Research Council, they note, such storage is "as safe as underground storage" for 120–150 years.