

promise more than they can deliver has long been a feature of scientists' work, but in recent decades overly bold promise-making has become more central to the scientific process.

It's easy to blame a media culture that demands "uncomplicated, definitive, and sensational statements" to drive stories, but scientists often have their own reasons for hyping their research, glossing over challenges they face, or laying out unrealistic timelines. After *The New York Times* ran a story in 1980 urging readers not to expect immediate miracles from research on cancer-fighting interferons, researchers complained that such public expressions of doubt would undermine their ability to get funding for their work.

And there's the rub. Intense competition for research dollars encourages scientists to overstate the importance of their research and the immediacy of the expected benefits. Moreover, a growing focus on scientific research as an engine of economic growth means that science must produce not only knowledge, but products that can be sold at a profit. Funders now customarily ask applicants for an estimate of their work's economic impact. Intense competition for publication in prominent journals adds further momentum to the cycle of scientists trying to "rhetorically overbid" each other.

More pressure comes from the fact that "politics is becoming more reliant on science to provide predictions to guide policy," Blackman writes. Last year, then-prime minister Anders Fogh Rasmussen of Denmark appealed to a gathering of climate scientists, saying, "I need fixed targets and certain figures, and not too many

considerations on uncertainty and risk." Recognizing uncertainty and risk, however, is central to good science.

Cures for diseases such as Alzheimer's, cystic fibrosis, and Parkinson's have seemed to be just around the corner for years. If the only thing that comes down the pike in the near term is more disappointment, the public's current high esteem for science may erode. Blackman cautions that scientists (and the journalists who cover them) need to be more guarded in describing what the public can expect from their research, and when to expect it. As the eminent physicist Niels Bohr quipped, "Predictions can be very difficult—especially about the future."

SCIENCE & TECHNOLOGY

Nuclear Power Goes Global

THE SOURCE: "The Growth of Nuclear Power: Drivers and Constraints" by Richard K. Lester and Robert Rosner, "Nuclear Energy and Climate Change" by Robert H. Socolow and Alexander Glaser, and "Nuclear Power Without Nuclear Proliferation?" by Steven E. Miller and Scott D. Sagan, in *Daedalus*, Fall 2009.

THE RISING SPECTER OF GLOBAL warming, along with expected increases in the price of oil, is reviving the fortunes of nuclear power around the world. Today's critics are talking less about the accidents at Three Mile Island (1979) and Chernobyl (1986) than about the threat of nuclear weapons proliferation exemplified by North Korea and Iran.

Today, 30 countries operate 436 commercial nuclear reactors, produc-

ing about 16 percent of the world's electricity with minimal emissions of greenhouse gases. Another 44 units are under construction, and, according to the World Nuclear Association, ground may be broken for an additional 70 in the next 15 years. There is also a larger and more indefinite "proposed" category. Some 50 countries have declared an interest in exploring nuclear power.

That sounds like a lot of activity, but it will take a much bigger surge of construction to make a dent in emissions of greenhouse gasses. Richard K. Lester and Robert Rosner, of MIT and the University of Chicago, respectively, report that the world would need to at least double the amount of electricity derived from nuclear power in order to eliminate just a quarter of the increase in carbon dioxide emissions expected between now and 2050.

The writers in this issue of *Daedalus*, which is devoted exclusively to nuclear power, are less concerned with technological problems than political ones. Lester and Rosner say there are two possible paths into a nuclear future. One is to continue the long-term trend toward standardization of everything from reactor design to training and regulatory procedures. Pioneered by France with its 58 reactors and increasingly embraced in the United States, which has 104, this strategy has produced an excellent record of safety and efficiency. But as developing countries seek nuclear power, smaller, more customized plants with more built-in passive safety features might be required.

What about the radioactive spent fuel? Reprocessing in "breeder" reactions creates byproducts needed in making weapons, but the more com-



A machine used to excavate a five-mile tunnel emerges from Yucca Mountain, a possible nuclear waste repository in Nevada, in 1997.

mon and desirable method is to store the wastes. Lester and Rosner say that existing surface storage techniques can be improved, but the longer-term solution probably lies in new “deep borehole” technologies that bury the wastes far underground.

Robert H. Socolow and Alexander Glaser, both of Princeton, note that uranium must be enriched in order to produce fuel suitable for power plants, and even a small factory could be modified to make the more highly enriched form used in nuclear weapons—enough to make 25 to 50 bombs.

For the next decade, most new plants will come on line in countries that already have nuclear power. But the list of longer-term aspirants includes many countries that are rela-

tively poor, unstable, and undemocratic, ranging from Indonesia to Algeria, Kazakhstan, Haiti, and Belarus. Some are plagued by high levels of terrorism, including Thailand, the Philippines, and Sri Lanka. This raises concerns about safety as well as proliferation, note Steven E. Miller of Harvard and Scott D. Sagan of Stanford, and makes it imperative to think carefully about prevention. Strengthening the Nuclear Non-Proliferation Treaty is

Dozens of countries, including many that are relatively poor, unstable, and undemocratic, want to build nuclear plants.

one obvious path, but without movement toward complete nuclear disarmament, a goal of the treaty, such revision would be futile, they believe. The incentives for nuclear power nations to become nuclear weapons nations would be too great.

Socolow and Glaser advance a detailed agenda for controlling proliferation as nuclear power expands, including multinational control of the fuel process, from enrichment through disposal, and an end to reprocessing. But they warn that panic over global warming could lead to bad decisions about nuclear power. Until a solid nonproliferation scheme is in place, they conclude, it will be riskier to expand nuclear power than to endure the increase in global warming it might prevent.