THE STATE OF SCIENCE IN AMERICA

We've got a great machine, but is it built to last?

BY **LISA RANDALL** ILLUSTRATION BY **ARTEK CHODOR**

Leonardo and other great artists did not work in isolation; they generally lived in vibrant artistic communities in times of great artistic accomplishments. Scientists, too, even when iconoclastic and individualistic, often make advances following other catalyzing scientific or technological developments. Artists, scientists, and other creative thinkers benefit from thriving communities in environments that value their contributions.

For the last 50 years or so, America has valued scientific achievements, and this environment has allowed science to flourish. Just as artists flocked to Italy in the 1500s, scientists have often chosen to work in American universities, laboratories, and companies. Many of these scientists were well-educated Americans, but just as important were the many foreigners who recognized opportunities here.

Within the last couple of decades, intense, dedicated scientific communities working with ever-advancing technologies have made stunning discoveries, such as the dark energy that accelerates the expansion of the universe, the sequence of the human genome, extrasolar planets that are more numerous and closer to their stars than most people anticipated, the solution to Fermat's last theorem, and effective treatments for AIDS, along with less-touted discoveries like drugs for migraines that greatly improve people's lives.

American values and education encourage some of the qualities that are most important for scientists: creativity, individuality, freedom of thought, and hard work. Many of the leading scientists of the last half century lived or worked here. The standard model of particle physics was largely worked out in the United States; many other scientific endeavors, like gene research, have also significantly evolved in this country. The thriving American economy has allowed these endeavors to be well funded, often with great benefits and rewards.

In the last five or so years, though, America's status as the preeminent scientific nation has been becoming less certain. We face at least two hurdles: education and funding. Great scientific achievements are still valued. But whereas a couple of decades ago many of the greatest minds chose to go into science, their counterparts today often choose business or Internet start-ups, for example, that offer higher financial rewards, thriving intellectual environments, and potentially less educational commitment. Given the current trends, there will be fewer American scientists in the future. Already foreigners are filling the gaps. Unless we encourage local talent, the advantages to working in America won't continue.

As for funding, we benefit from a strong economy and the opportunities it provides. Our universities are still among the richest, and our companies are among the best funded. But business, political, and other nonscientific interests can influence the choices we make, especially for expensive projects. A billion-dollar space science project might sound expensive, but it's worth noting that we could build two such projects with the $2 billion we're spending on the International Space Station every year. Though the ISS is a remarkable technological achievement, its scientific benefits would not have persuaded the scientific community to choose this project if it meant sacrificing targeted projects aimed at fundamental science. (And of course these expenditures pale in comparison with other governmental expenditures, to go unnamed.)

Many worthwhile projects are now happening overseas. I see it in my own field of research—high-energy particle physics. I'm a theorist, but I anticipate new data from the Large Hadron Collider (LHC), a particle accelerator on the French-Swiss border that will collide two beams of protons to probe the substructure of matter. The closest machine in America—Fermilab's Tevatron, which achieves about one-seventh the energy reach—is slated to close in 2010. We have nothing planned to replace it. As funding in America for particle physics experiments is declining, funding in Europe is on the rise. Clearly the opportunities for high-energy experimenters will be much richer in Europe in the foreseeable future. Eventually the expertise will move there, as it already has to some extent.

It doesn't help that American commitments can be unreliable. Construction for the Superconducting Supercollider began in Texas in 1991. Had it been completed it would have easily rivaled the LHC, but a change of government and priorities led to its cancellation in 1993. Of more immediate concern is the cancellation and delays of NASA's Earth-monitoring satellites. No matter what your view on human-induced climate change is, few deny that climate does change

and that we need to be able to monitor those changes in order to adapt. The loss of ability for weather prediction and long-term climate monitoring is unfortunate.

And climate change is a larger problem than simply monitoring the changes. The American government's eagerness to ignore scientific advice about climate and related energy issues severely impedes our ability to address this and other problems. Of course, many considerations enter policymaking, not just science. Weighing them for the benefit of everyone is complicated. But nearly everyone in the scientific community is dismayed by the short shift given to scientific evidence by this administration and sees opportunities for advances being lost. More people, both within government and without, need to understand scientific data and the underlying statistics sufficiently well to make informed decisions.

Religion is another issue that comes up in virtually any discussion of American science. I recognize that tirades on this subject can become wearisome, but it is incredible that in this advanced nation we let beliefs impede scientific research and the education of future generations. Biological advances certainly raise a number of moral questions, but we need an intelligent discussion of these issues, which can happen only if we recognize that research and education are critical to our retaining our competitive edge and our way of life. America's current preoccupation with the supernatural, seen in TV and the movies, is a disturbing and potentially antiscientific trend.

Yet despite occasional fear and distrust, America's science still thrives. In the past few years, people have discovered ways to sequence the genome at 1,000 times the former rate. In the next few years, people in my line of research will know how to take the next step beyond the standard model of particle physics. We still see fantastic students, both at the undergraduate and graduate level. And these younger students are facile with a variety of new tools to sift through information and equations, tools that expedite the rate of progress to levels not anticipated even a decade ago.

Also encouraging is the genuine thirst for knowledge in the public at large. People get excited about the science at the LHC and more theoretical subjects, like extra dimensions of space, as well as more immediate ones like the many recent biological advances. Much of science is difficult to understand these days, but many make the effort to bridge the communication gap and teach or learn about new developments. Hence this magazine, for example.

Perhaps we shouldn't even be asking about something so narrow as the state of science in America. Scientific advances don't need a visa. The modern ease of communication means that scientific ideas—unlike some scientists—can travel at will. Breakthroughs that occur here or elsewhere will change the nature of science and the pace of development all over the globe. Maybe such discoveries are just around the corner. ■

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