7 Science and Technology Issues: A University Perspective

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Introduction

America's research universities continue to make important contributions in education, research, and service to society. Federal support is a critical component of the resources received by such institutions. We have are compelling reasons to carefully examine the opportunities and challenges before us and to assess the level and balance of the research investment. President Bush has advanced a budget for FY 2002 that is basically level funding (or slightly lower when inflation is taken into account) for most science and technology areas. The exception is the National Institutes of Health (NIH), for which a substantial increase in funding is proposed. This chapter summarizes the responsibilities and challenges of the university within this context and from the perspective of a research university.

Balancing the Federal Research Investment: Meeting 21st Century Goals

The research universities of the United States are institutions of world-class stature engaged in addressing the most critical problems of the early part of the 21st century. Among the most important goals for this new century are the enhancement of human health and national security. The

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research and advanced education surrounding these two objectives provided the major rationale for substantial support to research universities for the past half century. During the Clinton Administration and now under the Bush Administration, the commitment to advancing human health (in part reflected in the growth of the NIH budget) continues to receive very strong support from Republican and Democratic Members of Congress. The growing investments in NIH have been well-placed, because the new opportunities for advancing human health are real and success in this research will significantly benefit American society. Because of this funding, research universities have been able to attract talented research faculty and students interested in pursuing exciting research areas that show much promise.

While significant budget increases have been supported for NIH, there is concern that the budget is not "balanced" with respect to the other areas of science and engineering, where important benefits will develop from the research enterprise. Indeed, a compelling case can be made that advances in the physical sciences and engineering will fuel more rapid progress in areas traditionally supported by NIH. Even in the areas of research supported by the Department of Defense, roughly level funding does not seem appropriate considering the importance of national security and the research opportunities in the physical sciences and engineering that support the technological developments arguably needed for defense.

Beyond the defense- and health-related research emphasized in the Bush agenda, the investment in research also contributes to improving economic strength and prosperity. Considering the strong arguments that acknowledge research as a critical financial investment with respect to the economy, the essentially flat budgets for science and engineering education and research at agencies like the National Science Foundation (NSF) are disappointing.

Addressing environmental challenges is also important. We can see truly innovative and exciting programs in this area, from "green chemistry" to plant science, where research universities can play a larger role. The public strongly embraces a commitment to enhancing the environment, and there are great opportunities for research. Although the Kyoto Protocol to the United Nations Framework Convention on Climate Change is a political lightning rod, it is certainly true that sustaining, if not enhancing, the environment should be a 21st century priority.

The mission of colleges and universities has long included a role for knowledge creation involving students. Science and engineering educa-

tion and research are certainly intertwined at the graduate level, and research opportunities provide undergraduates with a deeper engagement in their major. In general, research enhances the educational mission and expands knowledge. Colleges and universities can play an important role in enhancing K-12 science education through teacher preparation programs and outreach efforts. These contributions hold the promise of advancing educational achievement in science for the entire population, an important 21st century goal. Programs like those at NSF that encourage graduate students to work with K-12 teachers and students make a contribution to achieving stronger science education programs at all levels.

An overarching 21st century goal, of course, is to advance the quality of life, both domestically and internationally. It is certainly the case that advances are possible, and that many of them will stem from investments in research at research universities. However, it is most likely that greater progress will be made through a balanced investment, not just the enhancement of research directly related to human biology. Sustained national security, an improved environment, and economic strength all require significant investments in research and a balanced portfolio to optimize success in all areas of national importance.

Universities: Meeting the Challenges

Research universities and their communities realize the importance of science, engineering, and medical research and education. Such institutions have sought significant private support for enhancing their research mission. As a result, private and public research universities have enjoyed substantial increases in their endowments and great success in fundraising campaigns of over $1 billion. The following schools have secured commitments of more than $1 billion in recent or current fundraising campaigns: Stanford, Harvard, the Massachusetts Institute of Technology (MIT), Washington University in St. Louis, Johns Hopkins, Northwestern, Duke, Columbia, and Yale, as well as public universities like the University of Michigan, University of Illinois at Urbana-Champaign, University of Texas at Austin, and the University of California at both Berkeley and Los Angeles. These fundraising successes have enabled research universities to remain responsive to new opportunities in research.

Universities have committed substantial support for the development of new teaching and research facilities in science, engineering, and medicine. Washington University is developing buildings for biomedical engineering, chemistry, and earth and planetary sciences, and it is building a new cancer center. These and other facilities are part of a capital projects plan involving the commitment of approximately $1 billion over ten years. Investments of similar scale are being made at MIT, Johns Hopkins, and Yale, among others. Included in these efforts are commitments to renew existing facilities, to enhance research infrastructure, and to invest in the information technology needed to contribute in advanced education and research.

Research universities are also making important financial contributions to intellectual renewal through their support for new faculty. Start-up packages for new research faculty in the sciences, engineering, and medicine, even for assistant professors, represent very sizeable one-time expenditures that are fully supported by universities. An assistant professor appointment might involve financial commitments of the order of $500,000, while senior faculty appointments may require several times that amount.

It is well-known that the costs of conducting research are not always fully met by the financial support received from the federal government or any other funding source. Thus, in order to be competitive, universities must be able to meet the requirements of overt and subtle cost-sharing in connection with sponsored research. Major equipment support from the federal government often requires matching support from the university. Such matching funds must come from unrestricted sources. Similarly, recovery of legitimate expenses associated with research results in a shortfall. The "underrecovery" of expenses, such as those for the research library, safety, compliance, and financial personnel, must also be met with otherwise unrestricted dollars from the university. At Washington University, it is estimated that every dollar of research provided by the federal government results in the commitment of 25 to 30 cents by the university. Thus, with about $300 million in federal expenditures annually, the university needs a very large, unrestricted revenue stream for research. Current gifts and spendable income from endowment provide the resources needed. Being able to provide the resources and facilities for research enhances the federal investment and brings a substantial benefit to society.

Universities, of course, have a compelling interest to recruit the best people possible and provide the best environment for their research ac-

tivities. Such individuals will be those who compete most successfully for external support from the federal government, corporations, and foundations. The point is that substantial fundraising efforts of universities are being used to support the research and education enterprise and represent a very hefty commitment to meeting the challenges of the 21st century.

Balancing Scholarly Interests: Humanities, Arts, and Social Sciences

It is clear to many that universities are investing a large fraction of their unrestricted resources in the general areas of science and technology. There is legitimate debate in the academic community as to whether these large investments are equitable. In many settings important scholarly efforts in the humanities, the arts, and the social sciences receive a smaller share of a growing resource pie. Arguably, science and engineering education and research are fundamentally more costly than scholarly programs in the humanities and social sciences. Even so, there is a need to continue to balance the investments at research universities.

Perhaps surprisingly, many of the most creative and interesting applications of technology in education and scholarship are coming in the areas of the arts and humanities. From foreign language instruction to writing programs, from graphic design to music, new technology is being applied in very creative ways.

In the social sciences, scholarship and education regarding the impact of science and technology on society represent major opportunities and responsibilities for research universities. Further, advances in medicine pose many interesting ethical challenges for society. The sequencing of the human genome has opened up new frontiers in medicine to be sure, but these are accompanied by challenges for the medical, legal, and business professionals. Recently, stem cell research has raised much debate among political, religious, and research leaders. It is important that research universities remain places for the free exchange of ideas and forums for debating the issues facing society. Sustaining strength in all areas of higher education requires the same commitment to an overall, balanced portfolio of scholarship on our university campuses.

University-Based Research: New Products, Services, and Economic Impact

Most research universities have far more impact at the local and regional levels than at the national and international levels. Much of the revenue to universities is spent in the communities where they are located. Federal research dollars, in particular, represent economic impact that would not be present in the absence of the research university. Thus, many communities have come to value research universities for the positive effects on their economy. Many states strongly support their public research universities in order to assist them in being more competitive for federal research grants and contracts. Support for facilities, research infrastructure, and faculty plays a critical role in the success of research universities, and it is in the public interest that research universities be supported for these purposes.

Major visibility now surrounds the opportunities that stem from discoveries in science, engineering, and medical research that may have technological consequence. From new anti-cancer drugs, to procedures for genetic manipulation of plants, to advances in software, research universities are associated with important developments of intellectual property that have led to significant advances in local economies. The successes in Boston's Route 128 corridor, Silicon Valley, Research Triangle Park, and other parts of the nation have stimulated much interest in developing technology transfer efforts at research universities. Many new "science parks" and incubators are being developed around research universities to assist in the technology transfer effort. New companies from federally sponsored research not only create regional wealth, but also bring important benefits to society with the products they produce. Again, the overall federal investment is one that needs to be properly balanced in order to realize the maximum benefit for society, because exciting and significant opportunities remain across a wide spectrum of science and engineering.

Regarding the matter of balance, it is important to note that the strength of the American research university enterprise is the diversity among its institutions. Each university is encouraged to develop programs of importance in fulfilling its mission. The California Institute of Technology, for example, is largely a science-based institution, while the Massachusetts Institute of Technology places a much greater emphasis on engineering. Washington University in St. Louis focuses on the

life sciences, with major programs in biomedical research, plant science, and biomedical engineering. The focus of a research university comes about from both conscious decisions and tradition surrounding the university. In some instances the focus of a university has particular relevance to the community in which it is located. This is true for Washington University, which is playing a key role in a region-wide initiative in the life sciences, which includes both human biology and plant science. As the academic cornerstone of the initiative, Washington University plays a critical role in attracting talented people to do research, encouraging the development of new companies, and investing in the region financially. These elements of community commitment are typical of America's research universities and further strengthen their partnership with the federal government.

With approximately 125 medical colleges in the United States, many research universities bring very significant and direct health benefits to the communities surrounding the academic health centers. On the list of the 2001 *U.S. News and World Report* top 15 hospitals all but one (the Mayo Clinic) of the adult hospitals are associated with the medical school of a major research university. Academic health centers provide their communities with the best medical care available and also help the public they serve understand the latest advances in medicine that may be applied to patient care. This service to society is arguably the most important direct benefit to the people in a community served by a research university with a medical school.

Human Resources: Are We Doing Enough to Attract Talented People?

Science, engineering, and medical research is done by people. This truism is sometimes forgotten, but the strength of the U.S. research effort depends on being able to draw on the rich human resources we enjoy in this country. For much of the 20th century, science, engineering, and medical research was conducted by white males, largely leaving out women and members of minority groups. By encouraging the participation of women and members of minority groups we significantly increase the available talent pool from which to draw a strong, vibrant research community. This fact alone is compelling, in terms of developing a commitment to building diversity in the science and technology work force.

Research universities have long supported the objective of strengthening diversity. They have made substantial commitments and there has been much progress. However, much more remains to be done, especially in advancing women and members of minority groups to major leadership roles. Universities welcome opportunities to partner with the federal government in expanding opportunities for women and members of minority groups.

With the growing strength of research universities in other countries, particularly in Asia, many of the talented people originally from those countries can be lured "home." Further, international students from Asia currently studying science and engineering will see increasingly strong, exciting, and well-supported opportunities back home. For these reasons we need to make special efforts to interest U.S. students in science and engineering. Developing such interest must begin in childhood. Research universities see opportunity and responsibility in this arena through teacher preparation programs and community outreach programs.

America's great world standing in science, engineering, and medicine depends on sustaining interest in the pursuit of these areas by talented people. The federal government should substantially enhance its investment in this area.

21st Century: The Age of Biology

What justification can be offered for the very substantial increases in federal support for health-related research? Partly, of course, the answer rests in the fact that decision-makers are like all others—interested in longer, healthier, more productive lives. The stunning advances in medicine in the 20th century, including the eradication of many infectious diseases and lengthened life expectancy, are rewards of earlier investments. But the last quarter century saw a revolution in biology of such significance that the first part of the 21st century will almost certainly be regarded as the Age of Biology.

In the early part of the 20th century physicists and chemists made tremendous advances in understanding the fundamental nature of matter. From those advances have come the development of much of what we now regard as established technology, from lasers to synthetic fibers to a remarkably powerful information and communications infrastructure. The Age of Biology will spawn its technologies, too, and the biotech-

nology industry is destined for continued rapid growth. The products from biotechnology hold much promise in continuing the advance on improving human health. However, it is noteworthy that the "hot" areas of biology—genomics, structural biology, biomedical engineering, and computational biology—all depend on continuing advances in areas that are not traditionally biology. Thus, federal support to fuel advances in chemistry, physics, mathematics, materials science and engineering, and computer science, arguably, needs to be enhanced, in order to ensure a brisk pace of advances in both the applications of biology and other areas of technological importance. Again, striking the right balance of investment in research is key to the overall success of American science.

The federal investment in medical research is easily justified on the basis of the impact of the research advances and their applications to treating, managing, and curing disease. Cancer and cardiovascular disease rank high among causes of death, and focused efforts here will very likely yield significant improvements in longevity. In addition, the world faces new challenges in the area of infectious diseases. AIDS is a worldwide threat, but an immediate threat of great significance to the continent of Africa. The work on the human genome project is an important step in the diagnosis of genetic diseases and the next era of advance will focus on treating these diseases. The ability to fend off diseases is known to be at least partially genetic, too, and thus much effort is being appropriately directed to drugs tailored to an individual's genetic makeup for treating cancer, for example. Finally, in the human health area, treatments for age-related diseases such as Alzheimer's, macular degeneration, and osteoporosis will be more important, owing to the changing demographics of the American population due to the success of lifesaving medical advances.

Important as human biology is, it is critical to underscore once again the need to invest in other sciences and in engineering in order to realize the promise of the Age of Biology. Even in biology itself, it is important to emphasize the opportunity in the general area of plant science. Plant genomes can be sequenced with the same technology applied to the human genome. Genetic engineering of plants has important practical benefits. This work has the potential to lead to a second "green revolution," dramatically enhancing crop yield. Genetically engineered plants can reduce the use of pesticides and fertilizers, thereby sustaining environmental quality. High-value products from plants such as nutriceuticals and advanced materials may be important outcomes from

the research as well. When reviewing the balance of biological research, it is clear that the federal investment in plant science is well below what it should be to realize the potential from this area. Feeding the growing world population with healthier food while sustaining the environment will be an important 21st century challenge.

Conclusion

The federal government is the largest and most important sponsor of research at American research universities. The investment has brought great returns over the last 50 years, and enormous promise remains. The Bush science budget is basically flat, except for the National Institutes of Health. Considering the major challenges we face related to national security, environment, economic well-being, and education, coupled with the exciting and promising opportunities being presented by the research community, we have an excellent case for a larger investment in university-based research.