THE FUTURE OF UNIVERSITY/INDUSTRY RESEARCH

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The IBM Almaden Research Center, located in Santa Clara County, California, was dedicated on May 30, 1986. The new Center replaces facilities that formerly were housed in a building about five miles away, known as the IBM San Jose Research Laboratory. At Almaden, about 850 scientists, engineers, and support personnel are responsible for conducting research in the physical sciences, polymer science and technology, computer science, computer storage systems and technology, storage and input/output manufacturing, and input/output science and technology. The keynote address at the dedication was delivered by David P. Gardner, president of the University of California. This article is adapted, with permission, from the text of that address.

It is an honor to join you for the dedication of this exciting new research center. I am especially pleased to be participating today because of the strong ties between the IBM Research Division and the University of California, especially on our Santa Cruz and Berkeley campuses. IBM researchers have taught courses at UC, engaged in cooperative research with UC people, sometimes even joined us as permanent faculty members. Lest you think this is a kind of technology transfer in reverse, let me add that on occasion UC faculty have made IBM their permanent home as well.

IBM and the University of California, in fact, have a cordial and mutually beneficial relationship that goes back many years. Two of our campuses—Berkeley and UCLA—were among the nineteen universities in the United States that recently received major IBM grants for academic computing. Whether one looks at gifts, endowments, fellowships, equipment, or cooperative research, IBM has been extraordinary in its generosity to universities generally and to UC in particular.

Cooperative university/industry research is not new. The United States has had a model for university/industry cooperation since 1862, when the Morrill Act created the system of American land-grant universities with their commitment to research in the service of society. We have had more than a century’s worth of experience in working through the problems, risks, and challenges of moving the results of basic research from the laboratory to the marketplace.

But lately the question of research cooperation between universities and industry has taken on a new note of urgency. An important reason, of course, is our current national concern over international economic competitiveness. This concern has surfaced despite the fact that the United States is, by any measure, a leader in international science and technology. We have a much larger research enterprise than any other nation. American scientists write more than a third of the world’s published scientific articles and hold an impressive share of the world’s patents. Our research universities are regarded as the best in the world.

And, according to the National Science Board’s Science Indicators 1985, with notable exceptions, science and technology in the United States are strong, vital, and growing.

An imperative investment

It would be wrong to conclude, however, that all is well with the American research enterprise. For one thing, we cannot count on holding indefinitely our present international lead in most scientific and technological areas. Other countries have been quick to recognize the value of new knowledge and are increasing their investment in research and development. For another, the research enterprise in our universities—the principal source of our nation’s scientists and engineers and of most of its basic research—is under stress, a topic I will return to in a moment. And over the long term—not just next year or the year after that—we need to devote a larger and more predictable share of our national wealth to science and technology. This is not just important; it is imperative. Our nation’s economic health will depend on this investment, just as the general well-being of our society rests significantly on the vigor of the scientific enterprise.

In light of these circumstances, it is not surprising that policy makers are looking to foster closer ties between industry and the nation’s universities. The federal government has stepped up its efforts to encourage...
such cooperation by changes in tax law and patent policy that make it easier for industry and universities to collaborate. Federal agencies are encouraging cooperative research arrangements, some involving a three-way partnership among university, government, and industry. There is activity at the state level as well. I understand that virtually every state now has a program of one kind or another aimed at promoting collaborative research.

For the universities, cooperative research with industry provides opportunities for obtaining state-of-the-art equipment and facilities, conducting research in industrial settings, and creating job opportunities for graduates. Cooperative research provides universities with a welcome source of additional support, as well as opportunities to fulfill their public service mission in new and innovative ways.

At the University of California, we are involved an increasing number of research partnerships with industry, many of them in high-technology fields. For example:

- The University-wide MICRO project, established by the State of California in 1981 to support innovative research in microelectronic technology, is a three-way partnership that involves UC, the State, and industry.

- At UC Berkeley, fifteen industrial sponsors (including IBM) in a CAD/CAM consortium contributed over $500,000 each to add a floor to Cory Hall for the Electrical Engineering and Computer Sciences Department and the Electronics Research Laboratory.

- At the Lawrence Berkeley Laboratory, managed for the United States Department of Energy by the University, the Center for Advanced Materials involves both University and industry researchers. One of their goals is to explore new ways of accelerating the transfer of technology to industry. Another project that will involve industry is the Advanced Light Source, a machine capable of producing ultraviolet light and low-energy X-rays with properties well beyond previously attainable limits. It will make possible new applications of interest to industry—vastly improved biological imaging, for example, as well as smaller and more complex computer microprocessing chips. Scientists from IBM, by the way, have worked with UC scientists in designing components of the machine.

- UC Santa Barbara recently received funds from the National Science Foundation to establish a research center for robotics, at which faculty and industry researchers will work on the integration of robotic systems into microelectronic manufacturing.

- The Center for Magnetic Recording Research at UC San Diego is seeking ways to recapture this country's preeminence in magnetic recording. IBM is included among its industrial sponsors.

I could go on—but you get the idea. Like many other research universities, we are interested in expanding our links with industry and are hopeful about the possibilities of partnership.

Potential problems

We are aware, of course, that not everyone who has thought about university/industry research is enthusiastic about it. Many observers have underscored some of the problems that can crop up. Some worry that the search for knowledge and the search for profitable ideas are simply incompatible. Others are concerned that intellectual property questions will complicate or slow down the free dissemination of research findings, an absolutely fundamental characteristic of university research. Still others have expressed the view that such work may distract faculty members from other academic responsibilities.

Our experience at the University of California suggests that these and similar problems are not as intractable as they once appeared. We have found that cooperative research with industry has not interfered with other faculty responsibilities; on the contrary, it has often strengthened teaching and research. Our experience also tends to confirm that the overwhelming majority of industrial sponsors understand and respect the differences between the goals of university research and research in an industry setting. We have a set of carefully worked out guidelines for collaborative research that cover such topics as patent rights and publications. So far, we have found these guidelines adequate for protecting the interests of the University and of industry.

But there are some issues that I believe we will need to keep in mind as we expand our interactions. I will mention just four.

Untried technologies. Our guidelines for collaborative research seem to have struck the right balance between protecting the integrity of university activities and recognizing industry's interest in profiting from its support of research. Nevertheless,
there are some emerging research areas that will continue to bear watching. Biotechnology, for example, raises social, ethical, and sometimes environmental concerns that must be carefully assessed by both universities and industry. Just recently, for example, the University decided to delay field testing of a bacterium called “ice minus” that has been genetically altered to prevent frost formation on potatoes. The Environmental Protection Agency had given its permission to conduct the experiment at Tulelake, and UC researchers were ready to proceed. University people were— and are— convinced that the field test posed no threat to humans or any other living thing. But because of concerns expressed by local residents and potato growers, we are delaying the experiment in the hope that we can more fully explain what we are doing and why, and reassure the people living in the area that the experiment is indeed safe.¹

Other universities—and biotechnology firms as well—are having similar experiences. We are in the midst of a revolution in biotechnology that holds out the promise of truly astonishing advances as well as important commercial applications. But we must be sure that our research—collaborative or otherwise—is carried out with sensitivity to all the implications of these new discoveries. These questions are especially important here in California. We are the nation’s leader in biotechnology—roughly a third of all biotechnology firms in the country are located here—and we are taking major steps in research and training to protect that lead.

The academic infrastructure. The future of university/industry research depends on the strength of both partners, and universities these days are facing serious infrastructure problems. The problems are familiar: obsolete facilities (a cumulative need now equal to some fifteen to twenty billion dollars, according to Erich Bloch, Director of the National Science Foundation and a former IBM vice president), faculty salaries that are not competitive with industry’s, shortages of science and engineering faculty, and an inadequate number of American students in those disciplines at the graduate level.

More than anything else, we need to attract bright young people into science and engineering. And if we are going to do so, the effort must begin well before college. One of the most significant long-term threats to the vigor of American science is the decline in science achievement in our schools. A few years ago I served as Chairman of the National Commission on Excellence in Education, appointed by then-Secretary of Education T. H. Bell and charged with examining the condition of the nation’s schools. We were so troubled by what we found that we entitled our report A Nation at Risk as a way of getting across our profound concern about the urgent need to improve schooling in America. In the words of the report:

The risk is not only that the Japanese make automobiles more efficiently than Americans and have government subsidies for development and export. It is not just that the South Koreans recently built the world’s most efficient steel mill, or that American machine tools, once the pride of the world, are being displaced by German products. It is also that these developments sig-
nify a redistribution of trained capability throughout the globe. Knowledge, learning, information, and skilled intelligence are the new raw materials of international commerce and are today spreading throughout the world as vigorously as miracle drugs, synthetic fertilizers, and blue jeans did earlier. If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform of our educational system.

We found evidence of decline in just about every academic area, including science and mathematics. We should not be surprised, for example, that American students consistently score lower on international tests of student achievement in science and mathematics than do students in most other industrial nations. After all, in other advanced nations, courses in mathematics, biology, physics, and geography begin early in schooling and are taken by all students. The time devoted to these subjects, based on class hours, is about three times that spent by even the most science-oriented American students.

Fortunately, over the past three years we have begun to address the problems in the schools, and I earnestly hope that we can find solutions, although there is nothing inevitable about our doing so. One of the hopeful signs, of course, has been the willingness of business and industry to involve themselves in the problems of the schools.

But neither the universities nor the schools can reasonably expect the private sector to solve their problems. Those problems are of state and national concern. Universities must have the core support from state and federal governments that will permit them to carry out their basic missions. The schools must have resources and attention as they make a determined effort to turn things around. One might also note that the public will not be forthcoming with the resources if it is not convinced that the resources will, in fact, help turn things around.

A realistic balance. Universities must be careful not to overstate their potential or what they can reasonably contribute to our society, including what they can contribute to the interests of business and industry. As long as need not tell this group, basic research is predicated on the longer term. It may or may not pay off over the short term. Discoveries made now may take years to work their way into technical applications. So it is impossible to eliminate an element of risk from such research as may be undertaken jointly by our universities and by industry.

At the same time, universities must take care to see that they have their own priorities in order. They are not simply research institutes. The question of academic balance—how resources and attention are parcelled out among disciplines—is a real one for any university that intends to honor its raison d'être and preserve its essential character as a center of learning.

Understanding the challenge. We should be aware of the extent to which we are breaking new ground. I have mentioned the land-grant model and how it has facilitated the transfer of knowledge from the labo-

ratory to people who can use it. Complicated as that process has been, it has become enormously more complicated with the explosion of knowledge in our century and the increasingly sophisticated needs of our technological economy. We are betting that new knowledge can be applied to a whole range of industries on a scale that has never been attempted before, except in America's agriculture, where it has been done with phenomenal success. Under the circumstances, we cannot assume that we know all we need to know about collaborative research between universities and industry. We have some promising models and some exciting possibilities. We should be willing to experiment, however, and be ready to take advantage of our opportunities.

We know, for example, that the increasing specialization and cost of scientific instrumentation have put many new instruments out of reach of individual universities and even of many businesses. Thus the sharing of instrumentation and laboratories, and cooperation in research, will be ever more important in the future than they have been in the past.

UC, for example, is cooperating with the California Institute of Technology to build the world's largest optical telescope. This effort has been made possible by a gift of 70 million dollars from the W. M. Keck Foundation of Los Angeles. When the telescope is ready in the early 1990s, UC and Caltech will operate it cooperatively. This is an excellent example of public and private collaboration to achieve something neither of us could have achieved on our own.

Or consider the proposed Superconducting Super Collider, which, if built, will be the world's largest parti-
cle accelerator. It will cost an estimated three to six billion dollars, obviously far beyond the capabilities of any organization except the federal government. Construction of the Superconducting Super Collider would not only put the United States, once again, at the forefront of high-energy physics; it would also bring considerable economic benefits to the state in which it is located. So a number of states are mounting major efforts to attract it. California is one of them. This effort involves the active support and involvement of persons from state and local governments, cooperation among California’s public and private universities, and the active participation of the private business sector. This is one example of university-industry collaboration that I believe will be increasingly important, and increasingly fruitful, in the years ahead.

**What of the future?**

What about the future of university-industry research generally? I believe it is bright. We each have something to gain, and to learn, from the other. We have a tradition of cooperation and a record of success in applying research results. Most important of all, we have a common stake in an economy and a society that are strong enough to thrive in our increasingly complex, demanding, and technological world.

Here at Almaden, you have a research center that will make it possible for you to carry on the IBM tradition of excellent work at the forefront of knowledge. Yours continues to be a pioneering company, and this splendid new facility, which we dedicate today, reflects the dynamism and vitality of that company. It is also an explicit acknowledgment, indeed it is a reaffirmation, of the role that new ideas and new knowledge will play in the life of your company. It is, in microcosm, a reflection of our continuing quest to know and to understand.

A dedication is always an act of faith in the future, and I am especially pleased that you have invited someone from the public sector to help you celebrate. Congratulations!

**Note**

1. A temporary restraining order issued August 1, 1986, in Sacramento County Superior Court resulted in the experiment’s being delayed until Spring 1987. In the interim, the University of California prepared an Environmental Impact Report for the State of California.

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**Research relationships—industry and the university**

In the United States, research relationships between industry and universities have been numerous, constructive, and important since the turn of the century, and interest in such activities has increased significantly during the 1980s. Of the $14.2 billion spent annually on university research, about $600 million, or 5 percent, is provided by industry. Although small, this figure has tripled since 1980, and all indications are that the trend will continue. Government efforts, both federal and state, are also focusing increased attention on industry support of university research. An example is a plan by the National Science Foundation to establish up to 25 cross-disciplinary engineering research centers having both educational and research missions. Fourteen centers have been announced and funded at multimillion-dollar levels, but long-term support is expected to come from industry. Many winning proposals for centers established under the plan had significant industry support in terms of cash, equipment, and personnel.

State governments have become increasingly active in promoting environments that stimulate high-technology development through industry-university collaboration. An early example is the area around San Jose, California, known as Silicon Valley. Other successful “high-tech” locations include Research Triangle Park, North Carolina, and sites in or near Austin, Texas, Boston, Massachusetts, and Pittsburgh, Pennsylvania. Each of these initiatives has four essential characteristics, as follows:

- One or more prestigious research universities nearby.
- An infrastructure such as a technology park to foster joint industry-university projects.
- Sufficient funding to support new technologies and ensure seed money for young companies.
- Physical and cultural amenities to attract risk-taking entrepreneurs and innovative engineers and scientists.

Some states, such as New Jersey and New York, fund advanced technology centers and provide matching...
funds for projects undertaken by participating industries and universities. Pennsylvania promotes similar projects on a regional basis through its Ben Franklin Partnership. Connecticut provides funding, through its Product Development Corporation, for up to 60 percent of the development costs of a potential product. These programs suggest that more such university-industry-state relationships will follow.

**IBM’s involvement.** IBM and many other research-oriented companies have steadily increased the number of their research-and-development contracts and joint studies with universities. From 1980 to 1986, IBM’s contracted research with universities evolved as follows:

- From fewer than 100 studies at 55 universities to more than 1000 studies at some 300 universities.
- From less than $20 million to over $130 million conveyed to participating universities.
- From activity at a small number of IBM research, development, and manufacturing sites in the United States and other countries to participation in major projects by virtually every such site in the United States, Canada, Europe, and Japan.

Researchers and programmers in both IBM and the universities make final decisions on the projects to be initiated, on levels of funding, and on the universities and personnel to be involved in specific studies. Studies have been conducted in many academic disciplines, from physics and chemistry to the humanities and social sciences. Areas of investigation have included large-scale integrated-circuit design, computer architecture and languages, distributed processing and networking, expert systems, image processing, ergonomics, curriculum development, materials science, corrosion and fatigue, and electro-optics. Some studies evaluate the use of personal computers in the classroom; others seek to push the limits of supercomputers.

In all cases, the primary benefit is the cost-effective and timely acquisition of new knowledge that is of mutual benefit to IBM and the participating universities. In addition to providing new knowledge that is of immediate interest to the study teams, contracted research can, if properly managed, provide a unique education for students, enlightenment for both academic and IBM researchers, new ideas and directions for research, opportunities for publication, and enhancements to academic curricula.

Although research-and-development contracts and joint studies have proved beneficial for both IBM and the participating universities, some aspects of contracted research require attention and improvement. Specifically, the acknowledgment and communication of results, establishment of and adherence to guidelines, contract negotiation procedures, and study management need to be addressed by IBM. Universities should be encouraged to involve more undergraduate and graduate students in the studies, give seminars and request feedback on results of the work, publish when appropriate, and help reduce contract negotiation time.

Attempts have been made to address potential problems arising from implementations of industry-sponsored studies at universities. Major concerns are information exchange, ownership of intellectual property, and possible conflicts with colleagues and students. Other concerns include international agreements, copyright policies for software, and possible conflicts of interest with entrepreneurial companies in which there is faculty involvement. Some universities have established policies governing the nature and extent of university and faculty activity in the commercial application of scientific research.

In most instances, the academic attitude toward industry sponsorship of research remains positive. Contracted research is expected to increase in importance as a vehicle for achieving timely and reproducible results, maximizing options and alternatives, and minimizing exposure and risk.

**References**


Gary Kozak
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