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Introduction

Argonne and I, for various reasons, are generally interested in technology transfer and specifically interested in the development of commercial technology from basic and applied research in biology and medicine. One of my responsibilities accounts for my generic interest. I have lab-wide responsibility for technology transfer, that is, the conversion of discoveries made through tax-supported research into commercial products or services that benefit the general public. Technology transfer has been recognized by our primary research sponsor, the Department of Energy (DOE); by Congress, and increasingly, by industry as a key element in U.S. efforts to improve its technological competitiveness.

More specifically, as Associate Director of the lab, the Argonne Center for Mechanistic Biology falls within my purview. We have a very active group developing methods for genomic sequencing based on DNA hybridization. We will be running what I consider the principal user facility for structural biology in the U.S. sometime in 1996[1] and are in the process of developing a computational biology group that we hope will provide the software and hardware for converting biological data into simple chemical and medical technology.

Anyone who reads the newspaper or looks at television has to be aware that the nation is in economic trouble. Politicians, from the President to County Commissioners, either wring their hands or claim

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1 The Structural Biology Center at the Advanced Photon Source.

victory based upon tenths of percent changes in employment; gross national product or balance of payments. Joblessness makes good copy when there isn't a beached whale or a middling quality murder to report. Still, these headlines reflect an underlying weakness in the U.S. economy.

Loss of Market Dominance

It started a decade ago when we lost market dominance in what were then called the basic industries such as steel and automobiles. First, we lost in the international markets. Then, we lost at home. Next, we fell behind in high-tech markets such as consumer electronics and computers.

Underlying this was a destructive cycle: Weakened financial positions led to lower investment in research and development (R&D) and led to further loss of market; that led to further financial weakness. This cycle was aggravated by a decade of takeover sharks threatening leveraged buy outs; corporations taking poison pills and a corporate focus foreshortened down to the next quarterly dividend. Add to this a work force no longer at the forefront in literacy and mathematics, coupled with basic industrial technologies that require less hands but greater training. Throw in non-uniform occupational and environmental regulation, and you have the makings of a very bad brew.

Last year, it was reported that U.S. spending for R&D has started to fall for the first time since the 1970's while foreign rivals have increased research investments.[2] For example, Japan is said to equal or surpass the U.S. as the world's top patron of industrial R&D.[3] It is also worth noting that Japan's R&D budget overwhelmingly addresses *civilian* research, causing an even greater disparity in terms of potential market impact for their dollars versus ours.

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2 National Science Board, Science and Engineering Indicators (1992). This report indicates that annual national expenditures for R&D fell from $154.3 billion in 1989 to $151.6 billion in 1990. Preliminary analysis was also found to indicate that 1991 and 1992 totals might be down even further.

3 Competitiveness Policy Council.

Reasons for Loss of Competitiveness

From my reading, I conclude that there are many reasons for our loss of competitive position. For example, the target of heavy criticism, is our traditionally poor integration of publicly- and privately-funded R&D; we look especially deficient compared to the Japanese, where integration is part of the political and economic culture.

Also, we have lacked close collaboration between research universities, national laboratories, research hospitals and corporations. However, historically, we haven't needed it: For most of the modern era, our publicly-funded R&D centers were the acknowledged world champions in basic research. Our corporations were acknowledged world champions in industrial applications. The traditional theory seemed to work, i.e., that discoveries would be made in the public sector and trickle down through an intellectual gravity flow to industry and the public.

This may still be true in medical R&D, but we unfortunately held on to that theory long after losses in world markets indicated that it wasn't working well enough. Meanwhile, decades of separation between corporations, universities and federal labs had erected psychological and legal barriers.

Psychological Barriers

Three distinct species of elitism worked against collaboration between corporations, universities and federal labs. First, most industrial research organizations were permeated with the suspicion that inventions that did not come from the in-house organization probably were of questionable value. Second, many universities let traditional concern for academic freedom interfere with the role they could play in industrial support, research hospitals tended to limit collaboration with their related universities, and national laboratories were slow to give up their self image as free-standing centers of scientific and technological expertise. Federally-funded researchers tended to put new technologies on the shelf for customers to pick and choose — rather than to consider commercial applications of their inventions and pursue potential customers.

Legal Barriers

One set of legal barriers to collaboration seems to be our apparently unique antitrust laws and attitudes. These blocked research collaboration of many kinds and made corporate research and legal executives chary of involvement with one-another or with publicly-funded R&D. Extending well beyond antitrust, we seem to have had, at least for civilian purposes, a distinctly adversarial relationship between government and industry. Thus, we have had no creatures like Mitsubishi Shoji, trading companies that could cross technological lines easily and bring semiconductors to watches or ceramics to scissors.

Somewhat related was the apparently logical prohibition against the federal government granting to *one* company exclusive rights to discovery that had been paid for by *everyone's* tax money.[4] Congress, federal administrators and others had a mortal fear of government technology making someone rich. What if, perish the thought, this resulted in a Xerox or a Polaroid?

If we give invention to everyone, it lowers the chance that anyone will gain undue advantage from tax money or that anyone will become disgustingly wealthy. The flaw in this logic was revealed when it became apparent that few if any companies would invest the money needed to convert a scientific discovery into a market-ready product without some kind of reasonable opportunity to recoup their risk capital.[5] The result was that discoveries belonging to everyone, often ended up being exploited by no one.

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4 For an overview of the situation, *see, e.g.,* Robert Van Ravenswaay, *Government Patents and the Public Interest,* 19 Idea 331 (1978). [Ed.]

5 *See, e.g.,* Ronald E. Barks, *Accessing and Licensing Federal Technology,* Licensing Law and Business Report, May-June, 1992, at 76, "[F]or every $1 of research, a company spends $10 to develop the product and another $100 to take it to market." [Ed.]

The Times They Are A-Changin'

We seem to be entering an era where industrial delivery of research conceived in government labs is a blessed event — especially if it creates jobs for Americans — even if it should provide a few minor country estates. As discussed by Lawrence Rudolph elsewhere in this issue, agencies like the DOE, spurred by several Congresses and Presidents, have done a U-turn in dealing with proprietary rights. Corporations can now protect resources invested to develop a discovery made at a national laboratory.

One of the newest and best mechanisms to accomplish this is a cooperative R&D agreement (CRADA). Under a CRADA agreement, Argonne and a corporation make an (usually co-equal) investment in an approved project, and the company retains proprietary rights. Currently, Argonne has signed 30 CRADAs and is negotiating over 40 more.[6]

For example, Argonne fostered the organization of the Midwest Plant Biotechnology Consortium with sixteen midwestern universities and 35 agri-business corporations. We originally called a meeting of this group at which industrial representatives specified major problems that could be solved with scientific research. The universities and Argonne chose problems they believed they had the capability to solve. A series of partnerships were formed, and grants were awarded based upon relevance to application and technical excellence. Since 1988, we have averaged about $4 million per year to fund such research, and, in 1992, a new activity involving bulk chemical production through biotechnology was funded at about the same level.

Another example that could have trust-busters rolling over in their graves is our current Battery Research Program. The bulk of that DOE research funding will go to a collaboration with the Big Three auto makers called the United States Advanced Battery Consortium or USABC. Industry will match funds with the national laboratories and associated institutions to develop better batteries, better vehicles and,

6 Including ones with Baxter Health Care (blood), Notre Dame (bugs to eat contamination in soil), Caterpillar (inspection of ceramic-coated engine parts), Allied Signal (ceramic erosion in engines and petrochemical pumps).

especially, concepts designed to take autos out of the environmental equation.

Recently, General Motors (GM) on its own had a "garage sale" at which national labs were invited to offer their good ideas for sale through displays, literature and personal representatives. GM research teams engaged in intensive "shopping" at this pioneering bazaar.

Argonne has also chartered the Argonne-University of Chicago Development Corporation, or ARCH, to foster commercialization of scientific discoveries made at the university or within the laboratory. It negotiates with corporations to license inventions and patents, set up joint ventures or establish new companies.

Another traditional area of cooperation between Argonne and non-Argonne researchers has been through our "user facilities," giant research machines too expensive to duplicate at campuses and industrial parks. Such facilities are open to use by researchers from other national labs, industry, hospitals or universities.

Currently, Argonne is building what we believe will be the most effective user facility that the nation has ever constructed. More than 300 scientists and engineers will perform as many as 100 different experiments simultaneously on the machine. It is a $456 million accelerator called the Advanced Photon Source (APS). The APS will generate the world's most brilliant X-rays for materials research. These X-ray beams, 10,000 times brighter than those of existing X-ray sources, will reveal the atomic and molecular structure of materials to improve America's competitiveness in areas such as steels, medicine, semi-conductors, polymers, pharmaceuticals and catalysts.

The APS has attracted more industry participation in its planning stages than any basic research facility previously built in the U.S. One demonstration of its value is creation by thirteen pharmaceutical companies of a consortium to build and operate their own beam lines. A further indicator of APS's value to industry is that both Japan and Europe are rushing to set up their own version.

Conclusions

What might all of this mean for those interested in the human genome and/or development of commercial technologies from genomic research?

On the positive side, we now have contractual instruments and technology transfer models that, with a little work, should be adaptable to new private sector ventures in biology. They are being used; companies are receiving exclusive rights to intellectual property, and federal labs, their technical staffs and sponsors are seeking to make deals.

On the other side, we have a growing federal technology transfer bureaucracy, as office upon office gets involved in issues such as conflicts of interest, foreign preferences and profit dissemination. If anything can destroy technology transfer, especially to small businesses with finite legal budgets, this is it. Also, federal labs now have no unearmarked pots of money for codevelopment of technologies. Each piece of work that departs from what was originally proposed requires separate dispensation — stalling or stopping good ideas while agencies wait for the next fiscal year or until Congress considers budgets.

Moreover, federal technology transfer policies and practices are not uniform. Different federal laboratories and their scientists accept or reject particular cooperative projects based upon their histories, interpretations of law and perceptions of their sponsor's, e.g., the DOE's, attitude.

Finally, enabling legislation and pioneering mechanisms for technology transfer are insufficient, themselves, to overcome major barriers to collaboration. A major barrier is cultural differences among parties to these partnerships. To collaborate effectively, personnel in each institution must get to know the strengths and peculiarities of other institutions. A university researcher who disdains concern with market response is bound to have trouble working with an industrial partner, and a corporate researcher with no tolerance for federal bureaucracy has a hard row to hoe in working with a national lab. Likewise, an Argonne researcher unaware of university sensitivity to

dominance by large federal institutions probably is going to strike out in dealing with R&D partners from those institutions.

Overall — especially where research is far ahead of development, as with the human genome project — things are nevertheless looking good. I and other federal technology transfer personnel invite people from corporations to visit Argonne, Los Alamos, Oak Ridge and our other brethren, where they just might find something interesting.