

# RESEARCH MANAGEMENT REVIEW

The Journal of the  
National Council of University Research Administrators

Editor

Mary Ellen Sheridan  
Past President

## Editorial Advisory Board

Dennis W. Barnes	Virginia Harris	Edward L. MacCordy
C. Frederick Bentley II	Margery E. Hoppin	Ardis M. Savory
William B. Cole, Jr.	Patrick Kennicott	Steven Smartt
George H. Dummer	James R. Knill	Frank R. Tepe, Jr.
Earl J. Freise	John Lordan	Nan S. Wells
Milton Goldberg	Don I. Phillips	Linda S. Wilson

Concerned with the broad range of issues affecting the administration of research, *Research Management Review* provides a forum for the dissemination of knowledge about the study and practice of the profession of research administration. *Research Management Review* is published semiannually by the National Council of University Research Administrators at One DuPont Circle, Suite 420, Washington, D.C. 20036.

NCURA's annual membership dues pays for the subscription to *Research Management Review*.

One-year subscription rate is \$20.00. Orders for single copies must be accompanied with prepayment of \$10.00.

Subscription requests and changes of address should be sent to *Research Management Review*, One DuPont Circle, Suite 420, Washington, DC. 20036. Printed in the U.S.A. © National Council of University Research Administrators (NCURA), 1989.

NCURA National Office, One DuPont Circle, N.W., Suite 420, Washington, D.C. 20036, (202) 466-3894.

## NCURA Officers

Jane A. Youngers, President	C. Frederick Bentley II, Vice President
Kenneth R. Landorf, Secretary	Richard L. Wright, Treasurer



# RESEARCH MANAGEMENT REVIEW

The Journal of the  
National Council of University Research Administrators

Editor's Preface .....	i
“X-Rated” Questions About Campus-Based Research by Donald K. Hess .....	1
The Global Research Race: New Models of Research Management by William H. Davidson .....	7
Technology Transfer from University to Industry: Responsive and Responsible University Policy by Anne Wright.....	17
Organization and Promotion of Sponsored Research at a Mid-sized State University: A Ten-year Case History by John M. Mishler .....	33
Research at Liberal Arts Colleges: Is More Really Better? by Linda E. Parker and David L. Clark .....	43

## Editor's Preface

This issue begins with the Plenary Session Address by Donald K. Hess at the NCURA 30th Annual Meeting, November, 1988. The speaker posed a set of probing and thoughtful questions to the audience that day; these questions remain ones that research administrators and those who set the policies guiding the conduct of research in American universities would do well to keep reassessing. What research gets done, who does it, who funds it, and how should faculty and administrators balance the often competing demands between teaching and research for resources? There are no singularly correct answers, but answering these questions should draw a better understanding of where and how faculty and research administrators articulate and reflect their institution's standards.

At the 29th Annual Meeting, Dr. William H. Davidson addressed the NCURA audience on the topic of models of research management in the context of the global research race. His article here returns to the topic, emphasizing the particular research competition between Japan and the U.S. His conclusions remind us once again, that communication between the government, university, and corporate sectors is critical in the definition of national priorities and the distribution of research resources.

The national competitive spirit is generating an even more intense state-based race of sorts. Anne Wright's article focuses on California's efforts, at both the state and university levels, to secure and preserve a leading edge in several designated strategic technologies, particularly biotechnology. Many outside the university community, and perhaps some inside, have confused or merged the technology transfer activities of universities with their sponsored research programs. These are complex relationships and Ms. Wright's contribution provides an interesting example of some of the mechanisms that a highly successful state has embarked upon to keep its research productivity and technology transfer options vital and responsive.

At various times, we have probably all wondered whether administrative vision and planning actually assist in achievement of long range institutional objectives. John Mishler's article evaluates and compares two five year periods of sponsored program development at the University of Missouri-Kansas City. The second period included a set of special initiatives designed to encourage and support the university's goal of doubling its sponsored funding by 1990. That objective is one shared by many institutions; Dr. Mishler's critique of the process at his institution is welcome and useful.

Many NCURA members serve at predominantly teaching institutions including liberal arts colleges. The contribution by Linda Clark and David Parker raises important issues and presents some answers. Some may question that the authors set the no-research versus research case too strongly. Many liberal arts colleges support research at a scale and in a manner that contributes to but does not dominate their primary emphasis, that is, undergraduate education. The recognition of the value of a research component in these institutions may account for their disproportionate contribution to the Ph.D. pipeline. Drs. Clark and Parker's article will undoubtedly raise many questions. If the existing undergraduate programs do not generate sufficient pools of students to continue post-graduate education, isn't the scarcer resource the human one and not the facilities or materials to support the research investment in the undergraduate program?

Mary Ellen Sheridan  
Editor  
April, 1989

# 'X-Rated' Questions About Campus-Based Research

Donald K. Hess

(Editor's Note: This paper was presented as a plenary *session address* at the NCURA 30th Annual Meeting, Washington, DC., November 7, 1988).

Let me attempt to pose policy questions which I believe we, in our important roles as research administrators, think about silently but are reluctant to discuss openly. Let me speak my thoughts. . . and growing concerns. . . about the credibility and integrity of our institutions that perform research in the national interest.

Over the past four and one-half decades we have seen literally a mushrooming growth of federal and other sponsored research on college and university campuses: From \$350 million in 1940 to \$5.6 billion in 1986 just in the funded top 100 universities!

Campus-based research today is a massive enterprise that continues to grow not only in terms of dollars expended, but also in numbers of higher educational institutions engaged in this seemingly lucrative activity. Concerned policy makers from all sectors must ask what effect this growth will have on the academy and on the mission of campuses. Has education become the stepdaughter of research? Are the faculty more interested in research than in teaching? Do administrators view research more for its revenue than for its supplementation of the education program and process? And what will happen to the interaction between faculty and students as a result of the heavier research load on faculty? (We all seemingly know what effects it has on equipment and facilities!) Is research seen as an integral part of the teaching program, or merely as an excuse for a school to be positioned with an exclusive and elite set of institutions for public relations value?

A concern that administrators of higher educational establishments must have is whether institutional avarice puts to a critical test the public trust with which they are charged, including the preservation

---

Donald K. Hess is Vice President for Administration at the University of Rochester, Rochester, New York.

of multiple missions and the need to operate within a body of fundamental and uncompromised principles absolutely vital to an open and stable society. By illustration, higher education's hurried embrace of the "economic competitiveness" thrust that has swept the country by storm may result in serious erosions, compromises, and contradictions for the academy and place in jeopardy its credibility with the public. Perhaps I am wrong on this assertion. On the other hand one might test this hypothesis by raising a number of questions which deserve objective contemplation. What follows are questions which we may be fearful of raising aloud, but I shall raise them.

1. If the nation at this time cannot afford mega science projects, such as the superconducting supercollider, the human genome map, a laser micro fusion facility, the national computer network, or the space station without sacrificing small science, are research universities willing to stand up and speak out to help shape a responsible and affordable response for a national science policy? Or will those institutions that might benefit from these big science projects rush to defend them because those institutions have possibly found a new but likely false source of wealth at the expense of the public good in the long run?
2. As research project opportunities arise, even within the boundaries of small science, will institutions in search of a national image or other benefits seek them out even though there is no proven capability, logical program context, or perhaps even a strong commitment in the field within the institution? The NSF science and technology or engineering centers might, for example, test this question.
3. Is there on our campuses a willingness to "buy into" a new research program even though it is known that the program carries only seed money from the sponsor for a limited period? That the program cannot be funded internally on the campus (except at the expense of academic or student programs, or erosion of endowment)? That, knowingly, at the start of the project a return to the sponsor will be required for additional support, but the applicant will not admit to this in the initial funds request? In other words, for the initial provision of the "button" by the sponsor there must later also be provided the "overcoat!" This question will become more germane as we enter an expected era of increasingly more projects that will demand matching funds.
4. Is there among the mounting propensity to accept the concept of "pork," a kind of "kosher pork"? If so, what is the difference?

Is a congressional earmark for an institution illegitimate but a precisely defined project earmark legitimate? Would we look differently on either kind of an earmark if one or both such earmarks were for items that had been reviewed for merit? If they were reviewed for merit but not recommended by the responsible federal program agency? Are there limits to Congressional prerogatives on the matter of funding research designations? If so, what are the bases?

5. Let us look to the other side of the juicy slice of pork. Is there a reasonable limit to “merit” such that no more than a certain percentage of a total research program can be allocated to meritorious projects and another percentage to non-meritorious projects? Is it reasonable to override meritorious projects in order to spread the funds on some other basis, for example by geography [a case in point is the University Research Initiative (URI)], by kinds of institutions, by kinds of performers, by mix of programs, by new blood for the guild? And how are Mr. and Mrs. Taxpayer assured that the merit certifiers themselves are sufficiently meritorious to play the exalted role?
6. Do research universities look at research more as a business they want to perform, for its revenue opportunities and potential to illuminate nationally the name of the institution for public relations purposes, rather than as a critically integrated component of its education and scholarly mission?
7. Do universities look at pooled costs (overhead) as a lucrative revenue source (to replace or supplement tuition, gifts, or endowment earnings) rather than as a reimbursement of costs already spent in support of research? How can universities make a claim of the latter if they waive the costs initially or provide incentives of returned pooled costs funds to be used as discretionary money by the departments who generated the pooled costs in the first place?
8. Are universities, because of the great opportunities for various possible campus benefactions, willing to get involved in the quest of this country’s economic competitiveness efforts even if that requires submission to publication, visitor, and access controls that transcend traditional academic policies of openness? Are institutions willing to turn title of patents to nongovernment sponsors or to grant full-term, exclusive licenses to industrial sponsors just to receive research support from industry? Are universities willing to perform less basic research in place of more applied or technical development and engineering test or clinical

trial work? Are campuses willing to enforce conflict-of-interest policies as they pertain to faculty who consult with industry and perform on the campus government sponsored research of interest to the same industry in the same field with whom the investigator has a consulting arrangement?

9. With the current “competitiveness” push, one that will no doubt be continued regardless of today’s polling event, can we develop approaches to effect better faculty-industry collaborations without transgressing universities’ primary responsibilities and accountabilities to our mission, our professional tenets, and to society? Will there be willingness to relinquish some of those individual faculty concerns about privacy, such as limitations on one’s total professional outside effort; disclosure of the nature of outside work, and amounts and kinds of recompense; to forego officerships and equity holdings in sponsor’s organizations while at the university; and to patent protect but publish scientific results of the research?
10. Is it appropriate for any research institution or PI to take overt stands against controversial programs, such as the Strategic Defense Initiative (SDI) program, and at the same time willingly accept funds from the program and rationalize the program components to meet special general research interests of the institution or the investigator? Defense, I am sure, is not the only agency from which one might gather other examples.
11. Should universities conduct research on their campuses if there are no students involved for either education or training purposes? Would it be more appropriate to conduct that research in government or national laboratories or in industrial laboratories?
12. Are we so desperate as institutions, as scientists, and as research administrators, that we are willing to permit violation and compromise of our fundamental professional principles and erode the credibility the science field has as a whole by indulging unacceptable professional scientific practices, be it misrepresenting research findings, intentionally falsifying experimental data, refusing to follow required research procedures and good practices, and substituting an individual’s immediate and long-term benefit for the public’s intent and trust? If so, why should the public continue to have trust in the academy or in science? How can we decry still further onerous, government regulations and control over our much cherished freedoms? Can we continue to be worthy of the trust society must have in our institutions or even in the individuals, whether they be the PI’s or those of us who dedicate our time in the support of the research enterprise?

13. Why is it that we of all people, scientists and research administrators, as members of that keystone of an advanced society, the academy, cannot rid society of its ignorance and superstitions, as well as its distrust of science and research so that anti-vivisectionists, right of lifers, and anti-recombinant DNA research forces are not able to prostitute and control science for their vested, special and limited interests? Is it that our stand is wrong? That we are too elitist? That we do not or cannot effectively and consistently communicate our story? That there is a deeper distrust of the field of science and those who perform it than we are willing to recognize?
14. If the values of science and research are so profoundly central to the advancement this nation has made over the last half century, to its high relative standing among other advanced countries, and to our very high standard of living, why is it that there is such a strong skepticism of science, that there is no powerful body-politic force for fundamental science?
15. And a serious question almost never asked except by Frank Press: Given the likely leveling-off of research funds available from the government, the dire need for upgrading of existing research universities' equipment and facilities at some considerable expense, and the decline in the number of American graduate students in the sciences, should the nation decrease the number of research universities rather than have them grow in membership number, especially through the avoidance of the merit review process? If so, what is the right number of research universities to wear the mantle, and on what basis are they designated and by whom?

None of the foregoing questions was intended to be accusatory of any individual or group of institutions. The intent of these questions is to provoke individual as well as group deliberations by national and campus policy makers as we enter an uncertain era of likely reduced federal basic research support, more intense competition for fewer resources, and continued public doubt. It is in the interest of the nation's welfare and security that society at least raise if not come to terms with these intricate and complex points. National policy makers have an obligation to the country's future destiny, while campus administrators have a fiduciary responsibility to balance the present against the future in the context of both the national and local campus interest. Each of you can play a most vital and informed role on both levels. Will you?

# The Global Research Race: New Models of Research Management

William H. Davidson

Abstract: Public support for technology development has assumed new and larger forms in Europe and Japan. National technology development initiatives in these nations play an increasingly important role in many fields of research. In virtually every field of science and technology, researchers from Europe and Japan are competing aggressively to seize and maintain leadership positions. Such heightened international activity suggests the need for a more global perspective in the research management function. Increased international activity raises many questions for the U.S. research community and for US. science and technology policy. This paper explores some of the key international developments in the research management area and explores the emerging American responses to new global realities in science and technology development.

**A** new global research race is taking shape, involving most areas of science and technology development. The key participants in the race are American, Japanese, and European research institutions: institutions that are increasingly assuming new forms of research management. The scale, structure and funding of research activity are being dramatically affected by growing global competition in science and technology development.

Research programs in Europe and Japan often contain significant direct public funding. They also increasingly involve cooperative forms of research management, typically involving a number of industrial corporations, and often including public or university research laboratories. These new programs have structures that may prove to be incompatible with traditional methods of research management, especially the single enterprise and university-based models. As a result, the field of research management is experiencing dramatic pressures for change in many of its fundamental dimensions.

---

This paper is based on a speech given at the 1987 NCURA Annual Meeting in Washington, D.C. William H. Davidson is professor of Department of Management and Organization, University of Southern California, Los Angeles, CA 90089-1421,

### **The Japanese Research Agenda**

The Japanese model of research management has been shown to be capable of dramatic successes. One of the best known examples was the VLSI Project formally initiated in the mid-1970's. This project was built upon a previous effort involving Fujitsu Corporation and the Nippon Telegraph and Telephone (a government entity) research laboratories. The results of the Fujitsu-NIT project were then expanded and addressed in a program involving six major Japanese corporations, the NTT labs, and a Ministry of International Trade and Industry (MITI) research laboratory. The project was funded primarily with public funds provided by the Japan Development Bank (a government institution) at extremely favorable rates and terms. These loans were essentially free of interest and they were not to be repaid unless the project was successful. These no-cost, no-risk loans, called Hojokin loans in Japan, are increasingly common in funding major research projects in that country. The project participants each committed a number of their best researchers and additional funding to the effort, with the understanding that the core technologies developed in the project would be transferred directly back to the participating corporations.'

Within five years of the project's initiation, Fujitsu announced the world's first commercial 64kilobit random access memory chip. Since that time the core technologies developed in this project have been instrumental in catapulting the Japanese industry into a position of complete dominance in the world semiconductor memory market. Japanese firms have led the way in introducing new generations of memory chips from the 64k through the 256k, 512k, 1 Megabit, and 4 Megabit chips to the 16 Megabit RAM introduced in prototype form in 1988.<sup>2</sup> Japanese firms now account for more than 80% of the world's merchant semiconductor memory market. This example provides a vivid illustration of how state-supported cooperative research efforts can provide a technology base for global leadership in a commercial technology.

The structure, process and funding typified in the VLSI project have been replicated dozens of times in Japan in the past decade. Similar efforts are underway in a large number of targeted technology fields, including those listed in Table I.

In addition to these major programs, Japan has initiated several other important programs to support science and technology development. The ERATO program, or Exploratory Research for Advanced Technology Organization, initiated in 1981, is a \$200 million undertaking to fund development of radical or revolutionary technologies. This project has funded more than fifteen research efforts including

**Table I**  
**Selected Japanese Technology Development Initiatives**

Project	Focus	Public Funding Level
Optoelectronics (1979-85)	Optic fiber cable and optoelectronic devices.	\$160 m
Fifth Generation (1979-91)	New Computing Architectures	\$270 m
TRON (1985-90)	Advanced Microprocessor Technology	\$270 m
Sigma (1982-90)	Software Automation Technologies	\$120 m
PIPS (1979-85)	Pattern Recognition Technology	\$80 m
Biotechnology (1982- )	Basic Support for Biotechnology Research	\$235 m/year
Supercomputer (1981-90)	High Speed Supercomputers.	\$200 m
Photonic Data Processing (1979-85)	Photonic Processing Technologies	\$70 m
Next Generation Electronic Devices (1981-90)	Super-lattice, Gallium Arsenide, and other advanced IC Technologies	\$275 m
Inter-operable Data Base (1985-92)	Connectivity and Compatibility in Data Communications	\$150 m

SOURCE: Agency of Industrial Science and Technology, Ministry of *International Trade and Industry*, Annual and Periodic Reports.

those listed in Table II. These efforts typically involve a designated university or public laboratory and one or more participating corporations. Public funding may be supplemented by corporate contributions.

Four other large scale Japanese programs deserve discussion. The Technopolis and Teletopia projects, the Key Technology Development Center, and the Tsukuba Science City undertakings represent new models of technology development. The Technopolis program represents

**Table 2**  
**Selected Japanese ERATO Projects**

Project	Project Members
Amorphous Compounds . . . . .	Furukawa Electric Otsuka Chemical Gakushuin University
Fine Polymer Project. . . . .	Mitsubishi Chemical Matsushita Sophia University
Pure Crystal Materials . . . . .	Mitsubishi Electric Mitsubishi Metal Hamamatsu Photonics Semiconductor Research Institute
Ultra-Fine Particles . . . . .	ULVAC Corp Stanley Corp Meijo University
Bioholonics . . . . .	Nissho Teikyo University
Superbugs. . . . .	Riken Hamamatsu Photonics
Nano-Mechanics . . . . .	Nippon Kogaku Tsukuba Research Institute
Solid Surface Technology . . . . .	Tsukuba Research Institute

**a massive national** effort to create advanced technology development and commercialization centers throughout Japan. This effort involves public funding of more than \$100 billion to construct laboratories, development facilities, and commercial centers for technology-based businesses. The bulk of this funding is for construction and real estate, but a significant portion of the total can be considered public research and development spending. More than thirty Japanese cities have established such centers. A typical center might include twenty different laboratories and development organizations of private, public and mixed origins.

A related effort is the Teletopia Program, which focuses on development efforts for information technologies. The primary focus of this program is to develop value added networks, databases, information services, software, telecommunications, information network and financial services industries. There are close links between the Teletopia and Technopolis undertakings and many of the specific science and technology development projects mentioned earlier.

The Key Technology Development Center was created following the partial privatization of Nippon Telegraph and Telephone. NTT has historically played a central role in Japanese research activity, much like Bell Labs in the United States. In addition to its own activities, NTT has funded critical R&D efforts by members of Japan's electronics industry, as seen in its pioneering of VLSI efforts with Fujitsu, for example. NTT has been owned entirely by the Japanese government. The New Telecommunications Law of April 1985 calls for one-third of its shares to be sold in stages to the public. The proceeds of that sale will total approximately \$30 billion, and 10% of the proceeds are used to fund the Key Technology Development Center. The Center has already funded projects in fields such as data communications and biotechnology. Projects funded by the Center will be closely linked to the Technopolis and Teletopia programs.

The Tsukuba Science City complex also represents a model of relevance to the Technopolis effort. Tsukuba, however, is more focused on basic science and technology than on commercial development and sale of new products and services. It contains a center of scientific study and research more similar to a university model than a corporate development facility. About forty development laboratories exist in Tsukuba; almost all receive public support and involve corporate research efforts. Tsukuba represents a major national commitment to create a technology-based community that merges the gap between the traditional university models and corporate or public research facilities.

This brief discussion of several of the key technology development initiatives and structures developed in Japan in recent years provides some sense of the scale and scope of Japanese efforts to achieve world leadership in the field of science and technology. It also reflects the increasingly important linkages between public and private sectors, and between university and corporate development functions, in the field of research management. It also reflects the critical role of a now increasingly aggressive national science and technology policy in Japan.

### **European Developments**

While the new models of science and technology development have appeared in force in Japan only in the past decade or so, similar models have been used in Europe for some time. Cooperative European development programs were initiated in the computer and electronics industries several decades ago. The success of the AirBus consortium was built on an earlier model that produced the Concorde. Publicly funded cooperative development projects have a relatively long history

in Europe. Europe has a mixed record of success with this model, although the problems appear to be primarily in the area of commercialization rather than technology development. In any event, this base of experience provides a vehicle for increased cooperative research activity.

In June of 1987 the European Commission, the central governmental body that has played a relatively limited role in European science and technology activities prior to this time, was given responsibilities for managing the European Community's High Technology Initiative. This Initiative calls for roughly \$30 billion of public funding for cooperative research initiatives involving enterprises from member countries. The key programs under this umbrella include the EUREKA, ESPIRT, and RACE projects. EUREKA is particularly focused on information electronics projects. Through 1987 more than a dozen cooperative ventures have been funded under EUREKA, involving corporate participants from different European countries. Public agencies and enterprises, such as TNO in Holland, DGT in France and the Bundesministerium fur Forschung und Entwicklung in Germany play important roles in defining and implementing these research projects. Publicly owned enterprises, notably in France, but also in other European countries, often are principal participants in these research programs.

The principles of public support and participation, and cooperative research are well developed in Europe. University involvement in the research process does not seem to be as developed in Europe as it is in the U.S. and Japan. The principal model of research management in Europe appears to be taking shape as one that will involve private and public enterprises supported by public funding in community-wide cooperative research efforts. These efforts will be focused in areas carefully selected and supported by public policy makers. This approach will be reinforced as the process of European integration under the 1992 initiative further strengthens the need for common technology standards throughout the community. The rapid progress of European integration will also reinforce the willingness of individual governments to participate in cooperative activities with other community nations. The need to achieve global scale in technology development appears to be a critical objective in science and technology policies in the European community. more cooperative activity and greater public funding are the immediate results.

### **U.S. Response**

While significant shifts are appearing in the research and development activities of Japan and the European nations, it is very important to

note that striking shifts are also occurring in the science and technology arena in the United States. One of the first signs of fundamental changes in public policy appeared in the 1984 Cooperative R&D Act, a bill that was passed unanimously by both Houses of Congress. This bill, championed by Bruce Merrifield of the Commerce Department, eliminates antitrust liabilities for firms engaged in qualified cooperative development ventures. This legislation significantly alters the underlying antitrust environment to permit cooperative research programs between firms within the same industry. Since that time, a number of important new cooperative, industry-specific technology research efforts have been initiated in the United States. The first and most visible is the Microelectronics and Computer Center (MCC), in Austin, Texas. This project involves a dozen companies who each contribute funding and personnel to one or more of four technology development programs. In addition to MCC, the Semiconductor Research Corporation (SRC) in Research Triangle, North Carolina, also involves a number of firms engaged in cooperative research activity in the semiconductor industry. More recently, Sematech was created, bringing together another set of firms to focus on specific semiconductor technology development needs and opportunities.

The Sematech project provides insight into another critical shift of public policy in the high technology area. Sematech, while an industry initiative, received significant public support. An interagency task force chaired by an official of the National Science Foundation was instrumental in achieving public financial support for this undertaking. In fact, it is clear that the federal government is not only permitting cooperative R&D activities, it is actively encouraging and even initiating such efforts. In the aerospace industry, virtually all of the major new technology development projects are joint development undertakings shaped by the Department of Defense. Teams have been formed to develop alternative technologies for the Advanced Tactical Fighter (ATF) and the Advanced Tactical Bomber (ATB) projects, for example. The Department of Defense and the Defense Advanced Research Projects Agency (DARPA) have clearly been supportive of this joint development model.

In addition to these widely publicized and highly visible initiatives, a number of less well known cooperative research programs exist as well. For example, an association of 36 corporations fund a pump technology center based at the University of Virginia, and several industry associations fund technology development efforts at the Massachusetts Institute of Technology. An Institute of Textile Technology in Charlottesville, Virginia, manages basic textile research for a consortium of textile firms and offers masters and doctorate degrees

in applied textiles technology. Similar industry-specific cooperative research structures can be seen in the shoe industry, in the pipe industry, cement, plastics and many other sectors. It is quite common to see these institutes or centers based at a university.

In addition to providing an impetus to cooperative research activity, public policy has been highly supportive of technology development in the 1980's. The National Science Foundation budget has almost tripled during a time when many other departments have experienced shrinking budgets. NSF has launched several new initiatives, including the establishment of engineering and science centers at a variety of universities. Its Small Business Innovation and Research Fund (SBIR) provides low-cost loans and grants to a large number of promising new technologies in the pre-commercial stage. This program is specifically intended to encourage the development and commercialization of such technologies.

DARPA has also played an increasingly important role in technology development in several critical areas. DARPA has budgeted about \$850 million in supercomputer research in the 1980's. In addition, it has developed programs for the support of semiconductor technology development, including the VHSIC, ICAM, and gallium arsenide efforts. DARPA has even committed resources to a consortium aimed at launching an American high definition television technology.

Tax policy has also been supportive. The Federal R&D tax credit remains one of the few industry tax incentives left intact under the 1986 Tax Reform Act. The R&D tax credit received strong Congressional endorsement, while the investment tax credit was eliminated entirely, indicating the importance of R&D activity in the public policy community.

### **Summary**

There are indications that suggest U.S. science and technology policy has been sensitive to key trends in the global research arena. There has been a significant policy shift in favor of cooperative research activity, and public funding and support for technology development have increased significantly. At the same time it is important to recognize that continued efforts to improve the nation's science and technology standing will be necessary to maintain leadership in an increasingly competitive global arena. Further efforts to integrate the university research infrastructure with public laboratories and corporate research centers will be necessary to be effective in global research competition. In addition, linkages of this sort will be essential to insure timely and effective commercialization of technologies developed in university facilities. Communication among the three core sectors in the research

community: government, corporate and academic participants, will be essential in defining appropriate priorities for the use of scarce research resources. Further investments in infrastructure such as those seen in Japan, and broad national programs in targeted areas of technology development also seem to be warranted to ensure success of global research fields.

The challenges facing the new Bush administration are significant. In a variety of strategic technologies, including semiconductor, supercomputers, superconductivity, telecommunications, aerospace and advanced materials, American technology leadership can no longer be assumed. Existing programs in these and other strategic fields will need to be strengthened to ensure continued leadership. Further efforts to increase public support and to promote cooperative development of targeted technologies will be necessary.

These new realities are widely recognized in the public policy community. We can expect additional steps to extend and formalize support for science and technology development. The principal focus of an emerging national science and technology development policy might be on so-called joint-technologies, these which are critical to both military and industrial leadership. Broad bipartisan support appears to exist for focused efforts in joint technologies.

The global research race is just beginning. It will involve competition with European and Japanese researchers, many of whom operate in new institutional forms with new forms of funding and support and new research infrastructures. Given these shifts in the foundation of research activities in the industrial world, ongoing reassessment of research priorities, policies, and structures will be essential to the continued performance of the U.S. research community.

## REFERENCES

<sup>1</sup> Sakakibara, Y., "From Imitation to Innovation: The VLSI Semiconductor Project in Japan" Working Paper, Alfred I? Sloan School of Management, MIT, 1982.

<sup>2</sup> International Competition in Advanced Industrial Sectors: Trade and Development in the Semiconductor Industry, Joint Economic Committee, Washington, DC., Government Printing Office, 1982.

Davidson, W.H., *The Amazing Race: Winning the Technorivalry with Japan* (New York: Wiley, 1984).

## BIBLIOGRAPHY

Davidson, W.H., *The Amazing Race: Winning the Technorivalry with Japan* (New York: Wiley, 1984).

- Japan Technology Evolution Program, JTECH Panel Reports on Telecommunications, Technology, Science Applications International Corporation, May 1986.
- Mansfield, E., "Industrial R and D in Japan and the United States: A Comparative Study," *American Economic Review*, (May 1988).
- Okimoto, D., "The Japanese Challenge in High Technology," in Landau, R. and Rosenberg, N. (eds) *The Positive Sum Strategy* (Washington: National Academy Press, 1986).
- Patrick, Hugh (ed) *Japan's High Technology Industries*, (Seattle: University of Washington Press, 1986).
- Tatsuno, Sheridan, *The Technopolis Strategy: Japan, High Technology, and the Control of the 21st Century*, (New York: Prentice Hall, 1986).
- Trendscape, "Will the Japanese Do it Again," Fall/ Winter 1987, pp 30-41.
- Tyler, M.A., "Japanese Technology Research and Development: A Corporate Assessment," Washington: Science Applications International Corp., 1987.
- Yoshikawa, A., "The Japanese Challenge in Biotechnology," BRIE Working Paper Number 29, Berkeley Roundtable on the International Economy, University of California, Berkeley.

# Technology Transfer from University to Industry: Responsive and Responsible University Policy

Anne Wright

**Abstract:** A recent and growing trend in university research administration is the movement which has become known as “technology transfer.” In the context of a research university, technology transfer refers to the principles and processes adopted to assure the early identification of new technology and inventions, and commercialization of university research via private industry. Technology transfer can hold the key to economic competitiveness in the global arena, and universities must form their technology transfer policies with an understanding of the market demands driving industry.

Recent studies show that California industries face a struggle to survive and grow in an environment of increasingly stiff international competition and rapid technological change. This paper briefly describes the four strategic technologies which have been identified as important to California’s economy: biotechnology, advanced materials, information technology and manufacturing technology.

With current attention focused on the degree to which high technology applications affect state and national competitiveness in the global economy, this paper suggests that university technology transfer policymakers should not lose sight of their responsibility for directing university efforts to improve the human condition and benefit the public good.

While this paper focuses on technology transfer from the perspective of the current and projected economy of California, and within the University of California System, it may be useful in evaluating the potential impact of these trends on the national economy, and their effect on research administration at other universities.

---

*Anne Wright* is Senior Administrative Analyst, Office of Contract and Grant Administration, University of California-San Diego, La Jolla, California 92039.

## INTRODUCTION

The series of interactions loosely defined as technology transfer occur by means of the various intermediary linkages between the supplier of technology (the research university), and users generating the market demand for the application and commercialization of technology (industry). The interaction of generators with users comprise the research and development infrastructures within which technology transfer occurs.

The mission of the University of California is research, education and public service. Technological advances impact all these objectives because such developments are both a means and an end in educational and research processes, and because advances in science and technology can ultimately be applied to improve the standard of living and advance the public good.

The transfer of technology is an inherently dynamic process which is governed at the most basic level by economic principles of supply and demand. The challenge facing technology transfer policymakers within universities today is to structure these processes to consider market demand as one significant factor, without sacrificing any of the academic and social principles by which the university operates.

One of the best examples of this longstanding balancing act is the tension between the practice of business to rely on secrecy to maintain a competitive advantage, and the mandate of academia to make information available to all those it is likely to benefit. Another example stems from one of the reasons why university research centers are such resources of innovative and creative new technologies: the principle of maintaining independence to control the direction of research efforts. In contrast with this practice is the desire of industry to select and control research for purposes determined outside the university.

A more recently emerging example of the divergence in interests of university and industry is the issue of the university's obligation, if any, to affirmatively favor newer, smaller businesses over established large corporations. A related question is whether the university should favor industry within its home state over out-of-state business, or U.S. markets over foreign corporations.

It is not the purpose of this paper to attempt to resolve these questions, but only to frame the context in which they should be considered. It is suggested that before attempting to resolve issues which arise at the point where the interests of universities and industries diverge, an attempt be made to understand the economic factors which drive the industries interested in obtaining university technology, and

to determine the degree to which the university must be responsive to the demand of the marketplace in formulating technology transfer policies. On one hand, the university as a supplier has a responsibility to assure that the technology is applied for the benefit of the general public. On the other hand, the university must recognize the economic trends in the technology marketplace, and be responsive to the technology industries which generate the demand.

## **I. Responsibility for Technology Supply**

### *A. Past Accomplishments and Future Trends*

The successes of past technology transfer practices within California's universities are reflected in the statistics. In a background paper prepared for the California Economic Development Corporation in March, 1988, the Center for Economic Competitiveness of SRI International listed California as the national leader in total university R&D expenditures.<sup>1</sup> According to the report, entitled "California's R&D Infrastructure: Harnessing Technological Innovation for California's Future" ("SRI Report") over 25% of nationally sponsored research and development is conducted in California. California accounts for 13.2% of the national total university R&D expenditures. In 1985, the nine-campus University of California System accounted for \$839 million in research, or 68% of California's total for that period.<sup>1</sup>

It is significant, however, that in California, the bulk of this funding comes from federal defense spending industries such as aerospace, and to a lesser extent, from federal health-related research sponsored by the National Institutes of Health. Federal R&D spending is expected to total \$132 billion in 1988, a 7% increase over 1987. However, as reported recently in "Science News" a National Science Foundation analysis showed that this rate, when adjusted for inflation, represents the lowest rate of growth since 1977.<sup>2</sup> The NSF study also highlights a trend of federal funding, which began in 1982, toward supporting development at the expense of research. Roughly 68% of R&D in 1988 will go for development projects including engineering and the design of prototypes or processes.

The success of past efforts in technology transfer is no longer a guarantee of future success. Analysts within the California Economic Development Corporation predict that California's economy will become increasingly vulnerable as a result of reductions in the demand for defense-related products, and for the skills of California's work force. In a March, 1988 special report for the Governor, the CEDC warned that the heavy dependence on decreasing defense R&D support may

become a problem for the state's industries.<sup>3</sup> Entitled "Vision: California 2010" ("Vision Report"), the report suggests that technology transfer programs within California's universities can address this problem to the mutual benefit of industries and universities within the state of California.

Given the grim economic predictions, both university research programs and private industry will be impacted by the trend away from federal sponsorship of research. By considering this dilemma in the context of traditionally structured sponsored research relationships, it becomes clear that innovations in technology transfer are needed to avoid not only adverse effects on the standard of living and economy of the state, but to avoid significant erosion of the University of California's preeminent position in sponsored research. In this respect, at least, the university as a supplier of technology, and private industry as a user, share a strong common interest.

#### B. Effectiveness of Traditional University Technology Transfer Mechanisms-Sponsored Research and Licensing Programs

A primary vehicle for technology transfer has traditionally been industrial support of university-based research. Technology arising from such research is frequently transferred when industry elects to license inventions resulting from such research, an option which industry is typically granted in consideration for sponsoring the research. While this tidy approach of directly funding specific research projects in exchange for rights to resulting inventions has served the R&D infrastructure in the past, even this traditional method must evolve to meet the demands for more interrelation and cooperation between the parties.

There is no longer any simple distinction between government's role in the basic research, and industry's role in applied research and development. While the university's role in the R&D infrastructure is important, especially in the early stages of fundamental research, its focus must be broadened to recognize that not all research can be neatly categorized as "basic" or "applied" for purposes of technology transfer.

Private industry is increasingly interested in the intermediate area of research where the transition is made from basic or fundamental research to applied research. Dubbed "generic research" in the SRI Report, this category of research involves technology which is "pre-competitive," or several steps removed from immediate commercialization, but which has the potential to justify further research.

The SRI Report cites the “Centers of Excellence” established at several University of California campuses as models of generic research conducted within the university setting to the benefit of both the university and industry. The Center for Advanced Materials at UC Berkeley, and the Center for Robotic Systems in Micro-electronics at UC Santa Barbara both represent vital linkages for transferring technology because they enable industry to identify and capitalize on generic research.

A significant intermediate category of university research must be recognized, and strategies for technology transfer of the intermediate type of research must also be developed using the traditional linkages of sponsored research and licensing. Intent on the traditional categorization of all research into “basic” and “applied” categories, university research administrators may fail to recognize the value of such generic research to industry. Those who do so may miss the opportunity to form innovative and mutually beneficial relationships with private industry.

At the University of California, licensing activity is presently concentrated in a centrally located Patent Office serving all campuses. Advisors within the University, and outside observers agree that there is much room for improvement in the licensing system overburdened not only by a dramatic increase in the volume of such activity in recent years, but also by the increasing complexity of such arrangements sought by savvy entrepreneurs. The result of this bottleneck, according to a 1987 news report, is that the University is losing significant royalty income because of the licensing backlog and the time consuming nature of the process.<sup>4</sup>

In 1987, the University of California, San Diego, completed a study of the biotechnology transfer process.<sup>5</sup> The UCSD study, sponsored by the John A. Hartford Foundation’s Biotechnology Transfer initiative, (“Hartford Study”) was aimed at identifying key issues and exploring alternative mechanisms to develop the University’s capacity to select, develop and market projects that offer both scientific merit and commercial potential.

The Hartford Study recommended decentralization of the licensing responsibility to each individual UC campus to relieve this problem. To keep pace with recent developments, and in particular to compete successfully with foreign economic interests, the Hartford Study noted that past practices in licensing must be streamlined and expanded to permit timely transfer of both patented and unpatented university technology. Campus efforts in the licensing process can include coordination of the process and “troubleshooting” to facilitate communication and expedition of the licensing practices.

*C. Responsibility for Developing New University Technology Transfer Mechanisms*

The UCSD Hartford Study includes the results of separate surveys sent to campus research faculty and private biotechnology companies in 1987, and contains recommendations for organizing and coordinating campus technology transfer efforts. While it must be noted that the focus of this study was biotechnology, the results are illuminating and may be applicable in other strategic technology areas as well.

The faculty group identified the timeliness of technology transfer practices as of significant importance, and suggested that the licensing process at the University of California could be expedited by establishment of a standardized option license agreement in which patent filing fees are paid in advance. Respondents from private industry agreed that time is of the essence in transferring biotechnology. Responses from industry prompted the study authors to suggest that the University consider expediting more licensing activity with private industry. A parallel recommendation was offered in the Vision Report: "The University of California should develop policies and guidelines affecting patents, licensing and royalties that encourage better university/industry relationships."<sup>3</sup>

For universities considering the establishment of a technology transfer program responsive to the interests of those within the R&D infrastructure, the Hartford Study provides insight into the forms of technology transfer preferred by the biotechnology industry. The method of transferring technology most preferred by industry was by license agreements (42% of respondents). Preference for informal scientific meetings was a close second at 41%. Consulting arrangements with individual researchers were preferred by 28% of respondents, and formal scientific conferences were preferred by 22%. Interestingly, sponsored research relationships were preferred by only 17% of respondents, while 33% indicated that they did not use sponsored research as a means of obtaining technology from universities.

These statistics are significant in that they reflect the changing times and the opinions of an industry involved in one of the most rapidly evolving fields-that of biotechnology. The Study illustrates the degree to which the time-consuming traditional approaches of a large research university patterned after typical federal funding practices, are becoming obsolete. The Study noted that those institutions which cultivate innovative relationships with private industry outside of the traditional patterns have been successful in obtaining industrial research support. Massachusetts Institute of Technology has increased its level of industrial

funding 20% a year since 1976, a growth rate which the Hartford Study notes is higher than any other funding source for MIT and is equal to 15% of total research funding for 1986.<sup>5</sup>

## **II. Responsiveness to Market Demand for Innovative Technology Transfer Mechanisms**

Clearly, one approach to building a successful technology transfer program within a university is to focus on ways of attracting industrial support by becoming more responsive to the needs of both researchers and private industry. While the traditional mechanisms of sponsored research and licensing, either independently or in tandem, are still viable, attention must be directed to developing new relationships and linkages with industry to transfer technology for new product development and productivity improvement. It is suggested that there are two approaches to meeting this challenge: first, to develop systems to identify promising research and disseminate this information to industry; and second, to encourage creation of innovative collaborations between science and industry to foster the cross-fertilization that such linkages can promote.

### **A. Information Dissemination**

A first step in any technology transfer program is to develop a system or systems for gathering information about university technology and making it available to those whose support is sought. According to the Vision Report, “converting research into economic activity requires a better network through which ideas can be exchanged or transmitted. This network must have links between research facilities and industry as well as among firms.”

The Licensing Executive Society (LES) has established a numerical system of coding technical and scientific categories which may be used to create information data bases relevant to and accessible by subscribers from private industry. The LES system offers a standardized format for identifying information about new technologies which may make such information more accessible to industry. Access to technology may be offered through periodical publications highlighting projects of interest, catalogs of academic expertise available for consulting, and lists of inventions ready for commercial application.

### **B. Innovative Collaborations**

A university interested in transferring technology to private industry might explore collaborative relationships outside the traditional research

sponsorship and licensing relationships which are patterned after federal support of research programs. For example, industrial affiliates *programs* may be initiated in which member industries are given regular access to the general research within their specific field of interest for a structured annual fee. At the University of California, San Diego, the Center for Magnetic Recording Research member industries have subscribed to programs which enable the affiliates to receive annual reports of activities within the Center, and to attend periodic conferences in which areas of specific interest are highlighted, and to participate in personnel exchanges in which industry representatives spend a period of time "in residence" at the Center.

Several universities have established or work with *non-profit* corporations which serve as the intermediary agency between the university and industry and allow cooperation on a neutral third party basis thereby avoiding conflict of interest issues. The California Institute for Energy Efficiency is a proposed non-profit corporation which will be supported by California's utility companies and which, in turn will fund energy research at California universities.

Universities are also exploring the concept of *research parks* or *incubators* in which small new companies, who could not otherwise afford start-up costs, can participate in technology transfer in an economically sheltered environment. Universities can assist existing companies or industries to develop new product lines, and can assist entrepreneurs to initiate new businesses. The most successful example of this method of collaboration is North Carolina's Research Triangle Park, which was formed in cooperation with the University of North Carolina at Chapel Hill, Duke University at Durham, and North Carolina State University at Raleigh.

In addition, *conferences*, *workshops* and seminars for industry can be planned as periodic or single-purpose events to highlight a particular discipline or a group of related disciplines. Attendance at such conferences by scientists from industry provides an excellent opportunity for scientists within industry and within the university to discuss matters of mutual interest. While the return on such events might not be directly measurable or immediately apparent, the Hartford Report cited these relatively unstructured and informal exchanges as the form of technology transfer of greater interest to private industry. Such informal events also can provide the basis for long term relationships between university and industry which may lead to more formal joint ventures.

According to John Preston, Director of the MIT Office of Technology Licensing, one effective method of getting extremely embryonic technology into a position where it can be picked up by

a big company, is first to license a small firm, which builds the technology up to where it becomes compelling for a big company to get involved. Preston has noted that these entrepreneurial companies have significantly accelerated MIT's technology transfer. In FY 1988, of the 92 licenses granted by MIT, 16 were made to start up companies for this purpose. According to Preston, MIT alumni-founded companies in Massachusetts alone employ 180,000 Massachusetts residents, and have a total turnover of \$38 billion a year, which accounts for about 25% of the gross state product.<sup>6</sup>

### **III. Response to Demand for Transfer of Developments in the Strategic Technologies**

The 1988 SRI report identifies four technologies of strategic importance to California's economic future: biotechnology, information technology, advanced materials, and manufacturing technology: The report concludes that California's universities play a critical role in the state's R&D infrastructure and suggests technology transfer strategies which are responsive to the needs of the state's industries.

A comprehensive approach to technology transfer from university to private industry must take into account all these fields, and the interrelated and independent linkages within the R&D infrastructure necessary to effectively transfer the technology. Business enterprises rarely run within the narrow confines of a single academic discipline. Further, high technology development is a dynamic process, and by its very nature, continues to evolve to meet the changing demands of national and international economic, political and social developments. Accordingly, a key strategy in establishing technology transfer policies within a university would be to focus on early identification of inventions and new technologies. Technology transfer policies must be flexible enough to adapt to the evolving and frequently cross-disciplinary technologies strategic to industrial competitiveness.

In focusing on the general strategic technologies by category, however, universities can organize their approach to technology transfer into a format more easily understood and assimilated within the R&D infrastructure. Above all, from the perspective of the users generating the demand for transfer of technology, universities must recognize and appreciate the interests of industry regarding developments in the strategic technologies. Industry's priority is for timely receipt of information regarding such new technology and for university procedures which are streamlined to provide for timely transfer of commercially viable new products.

#### A. Biotechnology

An area which has received much attention among state, national and international policymakers is that of biotechnology. Biotechnology is broadly defined as any technique that uses living organisms to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses. Biotechnologies include recently developed techniques such as recombinant DNA or hybridoma technology, and gene' cloning and cell fusion. With over one-third of the nation's biotechnology firms located in California, the University of California's research results have a significant impact on the biotechnology industry.

Biotechnologies such as genetic engineering and recombinant DNA techniques hold great promise for rapid growth in a broad spectrum of applications in the fields of food and agriculture, health, energy and the environment. Because of recent advances in scientific and research techniques, biotechnologies may also promise the greatest economic return for the least capital investment. This characteristic makes biotechnology an attractive business venture, and may account for the fact that much university technology transfer effort to date has focused on this area. Public benefit to be realized from biotechnology includes advances in diagnosing and treating genetic diseases and improved drug delivery systems.

#### B. *Information Technologies*

This group of technologies includes the science of micro-electronics and impacts such industries as telecommunications, computer programming, computation and supercomputers, as well as the field of computer aided engineering and manufacturing, and new communication data networks.

As any adult familiar with current public elementary, secondary, and post-secondary education knows, computer literacy is fast becoming a vital addition to the "3 Rs" of traditional education. Computers are becoming essential in many aspects of public and private life, not only for the immediate information they process, but for the access they give us to the increasing wealth of available information.

The university which pioneers such advances in higher education contributes to the process whereby the public benefits from the increased use and understanding of computers through business education and personal life.

#### C. *Advanced Materials*

Advanced materials include superconductors, ceramics, nonmetallic composites and polymers. Research into altering surface structures, and

manipulating matter at the atomic level holds great promise for manipulating atoms and molecules for a variety of purposes. Progress in these technologies is vital to information technologies as well as many areas of production and manufacturing.

Like biotechnology, this cluster of technologies has also experienced rapid recent growth, and attracted public attention, as attested by the interest in the popular media of superconductivity. In May 1988, California's Governor George Deukmejian announced the creation of the California Competitive Technology program to seek new technology through an historic partnership between the state, California's universities and private industry.<sup>7</sup> Underscoring the economic importance of this research, Governor Deukmejian announced the California Superconductivity Project as the first major project of this new state program.

Public benefit to be realized from advances in these technologies ranges from improvements in home kitchens to efficient mass transportation systems.

#### D. *Manufacturing* Technology

Manufacturing technologies are applicable across industry sectors and are critical to assuring quality and increasing productivity necessary to maintain a healthy economy. Such technologies include computer automated manufacturing, electronics and sensor technologies, robotics, computer aided design and computer aided manufacturing.

California's competitive advantage in the semiconductor industry is being threatened by Japanese efforts in this field. These technologies are vital in producing innovations which improve the efficiency of the manufacturing process, and thereby increase productivity. The public benefits which may result from advances in these technologies include more efficient use of resources and manpower, and higher quality of consumer products and services.

### **IV. Achieving a Balance Between Response to Demand and Responsibility for Supply**

The goal of any organized effort of the university to transfer technology should be to achieve practical application of research findings of scientific and social value for the benefit of the general public. The issue facing university policymakers now is how universities will specifically establish technology transfer policies to implement this goal. In recent years, analysts on both sides of the R&D infrastructure have come to recognize that this fundamental goal of the university is compatible in many ways

with the goal of industry to apply advances in technology in order to maintain a competitive advantage in the new global economy.

In establishing technology transfer policies universities must determine the extent to which this focus on competitiveness will influence their approach. To succeed, a university technology transfer effort must seek a balance between the university's responsibility to serve the public good, and its response to the demands of private interests to create and develop university inventions involving the strategic technologies.

*A. Response to Market Demand **for** Strategic Technology*

Technology transfer activities within the University of California will directly benefit California's economy to the degree that they meet the demand of California's industries seeking to develop and commercialize new products and processes arising from university research. While the University's role in maintaining the economic health of the state may have been less direct in the past, the relationship between the university / suppliers and the industry/users of technology can be seen at the technology transfer linkage as one of direct supply and demand.

In taking the first steps toward creating a centralized campus technology transfer office at UCSD, the administration is acknowledging that direct technology transfer is an acceptable way to assure that Californians realize the potential advantages technology applications hold for improving the quality of life. The university recognizes that the fundamental laws of supply and demand operate to create economic realities of the open market in which university technology is transferred.

In California, market demand is generated by the interest of California industries in development and commercialization of new products and processes primarily in the strategic technology areas. Technology transfer strategies which recognize market demand make good common sense, as illustrated most clearly by the royalty income generated through a well directed licensing program which is responsive to market demand. The university benefits directly by earning royalty income to support future research, and the industrial licensee benefits directly by gaining a competitive advantage in the marketplace. Such traditional technology transfer relationships also benefit the general public by creating jobs and strengthening the economy, and by making technological advances, and the products they make possible, available to the general public.

Another and more innovative example of a university's implicit recognition of market demand is the Industrial Affiliates program created

to start the UCSD Center for Magnetic Recording Research. As a concession to the member affiliates, often competing with each other for the same market share, the University agreed to dedicate all inventions arising from generic research at the Center to the public. Competing industries agreed that they would all get the benefits of the same technology and the commercial edge, if any, would go to the most capable developer. This agreement to dedicate inventions to the public and thus forego potential royalty income, represented a major departure from longstanding University of California patent practice. The exception was made in this case to enable the campus generic research effort in this area to benefit from an unusual cooperation of industrial sponsors, who in turn would share the benefits of their pooled resources provided to establish the Center. Possibly a more significant aspect of this innovative relationship is that it assured that the general public would benefit directly and immediately from applications of any resulting developments in this technology.

#### B. Responsibility to Serve the Public Interest

It is important that the policies developed within the university to achieve technology transfer not be blindly aimed at accommodating the objectives of industry in the transfer process. Understanding industry's objectives is only the first step. The university must then determine the extent to which the focus on competitiveness advances the university objectives of education, research and public service. Finally, the university must assure that the academic principles of free exchanges of intellectual ideas and freedom to publish are not compromised in any linkages with industry to technology transfer.

Universities must consider other factors besides market demand in formulating linkages with the R&D infrastructure. According to George H. Dummer, Director of the MIT Office of Sponsored Programs, while it is appropriate that market demand influence licensing activity, it is essential to protect and preserve the integrity and values of the university itself with respect to university academic and research programs.<sup>8</sup> At a 1982 conference on university-corporate relations, George Low, then President of RPI, suggested a basic answer to how universities can make the most effective contacts with corporations interested in university technology.<sup>9</sup> His advice was simply that universities develop educational goals and plans, and carry them out with distinction. If such programs happen to interest industry, then the university has the basis for developing mutually satisfactory linkages.

## CONCLUSION

At this critical state where university technology transfer is evolving from a generalized concept for action into a series of specific practical applications designed to achieve technology transfer, the academic research community and university research administrators have a vital role to play in determining how universities will approach their relationships with industry in these matters.

The university cannot ignore the forces that motivate industry because these economic forces are real and effect us all. Technology transfer policies within California universities which focus on the strategic technologies are likely to best serve both the public purpose of universities and the private interests of industry. Technology transfer activities must be directed at making information on technology accessible to industry, and at transferring technology to industry in a consistent and timely manner.

Today, universities have come a long way from the isolation of the “ivory tower” where commercial motivations were sometimes seen to be less pure if not intrinsically improper. At the other extreme, university technology transfer policies established simply in response to objectives set by industry would betray the academic principles upon which the university is founded. Universities must recognize that industry objectives which focus on market demand and emphasize competitiveness must be balanced against the mission of the university to conduct independent research and serve the public. It is submitted that technology transfer policies will succeed to the extent they balance these competing interests of universities and industry.

In the end, the role of the academic institution in the international marketplace of high technology research and development may be that of a group conscience. Universities have a responsibility to work toward the benefit of the general public, and to preserve the principles which value the public good. University technology transfer policymakers may be responsible for reminding industry that today it cannot ignore the moral and social factors motivating academia, any more than the university can ignore the economic factors which motivate industry.

## REFERENCES

- 1 SRI International, “*California’s R&D Infrastructure: Harnessing Technological Innovation for California’s Future*”, Background Paper

- for California Economic Development Corporation, prepared by the Center for Economic Competitiveness, Menlo Park, CA, 1988.
- 2 *Science News* Vol. 133, No. 20, "R&D Growth Slows to Eleven Year Low", page 13, May 14, 1988.
  - 3 California Economic Development Corporation, "Vision: California 2010, A Special Report to the Governor", Sacramento, CA, March, 1988.
  - 4 *San Francisco Examiner*, "UC losing millions on inventions", page 1, October 18, 1987.
  - 5 University of California, San Diego, School of Medicine, "A Study of the Biotechnology Transfer Process", San Diego, October, 1987.
  - 6 Personal communication from George Dummer, MIT, to author, April 24, 1989.
  - 7 Press Release from Governor George Deukmejian's weekly radio address, Sacramento, CA, May 7, 1988.
  - 8 Personal communication from George Dummer, MIT, to author, January 26, 1989.
  - 9 Low, George, "Organization of Industrial Relationships in Universities," *Partners in the Research Enterprise: University-Corporate Relations in Science Conference*, December 14-16, 1982. (Conference proceedings published by *University of Pennsylvania Press*, 1983.)

# Organization and Promotion of Sponsored Research at a Mid-sized State University: A Ten-year Case History

John M. Mishler

*Abstract.* The various long-term factors and strategies used to promote sponsored program development during a five-year phase at the author's institution are analyzed. Implementation of a set of specific initiatives is cited as the major factor in establishing an institutional climate for change at the institution.

## INTRODUCTION

The current literature provides numerous indepth studies and case histories addressing some, but not all, of the myriad of factors related to the ability of predominately teaching-oriented educational institutions to acquire sponsored funds, e.g., institutional commitment, suitable infrastructures and resources, internal research grant programs, research-oriented faculty development programs, formula-based incentive plans, grant development seminars, sponsored program information systems, etc.<sup>1</sup>

With respect to case histories, however, the majority of these investigations have been limited to one or few such factors promoting sponsored research and data presented are often anecdotal or retrospective in nature. Such case histories are further hindered by: (a) lack of specific information regarding effectiveness of the identified factor(s) over a long term period (most findings are only reported on a short-term basis); (b) successful integration of this factor(s) in the context of other institutional, academic unit or faculty variables affecting the climate for sponsored programs; and (c) absence of an overall institutional strategy to foster receipt of sponsored funds combined with development and implementation of appropriate initiatives to support this strategy.

In light of the deficiencies noted in previous case histories, the present report identifies various long-term factors and strategies utilized

---

John M. Mishler is Associate Vice Chancellor for Research , *Office* of Research Administration (401 SH), University of Missouri-Kansas City, 5100 Rockhill Road, Kansas City, Missouri 64110-2499.

to promote the acquisition of external monies, during two distinct consecutive five-year phases in the history of sponsored funding at the University of Missouri-Kansas City (UMKC). The first or “Pre-Emphasis Phase” (Fiscal Years 78/ 79 through 82/83) was practically devoid of ‘any constructive effort or strategy to promote campus-wide sponsored funding; any results achieved were certainly due to the tenacity of a few dedicated faculty members. This non-organized, non-promoted phase averaged some \$780,000 per annum in sponsored research funds (see Figure 1). The second or “Emphasis Phase” (Fiscal Years 83/84 through 87 / 88) is an exact antithesis of the former, i.e, initiation of an institutional (system- and campus-wide) commitment for a sponsored research-oriented mission,<sup>2,3</sup> creation of appropriate administrative and faculty infrastructures,<sup>2,3</sup> development of suitable institutional, academic unit and faculty objectives and priorities to promote sponsored research,<sup>3</sup> internal research grant programs dedicated to acquisition of external funds,<sup>2,4</sup> implementation of a formula-based incentive plan/venture capital fund<sup>5</sup> and enhancement of university-pharmaceutical industry cooperation concomitant with the brokering/placement of clinical trials.<sup>6</sup> The organization and promotion of sponsored research under this latter phase has resulted in the average receipt of some 2.7 million dollars per annum; a more than 3.5-fold increase when compared to the average amount awarded during the former period.

The remainder of this report will describe the various initiatives and strategies utilized, during the Emphasis Phase, to foster this organization and promotion of sponsored research at UMKC; in some cases, assessment techniques (e.g., faculty questionnaires) were used to substantiate the usefulness of new policies, and these evaluation tools when utilized, will be documented. In addition, the success of these initiatives and strategies, on a long-term basis, are placed in the overall context of achieving a sustained growth in sponsored funding.

## **BACKGROUND**

The University of Missouri (UM) is a single land-grant institution with four campuses located in Columbia, Kansas City, Rolla and St. Louis and is governed by a Board of Curators. At UMKC, some 11,800 full-time undergraduate, graduate and professional students are enrolled in degree programs housed within the College of Arts and Sciences, eight schools (Basic Life Sciences, Business and Public Administration, Dentistry, Education, Law, Medicine, Nursing and Pharmacy), Conservatory of Music and two academic programs (Computer Science and Coordinated Undergraduate Engineering).

## **EMPHASIS PHASE HIGHLIGHTS**

As previously documented, authority to implement a sponsored research-oriented mission, is shared between the governing body and the chief executive officer of an institution! During the Emphasis Phase, the UM Board of Curators issued a system-wide directive to double sponsored funding on all four campuses by 1990.<sup>3,3</sup> At UMKC, this edict resulted in adoption of the following initiatives and strategies to fulfill this goal:

- **Campus-wide Objectives and Priorities**

The chief academic officer constituted an Enhancement of Research Committee and charged this body with identification of campus-wide mechanisms to: (a) improve research capabilities; and (b) double sponsored funding by 1990. The final Committee report<sup>3</sup> recommended that specific priorities be placed on three levels, i.e., institutional, academic unit and faculty.

Institutional priorities should address creation of a campus-wide pool of graduate research assistants, assignment of laboratory space to sponsored research-oriented faculty, funds to purchase state-of-the-art equipment, monies to modernize facilities, internal expenditures to maintain current research grant programs and to insure that non-academic units (e.g., physical plant) support campus-wide goals for sponsored research.

Academic units should implement generic plans to create research-oriented faculty development programs with: (a) merit system(s) to increase salaries of faculty who secure sponsored funding; and (b) reduction of teaching workloads for such faculty. A goal-setting system should also become a vital part of these faculty development programs. In addition, areas or centers of excellence should be identified and supported. Finally, each academic unit should develop sound management, data and financial systems.

Faculty should develop research skills to participate more fully in sponsored funding activities. In addition, faculty should engage in research which complements or coincides with academic unit areas or centers of excellence;

- **Administrative and Faculty Infrastructures**

In the overall scheme of management, one critical element is required for all central support activities related to internal and external research endeavors; namely, an administrative research unit! During the Pre-Emphasis Phase, campus-wide research

programs were administratively-housed within the Office of Graduate Studies and Research. In the Emphasis Phase, this unit was separated into two distinct entities, i.e., Office of Research Administration (ORA) and Office of Graduate Studies.<sup>2</sup> In addition, a new position of Associate Vice Chancellor for Research was established to specifically direct efforts at acquiring sponsored funding. With creation of both ORA and the Associate Vice Chancellor for Research position, there now existed a central focus for administration of all campus-wide research programs.

One significant event, which also occurred during the Emphasis Phase, was reconstitution of the UMKC Research Council (a faculty body representing the disciplines of the humanities, sciences and social sciences).<sup>2</sup> Senior research-oriented individuals were appointed (rather than elected) to this faculty body and, in addition, were given more direct responsibility for developing and implementing campus-wide research policies;

- *Institutional Research Grant Programs*

During the Emphasis Phase, ORA (in cooperation with the UMKC Research Council) promulgated new policies affecting quality and disbursement of institutional research grants. In order to improve the overall quality of internal grant proposals, for example, UMKC Research Council in-house evaluations of these proposals were augmented by reviews received from external peer referees.<sup>4</sup> A faculty *questionnaire* was used to measure the impact of such an external review mechanism, and applicants indicated overwhelming support for this new policy.

These newly-promulgated policies significantly changed the method in which institutional research grants are subsequently awarded and disbursed, i.e., ORA/UMKC Research Council adopted clear and explicit language stating that award of a research grant was an “obligation” to submit a more comprehensive external proposal, following completion of these internal projects.<sup>2</sup> This change in the award/disbursement policy greatly enhanced the internal to external grantsmanship transitional process, e.g., for each dollar of institutional monies awarded during the Emphasis Phase, 2.35 dollars of sponsored funding were received. In contrast, during the Pre-Emphasis Phase, each dollar of institutional monies awarded, generated 0.42 dollars of external support. A *faculty questionnaire* was utilized to assess the usefulness of providing institutional monies during both phases and the subsequent receipt of sponsored funds directly attributable to provision of these institutional monies;

- Formula-based *Incentive Plan/Venture Capital Fund*

The currently-utilized UMKC formula-based incentive plan allocates 17% of the total recovered indirect costs on sponsored programs to ORA. With this portion of incentive plan monies, ORA developed a new initiative, i.e., the Venture Capital Fund. These ORA Fund monies are, in turn, provided to faculty or academic units with proven (or anticipated) track records in sponsored funding, with the idea of generating a “return-on-investment”, i.e., ORA Fund will be replenished by indirect costs recovered on external grants (contracts) received by successful recipients of these monies. ORA Fund monies are used to support equipment purchases, guest speakers/visiting professors, travel to external agencies, research assistants /technicians, supplies, summer stipends and short-term loans;

- Brokering of *Clinical Trial Placement*

In order to foster an interdisciplinary research program among UMKC health science schools (i.e., Basic Life Sciences, Dentistry, Medicine, Nursing, Pharmacy and affiliated hospitals), a new administrative position was created within ORA, to specifically broker placement of clinical trials between pharmaceutical companies and these specific academic units.<sup>6</sup> In its initial two-years of operation, this new initiative has generated \$448,698 in additional sponsored funding at UMKC; and

- *Miscellaneous Considerations*

Coinciding with the aforementioned initiatives and strategies, certain other events occurred during the Emphasis Phase; their impact on enhancement of sponsored programs is difficult to quantify, even though they have generally contributed to strengthening the climate for research at UMKC. First and foremost, UMKC created two new academic units, i.e., School of Basic Life Sciences and the Computer Science Program, in addition to the recruitment of nationally-recognized scientists to serve as dean and director, respectively. In addition, a well-recognized and research-oriented individual was appointed as dean of the School of Dentistry. These three academic officers have, in turn, implemented policies to recruit more sponsored research-oriented faculty into their respective units. Finally, opportunities under the Missouri Research Assistance Act grant competition, have greatly increased sponsored funds received on behalf of UMKC.

## IMPACT OF NEW EMPHASIS PHASE INITIATIVES

The overall impact, of two specific initiatives introduced during the Emphasis Phase, are displayed in Table 1. The promulgation of new policies affecting the award and disbursement of institutional research grants,<sup>2</sup> in combination with monies received from the brokering/ placement of clinical trials,<sup>6</sup> resulted in the award of an additional \$3,067,903. This latter sum represented some 22% of the total sponsored research funds received during the Emphasis Phase. In contrast, \$509,492 was awarded as the result of institutional research grants disbursed under old policies; this represented 13% of the total campus-wide sponsored research monies received during the Pre-Emphasis Phase. The creation and implementation of these two new initiatives during the Emphasis Phase resulted in an approximate six-fold increase over sponsored research funds received as a direct by-product of institutional research grants awarded in the Pre-Emphasis Phase. In addition, two other measures substantiate significant progress made during the Emphasis Phase; namely, the percentage of awarded proposals for research rose from 32 to 56%<sup>2,3</sup> and the percentage of monies received for research, compared to the total funds awarded for all sponsored programs, rose from 25 to 39%.<sup>3</sup>

**Table 1**

	Pre-Emphasis Phase (FY 78/79 through 82/83)	Emphasis Phase (FY 83/84 through 87/88)
Total Campus-wide Sponsored Research Dollars Received	3,891,764	13,664,744
Total Sponsored Research Dollars Received Per Internal Initiative:		
(a) Faculty Research Grants:	<b>509,492</b>	<b>2,619,205*</b>
(b) Clinical Trial Placement:	Non-existent	<b>448,698**</b>
% Contribution of Internal Initiative(s) to Total Campus-wide Sponsored Research Dollars Received:	13	22

\*FY 83/84 through 86/87 only (see reference 2)

\*\*FY 86/87 through 87/88 only (see reference 6)

Finally, it could be argued,<sup>7</sup> that the sustained growth of sponsored research during the Emphasis Phase was simply related to a larger total average number of faculty and graduate students submitting external proposals during this period, rather than due to the new incentives and programs introduced. As shown in Table 2, however, the total average number of faculty and graduate students, during both study phases, was relatively equal. An additional explanation, with respect to the results achieved during the Emphasis Phase, could lie with data<sup>2-5</sup> which support the notion that these new incentives and programs provided: (a) existing faculty and graduate students with specific tools by which to compete more effectively in the sponsored research arena; and (b) newly-recruited, research-oriented faculty with an environment to better foster their professional growth.

**Table 2**

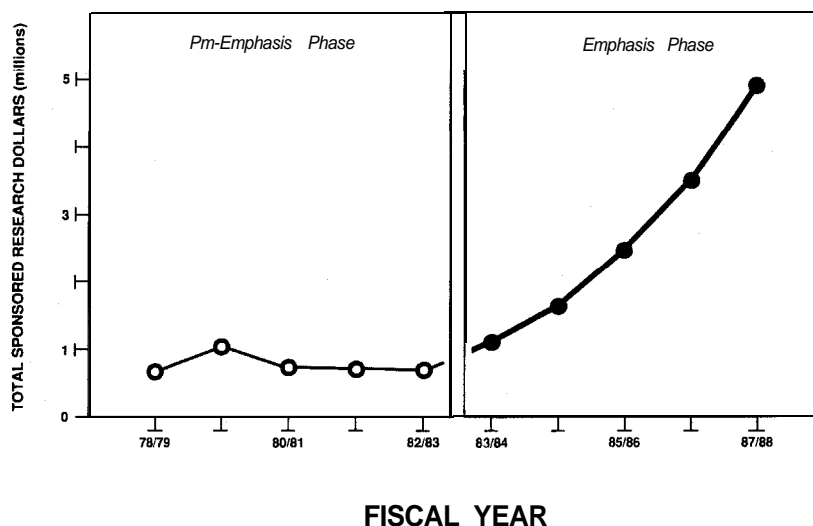
Total Average Number of:	R-e-Emphasis Phase (FY 78179 through 82/83)	Emphasis Phase (FY 83184 through 87/88)
Faculty Members*	480	493
Graduate Students	3,311	3,306

\*FTE Ranked

## CONCLUSIONS

In the context of purpose and commitment, an institution can adopt a sponsored research-oriented mission.' In the ten-year history of sponsored funding at UMKC presented herein, absence of such a purpose and commitment is graphically portrayed in Figure 1; namely, during the Pre-Emphasis Phase, an average per annum sum of \$780,000 was received in support of sponsored research. The Emphasis Phase, however, during which an institutional purpose for and commitment to sponsored research programs were initiated, contrasts starkly with the former period. The ability to develop institutional, academic unit and faculty objectives and priorities, in the framework of system- and campus-wide directives to double external research expenditures by 1990, established an appropriate climate for change. In addition, implementation of new initiatives and strategies, specifically directed toward nurturing such a climate, is a major factor identified with the significant growth of sponsored research at UMKC.

**Figure 1**



The total amount of sponsored research funds received during two distinct five-year periods at the University of Missouri-Kansas City.

In conclusion, the three most vital ingredients required, for an institutional change of this magnitude, are patience, persistence and farsightedness. The absence of these qualities will subvert the ability to implement modification of an institution's behavior toward adopting a mission to support sponsored research.

## REFERENCES

- 1 Mishler, John M. "Enhancing the Prospects for Acquisition of Sponsored Funds at Small to Mid-level Colleges and Universities: A Guide for Program Development," *Research Management Review*, 2 (1988), 17-31.
- 2 Mishler, John M., and Joy D. Loesch, "The Directed Transition from Internal to External Grantsmanship," *Journal of the Society of Research Administrators*, XIX (1988), 23-30.
- 3 Mishler, John M., "Institutional, Academic Unit and Faculty Objectives and Priorities to Enhance Campus-wide Sponsored Research," *Grants Magazine*, 10 (1987), 137-142.

- 4 Mishler, John M., and Edgar J. Ellyson, "Internal Grant Management. Results of a Pilot Study to Enhance the Quality of Proposals by Using External Peer Review," *Journal of the Society of Research Administrators*, XVIII (1987), 17-23.
- <sup>5</sup> Mischler, John M., "Recovery of Indirect Costs on Sponsored Programs: A Means to Create an Institutional Venture Capital Fund," *Grants Magazine*, II (1988), 18-20.
- <sup>6</sup> Mishler, John M., "University-Pharmaceutical Industry Cooperation: Creation of a New Administrative Position to Broker the Placement of Clinical Trials," *Journal of the Society of Research Administrators*, XX (1989) 11-15.
- 7 Comment received from anonymous member of the Editorial Review Board, *Research Management Review*.

# Research at Liberal Arts Colleges: Is More Really Better?

Linda E. Parker  
and  
David L. Clark

**Abstract.** Colleges and universities depend on their reputations to enable them to compete successfully for students, faculty members, and financial support in order to survive. To become more competitive, institutions pursue strategies designed to take on characteristics of large research universities, and, in so doing, increase their prestige. This paper focuses on what is involved in such endeavors at liberal arts colleges. Specifically, it examines the costs of enhancing the level of research activities at these institutions, policy issues related to research enhancement regarding the costs and trade-offs involved in this means of augmenting institutional prestige, and the potential impact of this on their budget and teaching program. Based on these considerations, the main conclusion is that because liberal arts colleges provide valuable undergraduate education in science, mathematics and engineering, decisions about enhancing their level of research activity must be made carefully, with a clear understanding of what such an effort would entail, what it would cost, and how it could affect existing strengths and contributions.

**U**ndergraduate education is the cornerstone of science and engineering in the United States. Undergraduate training is designed to prepare students in fields for which the PhD is necessary for academic careers and in fields requiring bachelor's or Master's degrees for careers in industry. "The character of the undergraduate experience is usually decisive for imparting the skills and expectations needed for participation in science or engineering:"

---

Linda E. Parker is Program Analyst, Program Evaluation Staff, OBAC, Rm. 425, National Science Foundation, 1800 G Street, NW, Washington, D.C. 20550

David L. Clark is Parrish Professor of Education, Department of Educational Leadership and Policy Studies, 194 Ruffner Hall, Curry School of Education, University of Virginia, 405 Emmet Street, Charlottesville, Virginia 22903

A number of liberal arts colleges aspire to the development of a greater level of research activity to enhance their institutional prestige.<sup>2</sup> They look to universities as their model. In a speech delivered at Carleton College, Erich Bloch, Director of the National Science Foundation, commented:

There is a real danger that many colleges may effectively look only one way: towards the universities and their roles in research and graduate education. There seems to be more prestige, for better or worse, in that direction, and nearly everyone wants to move up.<sup>3</sup>

Concern has arisen about such aspirations on several fronts. On one hand, there is uncertainty regarding the ability of such institutions to safeguard the key cultural values that contribute to high morale among their faculty in the face of an increased emphasis on traditional research.<sup>4</sup> A second concern is that the development of a research mission would divert resources and attention from the crucial undergraduate science and engineering training that they provide for the nation. Finally, there is a strong possibility that those making decisions about whether a given institution should increase the level of its research activities do not consider the totality of factors that such decisions entail.

This paper examines:

1. the costs of enhancing the level of research activity at liberal arts colleges,
2. the policy issues related to research enhancement regarding costs and trade-offs involved in this means of augmenting institutional prestige, and
3. the potential impact of this on their budget and teaching program.

### **SCIENCE BACCALAUREATE PROGRAM IN LIBERAL ARTS COLLEGES**

Four-year colleges enroll a significant percentage of the freshmen who declare science majors.<sup>5</sup> In 1984, these institutions accounted for 43% of the nation's freshman science majors.

Private liberal arts colleges comprise more than one-third of the baccalaureate-awarding institutions in the U.S.<sup>6</sup> During the 20th century, they have provided the baccalaureate training for a significant portion of those who earned doctorates in the sciences.<sup>7</sup> From 1910 to 1969, 25 such institutions produced about 30% of the baccalaureate recipients

## Research at Liberal Arts Colleges

who subsequently received science doctorates. During the same period, 137 undergraduate institutions graduated approximately 60% of the baccalaureates who become PhD's in science, even though these institutions accounted for only 7% of the total number of institutions that offer the baccalaureate.

According to Eckley, the focus of liberal arts colleges is "overwhelmingly undergraduate teaching; that is their mission."<sup>6</sup> Their cultures center on a commitment to the development of the student as a whole person. To this end, "the faculty of these colleges know that their vocation is teaching and that this role is central to their institution!"<sup>+</sup> Scholarship is broadly defined. It emphasizes keeping current in one's discipline and applying new knowledge to teaching. Although some faculty conduct research with publishable results, it is expected that all forms of scholarship will take place in the context of a primary commitment to translate and infuse new knowledge into good teaching.<sup>4</sup>

### **INVESTMENT COSTS OF RESEARCH ENHANCEMENT**

In conjunction with the 1986 conference at Oberlin College, Carrier and Davis-Van Atta conducted a study of the condition and needs of science at leading private liberal arts colleges.<sup>8</sup> often described as "research colleges." The study concluded that more than one billion dollars would need to be invested in the following decade by the institutions that the study addressed if they were to enhance their positions in research and science education. This amount of money was calculated **to** be necessary to provide growth in teaching staff, significant increases in faculty salaries to compensate for a decreased supply of faculty nationally, and major investments in laboratory instrumentation and basic physical facilities, libraries, start-up costs of new research projects, and leaves for junior faculty. The authors also concluded that many existing buildings and facilities would need major renovations or complete replacement.

The average age of buildings at the institutions in this study was 50 years.<sup>8</sup> The report found that old buildings had generally been renovated, rather than replaced, and concluded that, beyond additional renovations, a significant number of new facilities would have to be constructed at the institutions in the near future.

In academic year 1985-86, 50% of the academic research instrumentation systems at the 50 institutions were judged to be state of the art, while 43% were considered adequate and 7% inadequate. Of the state-of-the-art systems, 62% were between one and five years

old, as opposed to 36% of the adequate systems.<sup>8</sup> Of instruments in the \$10,000 to \$1,000,000 range, the average cost per science department of meeting immediate needs in 1985-86 was \$144,543, while the figure for meeting projected five-year needs was \$147,216 per department. In 1984-85, 41% of the cost of instrumentation purchases was covered by internal institutional funds, 24% by private non-profit sources, 15% by Federal funds, 13% by business and industry, 1% by state funds, and the remainder from a variety of sources.

No evidence could be found to indicate that Carrier and Davis-Van Atta used any of the existing price index trends in their predictions of costs over the 10 years with which they were concerned.<sup>8</sup> As a result, the \$1 billion investment prediction is most likely understated. For instance, the average square foot replacement cost for existing buildings was listed as \$107. This figure is clearly low; it may be as much as 50% understated. As the authors noted, the 1985-86 adjusted cost per square foot of construction performed in the previous five years at the institutions in the study was cited as being \$157. An explanation for basing calculations on the lower figure could not be located in the report.

Several price indices highlight the importance of factoring in inflation projections in capital expenditure calculations. The index most commonly used, the Consumer Price Index (CPI), would provide more realistic costs, but would still understate the rate of inflation experienced in higher education and sponsored research activities.<sup>2</sup> The CPI, which measures changes in prices of goods in a fixed marketbasket defined by the Department of Commerce, rose 72.5% during the 1977-87 period. The Research and Development Price Index (R&DPI) rose 75.6% during the same period. This index "measures changes in prices of goods and services bought by universities for sponsored research." Indirect costs are excluded, as are expenditures for major instrumentation, equipment, and separately budgeted physical plant and permanent fixed equipment investments. The exclusions are worth noting, as they may be subject to similar or even greater, inflationary pressures; however, no indices pertaining to these items could be located. By implication, then, the R&DPI may under-report inflation in academic R&D.

Beyond the importance of using price indices, one should use the index that most resembles the prices that need to be adjusted, as annual changes in the prices included in each index are not necessarily identical. The R&DPI has consistently surpassed the CM in annual percentage change since 1982. For example, the respective percentages in 1985 for the CPI and R&DPI were 3.9 and 6.2, while in 1987 they were 2.2 and 4.2. Clearly, using the CPI to adjust the prices of R&DPI items would significantly understate the rate of price increases in those items.

Returning, then, to the unadjusted \$1 billion investment estimate, some of the component estimates were based on 1984-85 costs, while others were based on 1985-86 costs. To give a rough idea of the understatement of the total estimate, the R&DPI increased 15% between 1985, the year in which the study was conducted, and 1987, the year in which the report was released.<sup>2</sup> Between 1986 and 1987, the R&DPI increased by 8.8%. Thus, by the time the report was completed, the \$1 billion figure contained cost components that had become between 8.8% and 15% understated.

### **SOURCES OF INCOME FOR RESEARCH ENHANCEMENT**

Returning for a moment to the \$1 billion estimate of the total investment cost of the institutions' research enhancement effort, Carrier and Davis-Van Atta concluded that each institution would have to launch a major capital campaign in order to finance the effort. Tuition income accounts for 60% to 80% of the operating revenue of liberal arts colleges that participated in the study. The authors concluded that, with tuition costs at private colleges traditionally being high, it would be unrealistic to expect that additional income for capital investment could be raised from higher tuition rates, as institutions adopting this strategy would be putting themselves at a disadvantage with respect to their competitors. Further, access to high quality private undergraduate science and engineering education would be decreased. The other main sources of revenue for these institutions are endowments, providing 10% to 20%, and gifts from alumni and friends of the institutions. Although some additional income could be obtained from gifts, the authors conclude that, as a group, alumni do not possess enough wealth to provide a significantly greater level of support.\*

The heavy dependence of liberal arts colleges on tuition income has further implications regarding the ability of many of them to support capital and ongoing costs of enhanced research activity. From the early 1980s through the mid-1990s) the college-age population will decrease by 22%. For all institutions this translates into increased competition for fewer students. In the face of this, liberal arts colleges must contend with the fact that the total cost of attending a public university is approximately 60% of the cost at private liberal arts colleges.<sup>6</sup> This disadvantage becomes more pronounced as one moves away from the prestigious institutions studied by Carrier and Davis-Van Atta.<sup>8</sup>

Table I illustrates the sources of revenues and importance of each source for all four-year public and all four-year private institutions during

the 1983-86 period. Private institutions derive twice the proportion of income from tuition as public institutions, and depend on tuition for almost one half of their total revenue. Private gifts, grants and contracts, and endowment income provided private colleges with 14.6% of their income, more than three times the percentage received by public colleges. Alternatively, public institutions received over 40% of their income from state governments, which is more than 22 times the proportion received by their private counterparts. There was no marked difference between the public and private colleges regarding Federal revenue contributions, the magnitudes being 13.5% and 12.3%) -respectively.

**Table I**

---

*Current Fund Revenues of 4-year Institutions: FY 1983-86<sup>9</sup>*

---

Source	Percent	
	4-Year Public	4-Year Public
Tuition	24.6	48.1
Government	56.9	14.8
Federal	13.5	12.3
State	42.9	1.9
Local	0.5	0.6
Private gifts, grants and contracts	3.7	9.3
Endowment income	0.7	5.3
Hospitals	8.6	10.1
Independent operations	0.3	6.0
Other sources	5.3	6.5

---

In summary, Table I shows that the main sources of revenue for private four-year colleges are tuition (48%) private gifts, grants and contracts, and endowment income (14.6%) and Federal government (12.3%). For public colleges, the main sources are state government (42.9%) tuition (24.6%) and Federal government (13.4%). Situations outside of individual institutions call into question their ability to obtain significant amounts of new revenue from these sources. Specifically:

- Demographic realities suggest that some institutions will have difficulty maintaining a student body large enough to keep them open; some liberal arts colleges are already in poor financial condition.
- Neither private nor public colleges can expect to gain significant amounts of income to support a research enhancement effort from tuition.

- State governments will probably not be able to, or interested in, supporting such efforts significantly unless there is a reversal in the current trend toward the states being given responsibility for financing and running programs originally handled at the Federal level.
- Federal support for colleges and universities has fluctuated in recent years. Constraints on discretionary domestic spending are likely to increase in the future as the significance of the Federal budget deficit becomes more apparent.
- Finally, revenue from private sources, including capital campaigns, has become more difficult for institutions to obtain in recent years because of changes in the tax code. Currently, it is less attractive for individuals or corporations to give gifts to institutions than it was at the beginning of the decade. Unless this situation changes, increases in development revenue of the magnitude necessary to finance serious research enhancement efforts are unlikely.

### **POLICY CHOICES IN RESEARCH ENHANCEMENT**

If liberal arts colleges truly believe that they can participate successfully in the sponsored research arena, they must consider and plan for the volatility of the Federal research environment. They must also be willing to assume a wide variety of costs associated with conducting a greater level of research. Finally, they must consider the opportunity costs of a decision to pursue a research activity enhancement strategy.

#### Competing for the Federal Investment

Research enhancement efforts do not take place in a vacuum. Federal funds for academic research fluctuate annually. Funding levels are set by a complex process involving a wide variety of often competing interests. For more than a dozen years, “the pool of money to support research has not kept up with the number of excellent proposals that have been submitted to the [Federal funding] agencies. That means that the competition is keener, and there are more disappointed applicants who have submitted good proposals.”<sup>10</sup> As competition increases and money tightens, there is a tendency for agencies to support researchers who have acknowledged track records and established research programs.

Researchers without established reputations are at a disadvantage in the competition for funding for another reason. Research grants lasting more than a year are often obligated in annual increments. From

the agency's standpoint, this means that a certain percent of each year's research budget must be spent on these continuing grant increments, leaving the residual for funding new proposals from both established researchers and those seeking support to establish a research career. "The greater the number of institutions that seek to become active participants in sponsored research, the more proposal pressure there will be from researchers new to the sponsoring agencies on the most unstable portion of agencies' research budgets.

Competition for funding has become so keen that top-level research universities feel that they must engage in the expensive pursuit of offering lucrative financial and research facility packages to world-class researchers to entice them to do their research at a different institution. Michael I. Sovern, president at Columbia University, has stated that the research community has "entered the era of free agency. If you [your institution] want[s] to stay competitive, you have to pay a lot more".<sup>11</sup> The greater the reputation of an institution's research faculty, the greater the prestige of the institution and the greater likelihood that it will receive large sums of research support.<sup>11,12</sup> Fiske noted that the raiding of faculties has been on the increase during the last few years because of the growing number of institutions that are interested in placing themselves on the academic map.

Ultimately, the dynamic that operates among all institutions that are not content with what they are doing and how they are doing it is the desire for greater institutional prestige. The prime way to increase prestige or reputation relative to peer institutions is to put a greater amount of institutional attention on conducting research.<sup>12,13</sup> Using different economic concepts and models, McGuire et. al. and Garvin illustrate why institutions that aspire to greater prestige engage in research activity enhancement strategies in order to increase the amount of research funding they receive. Among the components of such strategies are increases in the number and/or quality of the research faculty and capital. The phenomenon of faculty members acting as free agents demonstrates how important prestige or reputation enhancement is to those institutions already engaging in a significant amount of sponsored research. As the top research universities know and others who aspire to be like them will find out, reputational enhancement is "an expensive endeavor in terms of faculty and capital for a research university to try to raise its reputation. . . . A 10% increase in the research funding-faculty combination of inputs will increase reputation by less than three percent. In fact, the costliness of the production process may be the principal reason why institutional reputation changes so slowly over time."<sup>12</sup>

*Adjusting to the Vagaries of Federal Funding*

In addition to contending with the costs of greater competition for finite Federal funds for research, there are a wide variety of costs that institutions must incur, or be prepared to incur, when they engage in significant research activity. Among the most insidious are those resulting from the volatility of research funding levels on an annual basis; shifts in research areas in which agencies are particularly interested; delayed passage of agencies' authorization and appropriation bills, delays in money reaching institutions; wholesale reductions, or sequestrations, in funding levels for projects on which agencies had committed funds; and institutional staff and facilities required for the administration of Federally sponsored research. As an example of the significance of these costs, the Department of Defense instituted an unexpected six-week freeze on awarding any new contracts during the summer of 1988 and a partial reduction in the size of awards made after the freeze.<sup>14</sup> The result was that the Department saved more than \$500 million and slowed the rate of spending to the level to which the Congress and the White House had previously agreed. At the University of California at Los Angeles, 15 projects, accounting for \$1.4 million, were delayed by the freeze. UC Berkeley had 28 projects worth \$12.7 million that were put on hold. Administrators at Berkeley stated during the freeze that if the funding were not received by September, they might have no choice but to lay off 41 students involved with seven of the affected projects. In cases like this, the departments with which these graduate students were affiliated would have to use local discretionary funds or request emergency support from elsewhere in the university in order to keep the students employed in their departments.

This occurrence and others, such as Gramm-Rudman-Hollings deficit reduction sequestrations, happen with little warning, as do many decisions by funding agencies to decline research proposals. The more heavily involved in sponsored research an institution becomes, the more it must be aware of the consequences of dependence on sponsored research funds, especially given the current instability in Federal research funds. Beyond being aware of the consequences of dependence, institutions must be prepared to protect the investment they have made in their research enterprises with financial and administrative policies that insulate their investments from the worst aspects of this sort of dependence in an uncertain environment.<sup>15</sup>

### Technical Support

Day-to-day management and administration of research require adequate staffing at the departmental or school level and the office of sponsored programs to handle the anticipated volume of pre-award and post-award work that an increased level of research activity would generate, and institutional managers who are concerned with instituting appropriate policies that address issues surrounding the heightened level of research activity. They also require adequate budgets. One institution engaged heavily in Federally sponsored research illustrated this with the findings of a study that it conducted of the unit cost of executing ten research administration functions. The cost for preparing each noncompetitive proposal for second and/or third year funding for a multi-year incremental award in 1986 was \$978.57. Preparing each equipment purchase approval cost \$372.02. For each of the 650 Report of Expenditures (ROE) prepared annually at that institution, the cost was \$319.50. Finally, executing each foreign travel approval cost \$224.41.<sup>16</sup>

### Opportunity Costs

Perhaps most important to an institution considering a significant investment in enhancing its level of research activity are the opportunity costs of such an investment. In general, undergraduate education enhancement is an opportunity cost of research enhancement so that pursuing the latter means a corresponding forgone opportunity to invest the same resources in undergraduate education. Although the liberal arts college study investigated the costs of enhancing both research and undergraduate education simultaneously, other institutions aspiring to enhanced institutional prestige via more significant research activities do not have a second focus on upgraded undergraduate education.

Anytime one major activity is enhanced, an opportunity has been missed to do other things. At institutions that have undergraduate education as a major focus, the opportunity costs involve undergraduate education. Although diverting instructional funds may not initially be part of the enhancement plan, it may in fact become necessary to do so to cover significant unexpected costs. Student services might also become the target of fund diversion when return on the investment in research is lower than projected. Two additional opportunity costs would be enhancing institutional programs and curricular reform. At a time when the latter two activities have been deemed of paramount importance in undergraduate science, mathematics, and engineering programs by the National Science Board (NSB), these are serious costs.<sup>17</sup> Finally, hiring new faculty members to become the critical mass of a

department's research activities means missed opportunities to use the same funds to hire new faculty members who are interested primarily in teaching science and engineering or, alternatively, to provide for professional disciplinary refreshment for existing faculty.

The 1986 NSB report, known as the Neal Report, detailed the problems that four-year colleges face because their small departments rarely have more than one faculty member for each subdiscipline and the corresponding heavy teaching loads. To counter the disciplinary isolation of college science faculty members, the Report advocated such refreshment activities as attending professional meetings, and, "where personal and institutional resources permit or can be augmented, a sabbatical leave in a research institution is preferred because of the immersion it represents. Unfortunately, the very institutions whose faculty need this refreshment the most are the ones least able to bear the full cost."<sup>17</sup> The opportunity costs of hiring research faculty at colleges and universities that engage in a marginal amount of research may be even more significant in light of the difficulty these institutions have retaining such faculty members as a result of the ability of industry and larger universities "to lure them away with promises of greater support for research!" In other words, these institutions forego an opportunity to enrich or build their institutional faculties and then run the risk of losing the research-oriented faculty members they do hire.

## CONCLUSIONS

The contribution that liberal arts colleges make in terms of undergraduate training in science, mathematics, and engineering is incontrovertible. Without it, the nation would not be able to produce the number and quality of scientists, mathematicians, and engineers that it has in this century. These institutions find themselves in a higher education arena in which conducting research is considered more prestigious, and therefore more highly valued, than providing excellent undergraduate preparation for research careers. As policy makers struggle with pressure to increase institutional prestige by pursuing strategies to increase their institution's level of research activity, they must understand precisely what such a decision entails and what it would cost.

The reality that decision makers must recognize is that the probability of the majority of institutions that pursue such a strategy eventually recouping their investments, much less experiencing a net increase in revenue, is highly unlikely, given the pre-existing formidable competition for limited research funds. At the same time, undergraduate instruction is unlikely to receive the attention that it needs while institutions pursue their enhancement efforts.

For liberal arts colleges, the real decision is whether it is wise to jeopardize the quality of the undergraduate science, mathematics, and engineering education for which they are highly regarded and valued by adopting strategies to increase the amount of research they conduct for the sole purpose of enhancing their prestige in the higher education community. For the sake of the highly valued contribution that these institutions make in terms of supplying future scientists and engineers, the decision must be made with the utmost care.

Author's note: Any opinions, findings and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## REFERENCES

- 1 U.S. Congress, Office of Technology Assessment. *Educating Scientists and Engineers: Grade School to Grad School*. Washington, D.C.: U.S. Government Printing Office, 1988. OTA-SET377.
- <sup>2</sup> Research Associates. *Higher Education Prices and Price Indexes: 1987 Update*. Washington, D.C.: Author, 1987.
- <sup>3</sup> Erich Bloch, *Competitiveness: The Strategic Role of Education*. Speech presented to Carleton College, July 13, 1988. Washington, D.C.: National Science Foundation, 1988.
- 4 R. Eugene Rice and Ann E. Austin, "High Faculty Morale: What Exemplary Colleges do Right!" *Change*, (March/April 1988), 51-58.
- <sup>5</sup> David Davis-Van Atta, Sam C. Carrier, and Frank Frankfort, *Educating America's Scientists: The Role of the Research Colleges*. Oberlin, OH: Oberlin College, 1985.
- 6 Robert E. Eckley, "Liberal Arts Colleges: Can They Compete?" *The Brookings Review*, (Fall 1987), 31-37.
- 7 M. Elizabeth Tidball and Vera Kistiakowsky, "The Baccalaureate Origins of American Scientists and Scholars." *Science*, Vol. 193 (August 20, 1976), 646-652.
- 8 Sam C. Carrier and David Davis-Van Atta, *Maintaining America's Scientific Productivity: The Necessity of the Liberal Arts Colleges*. Oberlin, OH: Oberlin College, 1987.
- <sup>9</sup> U.S. Department of Education, Center for Educational Statistics, *Current Funds Revenues and Expenditures in Institutions of Higher Education: Fiscal Years 1983-86. Bulletin*, (February 1988), 1-22. CS 88-258b.
- 10 George T. Mazuzan, "Peer Review: The Heart of the Research Enterprise!" *SUNY Research*, Vol. 8 (May/June 1988), 1-4.

- 11 Edward B. Fiske, "Attracting Star Professors Starts Sounding Like the Bidding for Top Athletes!" *New York Times*, (July 27, 1988), B6.
- 12 Joseph W. McGuire, Marie L. Richman, Robert F. Daly, and Soheila Jorjani, "The Efficient Production of 'Reputation' By Prestige Research Universities in the United States!" *Journal of Higher Education*, Vol. 59 (July/August 1988), 365-387.
- 13 David A. Garvin, *The Economics of University Behavior*. New York: Academic Press, 1980.
- 14 Kim McDonald, "Pentagon Ends Contract Freeze, But Universities May Not Benefit." *The Chronicle of Higher Education*, (July 6, 1988), A-13.
- 15 Linda E. Parker, *The Impact of Fluctuations in NSF Funding on Hard Science Departments at a Research I University*. Unpublished dissertation. Charlottesville, VA: University of Virginia, 1988.
- 16 James P. Lewis, "Research Administration-The Cost in Dollars and in Faculty Time." *SRA Journal*, (Winter 1988), 39-46.
- 17 National Science Board. *Undergraduate Science, Mathematics, and Engineering Education*. Washington, D.C.: Author, 1988. NSB 86-100.