

MAKING RESEARCH
A PART
OF THE PUBLIC AGENDA

A compilation of papers originally presented at a conference
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Editor – Mabel L. Rice
Technical Editing – Joy Simpson

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INTRODUCTION

Mabel L. Rice
University Distinguished Professor
Director, Merrill Advanced Studies Center
University of Kansas

The papers in this collection represent discussions that took place at the fourth regional conference sponsored by the Merrill Advanced Studies Center on the topic of research in public universities. We hosted “Making Research a Part of the Public Agenda” on June 7 - 9, 2000 at the retreat center in Valley Falls, Kansas. The gathering included twenty-two administrators and senior faculty scientists from five research institutions: The University of Kansas (including the Medical Center), Kansas State, Nebraska (including the Medical Center), Missouri at Columbia, and Iowa State University. George Walker, Vice President for Research at Indiana University, was the keynote speaker and commentator. We were fortunate to be joined by a Kansas legislator, Representative Ralph Tanner, and by the chair of the Kansas Board of Regents, William R. Docking. Also, this year, we included business leaders from the Kansas City metropolitan area for a special panel on plans to create a research center in the life sciences. Keith Yehle, a member of Senator Pat Roberts staff, joined us once again. We also hosted Heather Wingate, chief of staff for Senator Sam Brownback.

This year’s topic followed naturally from the three previous regional conferences. The inaugural conference in 1997 focused on pressures that hinder the research mission of higher education, with special consideration of public research universities. In 1998, we turned our attention to competing for new resources, and ways to enhance individual and collective productivity. In particular, our keynote speaker of that year, Michael Crow, encouraged us to identify niche areas for research focus, under the premise that it was most promising to do selective areas of investigation at the highest levels of excellence. In 1999, we examined in more depth cross-university alliances. Keynote speaker Luis Proenza encouraged participants to think in terms of “strategic intent” and he highlighted important precedents in university-industry cooperation as well as links between institutions.

This year, we again invited five universities representing the four-corner states of Kansas, Nebraska, Iowa and Missouri. We focused on the impact of the sciences, in particular, with an eye toward economic development and improvements in the quality of life. The following collection of papers captures the energetic and enthusiastic nature of the dialogues that took place at the conference, beginning with the keynote

address of George Walker. He encouraged us to meet the needs of our state citizens, business leaders and students who are quite able to "carry our water" and champion the cause of research as a valuable state resource.

Over the two days of the conference, presenters and discussants explored the dynamic interface between research initiatives at public universities and the response of public constituencies in light of actual and potential research outcomes in science. Central to this discussion was our attempt to understand the public's perception of research activities and our collective views on the role of the university. Key issues included the university's obligation to communicate effectively about the conduct, outcomes, and costs of research endeavors. We also discussed the need to ensure creative inquiry, and to recognize the social benefits of research. In addition, we explored the efficacy of collaborative inquiry in order to advance research, pool intellectual resources, and distribute costs across a broader base of support. It is clear that these issues transcend the research lab and the local campus, and extend into the hallways of state legislatures and the Congress. These are vital issues for governing educational boards, local communities, and the commercial sector, as well as our private donors and individual citizens who participate as advocates for the university.

It is with pleasure that I encourage you to read each of the following contributions for a sense of many issues involved in research and the wealth of possibilities for public engagement. I wish to express deep appreciation for the assistance of Joy Simpson in the organization of the conference, in her careful notes taken during the proceedings, and her editorial finesse in the preparation of this document. Patsy Woods provided valuable assistance with the financial arrangements for the conference. As always, the proprietors of The Barn bed and breakfast provided a congenial atmosphere for discussion and conversation.

EXECUTIVE SUMMARY

KEYNOTE ADDRESS

George E. Walker
Vice President for Research
and Dean of the Graduate School, Indiana University

- It is important to establish vigorous, informed, cooperative efforts that promote the value of university research within federal, state and private sectors.
- The message we give the public must be focused and sincere. We must know and respond to the public's agenda for us.
- How does the public rate the value of university research? In general, they see its benefits, but suspect that it takes away from the learning experience for the undergraduate. It is important to improve the learning environment in tangible ways that allow stakeholders to see research as part of teaching and learning. At Indiana, we make sure large numbers of undergraduates have a research experience.
- You must have undergraduates, citizen groups, business leaders and powerful legislators and executives who are willing to "carry your water" for you. Hoosiers for Higher Education is a large grass roots organization that recruits alumni to educate the general public about the University and higher education issues. These volunteers keep in contact with elected officials. They advocate for our institution wherever they go and none of them are affiliated with the University.
- As a marketing strategy, we impress on students that the prestige of the institution depends on research and this adds value to their degree. As a result, our undergraduate students specifically requested that their tuition be increased an additional one percent, with that money invested in hiring more faculty to teach and do research.
- To generate graduate student enthusiasm and earn their trust, we have at Indiana initiatives involving day care, health insurance, and a placement center. We give them representation in faculty governance, and on key university committees. The Graduate Student Organization meets once or twice a year with the Board of Trustees and this has been a positive experience for them and the Trustees.

- Faculty morale is important. Faculty can play a vital role in advocating for research because of their enthusiasm and their knowledge. Link faculty together through your funding mechanisms so that they support each other. At Indiana, the researchers in the humanities care about the Cyclotron Facility in the sciences because they know that resources generated by the Cyclotron are a significant source of funding for their own centers.
- We support and publicize research and scholarship on teaching.
- We make sure every small and medium business in Indiana receives assistance and information through the Industrial Research Liaison program. We also provide access to the university's best strategists and scientists, laboratories, tools and information technology through the Advanced Research & Technology Institute, a private not-for-profit agent of Indiana University.
- At the federal level, top university officials regularly visit our congressional delegation. Our people also have leadership roles in the national higher education associations where we are seen advocating for support from federal funding agencies.
- Cooperation among institutions is especially important at the state level. When we approach the legislature, we work with Purdue University on major funding initiatives and we both win.

RESPONSE TO THE KEYNOTE ADDRESS

Robert E. Barnhill
 Vice Chancellor for Research and Public Service
 University of Kansas

- Leadership at every level is essential for institutional research competitiveness. This includes the faculty as well as administrators.
- Only the flexible will thrive. Universities must be flexible in their approach and they must have clear goals and expectations.
- Strategic intent by top leadership, coupled with natural advantages and local expertise, can lead to research enhancement that lifts the entire institution.
- Performance metrics are important because we will become what we measure. Universities often do not set research goals, or if they do,

the goals don't have quantitative measures. If we want the support of the public, it is essential to have quantitative, easily understood goals.

- An institution has arrived at a suitable research destination if it has: high institutional rankings; world class research areas; cash; full utilization of the university community; and it adds value to society.
- In the late 1990's, we assessed the feasibility of conducting world class research on the four campuses of the University of Kansas by issuing a call for proposals. The steering committee reviewed these proposals and selected four megathemes: information technology, human biosciences, the human condition, and environmental science & engineering. We then inventoried the three research universities of Kansas and determined four strategic initiatives in science and technology for the state: Information Technology, Human Biosciences, Agricultural Biotechnology and Aviation. We are promoting these initiatives at the state, regional and national levels.
- Graduates are the largest form of technology transfer from research universities. At the University of Kansas, we have quantified the economic impact for our state. The graduates of our three Kansas research institutions, whose income is a result of their degrees, pay \$700 million in state taxes annually, a figure that exceeds the annual state appropriation to these universities.
- The University of Kansas is participating in a poll of the public through Research!America. It will assess the support of science in general in our state.

PANEL OF RESEARCHERS

J.E. Leach, Plant Pathology, Kansas State University

Harris Cooper, Psychology, University of Missouri - Columbia

Valentino Stella, Pharmaceutical Chemistry, University of Kansas

Steven Barlow, Speech-Language-Hearing, University of Kansas

- Undergraduate programs are enriched by graduate programs. When we bring undergraduates into the laboratory, working with graduate students, we teach them the scientific method and collaboration. They even come to understand globalization. When a university has a good research program, undergraduates are exposed to state-of-the-art equipment and technologies.
- The amount of social research available to policy makers has dramatically increased and yet the promise of evidence-based decision

making in social policy remains largely unfulfilled because disparate results and flaws in design discourage policy makers from using university research. Many social scientists now agree that the key to providing accessible policy information is to synthesize research findings through systematic reviews of multiple studies. Two such online resources are now available for policy makers: The Cochrane Collaboration and the Campbell Collaboration. The Cochrane Collaboration prepares, maintains and ensures accessibility of systematic reviews of the effects of health care interventions. The Campbell Collaboration works in much the same way in the areas of public policy on education, crime and justice, and social welfare.

- We have the ability to move new technologies beyond the concept stage to commercial reality. This brings value to society in terms of rapid access to health improvement, and it brings economic benefits to the University and the State. The University and the companies created from research at the University must protect intellectual property by filing patents in a timely manner. It is better to delay publication of information on novel technologies until patents or copyrights are filed. Patent protection is essential for commercialization, but its real value lies in enabling development of a new drug which might save lives or enhance the quality of life. Companies will not invest in research that does not have a patent. Delaying publication until patents are filed conflicts with the traditional aim of academia ▽ sharing new knowledge in a timely manner. But the cost to society is great when a promising new technology is never developed because it was not protected prior to publication.
- Many neurological problems in children born prematurely are not discovered using traditional diagnostic tools until the child is a toddler, or enters preschool or elementary school. The key is early identification. During the past decade, a new approach and corresponding technology has been developed with the mechanisms of neuroplasticity in mind for use with premature infants at risk for brain insult. Collaboration is essential for research in this area. To be successful, one must enlist hardware and software engineers, mechanical design specialists, machinists, electrophysiologists, statisticians, pediatric nurses, developmental pediatricians, neonatologists, and researchers. Gaining access to clinical test sites is critical; the principal investigator must convince the host site that the question under study is significant and bears direct relevance to patient care, with little or no risk to the test population. Biomedical research costs money and extramural support is essential.

ADMINISTRATIVE PERSPECTIVES

Jack Burns, Vice Provost for Research, University of Missouri
Thomas Rosenquist, Director, Research Development, Nebraska Medical
James Guikema, Associate Dean, Kansas State University
Brady Deaton, Provost, University of Missouri - Columbia
Marsha Torr, Vice Chancellor for Research, University of Nebraska

- Learning about science and technology ranks highly on the personal agendas of most citizens, yet only one in nine persons believe he or she is well-informed, and only one in four claim to be scientifically literate. Science reporting is essential to forming public opinion. Traditional public relations departments are the information outlets on university campuses. More and more public research universities, however, have decided to take the message directly to non-academic audiences through alternative means. The University of Missouri-Columbia has developed *Illumination*, a full-color, 32-page research magazine issued by the Office of Research Publications. Its purpose is to inform, entertain, inspire and show Missouri residents how state and federally funded research benefits them. It also explains to the public how research enhances the teaching mission and it demonstrates the leadership of the University of Missouri nationally. *Illumination* provides public recognition of individual scientists and scholars whose contributions might not be recognized by the media. This is the perfect time to grab hold of the public's attention as scientific discovery expands the boundaries of human knowledge in new ways.
- Research sponsored by a grant from the National Institutes of Health became an explosive political issue in Nebraska once media coverage showed that it involved embryonic neurons obtained from elective abortions. Despite the worthwhile purpose of the research addressing a major incurable neurodegenerative disorder the issue polarized the community, brought about public debate between the Governor and the University President, and made the integrity of research a divisive issue in the Nebraska legislature. Among the lessons learned are: some research issues are explosive and dangerous; universities that conduct controversial research must be fully prepared; and the university must be aggressive in assuring the integrity, independence and objectivity of its research enterprise.
- By working with K-12 education, we reach important partners who carry our message that university research deserves state-wide investment. Kansas State University places education students who

will teach biology in research settings in their sophomore and junior years so they experience the scholarship of science. The University of Kansas has a program to place graduate students in the sciences in K-12 classrooms.

- We are now into a third generation approach for building research systems on most of our campuses. The first generation consisted of hiring good scientists and providing them with the best support and facilities possible and leaving them alone. This caused many scientists to prosper, but had less benefit to society than expected. A second generation approach incorporated more systematic quantification of the relative costs of individual projects and involved monitoring progress against objectives, particularly in the private sector. Each project may have had great merit in the second generation, but the collective effort wasn't always attractive. A third generation approach involves designing a purposeful and strategic web of interlocking research activities, focusing on interdisciplinary and multidisciplinary approaches to key scientific issues. The third generation requires constant monitoring and adjustments to achieve breakthroughs in science, but higher education and research must incorporate processes of continual change.
- We must look at the public policy dimensions of what we do. It challenges our best thinking in science. And we must develop a culture of openness.
- Universities have traditionally been on high moral ground, presenting unbiased, in-depth assessments of complex issues. However, we are experiencing a shift as universities face tremendous pressure to find dollars that will build quality, cutting-edge programs, and as we enter into unknown realms which scientists now have the means to explore and manipulate. Contemporary issues—often involving research and rapidly changing technologies—are at the very least confusing to the public and may in the end shake the public's long-standing confidence in the universities. How do we shape public perception in the brave new world?

EPSCoR REPORT

Thomas N. Taylor, Director of Kansas NSF EPSCoR, University of Kansas

- The Experimental Program to Stimulate Competitive Research is premised on the belief that universities and their science and engineering faculty and students are valuable resources that can potentially influence a state's development in the 21st century just as

- agriculture, industry and natural resources influenced economic development in the 20th century. The goal is to identify, develop, and utilize a state's academic science and technology resources in a way that will support wealth creation and a more productive, fulfilling way of life for a state's citizenry. EPSCoR increases the R&D competitiveness of an eligible state through the development and utilization of the science and technology resources at its major research universities.
- Kansas joined EPSCoR in 1991 and has received three awards to date. The program in Kansas links faculty at the University of Kansas, Kansas State University and Wichita State University. Kansas is an EPSCoR state because in 1989 it ranked 33rd among states receiving federal R&D support, and less than one-half of one percent of all federal research dollars awarded to colleges and universities.
 - Kansas NSF EPSCoR has: fostered inter-institutional, inter-state, and regional research projects; assisted in hiring faculty; funded multi-user equipment; provided start-up funds to faculty early in their careers (FIRST Awards); supported special initiatives; sponsored strategic planning workshops; funded faculty travel to funding agencies; fostered industry-university research partnerships; provided editing assistance to faculty who are writing proposals; and funded large infrastructure-building research projects.

STATE POLICY AND UNIVERSITY RESEARCH

William R. Docking, Chair, Kansas Board of Regents

Kim Wilcox, Executive Director, Kansas Board of Regents

- The Kansas Board of Regents was recently given increased responsibilities. It now supervises and coordinates the state's 19 community colleges, 11 technical schools and a municipal university, in addition to continuing as the governing board for the state's six public universities. Of these many institutions, only three are designated doctoral degree-granting, research institutions. Thus, the time and energy available to devote to research is necessarily limited.
- By its nature, research is a "local" activity. The Board sees its role in these capacities: determining institutional direction and providing institutional support. Otherwise, it chooses to give faculty and scientists the freedom to do research without fear that the Regents will try to shape the direction of their efforts. However, as stewards of the public's trust, the Board is responsible for ensuring that the research is focused so as to meet the needs of the state in the broadest sense. This is accomplished largely through institutional mission. The Board

works with the institutions to minimize unnecessary duplication, and to define focus. The result is that the state does indeed have three engineering schools, but each with a unique focus—the University of Kansas is known for digital communications, Wichita State University for aeronautics, and Kansas State University is known for agricultural engineering. The Board monitors compliance with university mission especially in the approval process for new academic programs. And it has considerable influence over legislative funding requests for new research centers and initiatives. In terms of institutional support, the Board works on funding initiatives such as the Partnership for Faculty of Distinction program, which uses state matching funds to encourage the creation of endowed professorships by private donors. The Board is also proud of the ongoing programs and funding established through the Kansas Technology Enterprise Corporation (KTEC).

- The relationship between state policy and university research is bi-directional, in that research should inform public policy and policy decisions often direct/fund research. We should work to ensure that the outcomes of research result in changes in society. One of the most fundamental means of realizing social change is the legislative process. Yet, academia has not been effective in helping legislators make informed policy decisions based on research. The Universities must take responsibility for bridging the gap.

INITIATIVES IN KANSAS CITY ON BIOMEDICAL RESEARCH

Jared J. Grantham, M.D., University of Kansas Medical School
William Brundage, Exec. Director, Kansas City Area Life Sciences Institute
James Spigarelli, President and CEO, Midwest Research Institute

- The University of Kansas has created a strong growth environment for renal research, and has established a successful clinical care unit through repeated investments in this research area since 1952. As the field developed, so did KU's program so that by today it has achieved national and international recognition, and is responsible for having trained 50 nephrologists, many of whom work regionally. Its clinical care program is one of the best, boasting the highest three year success rate for kidney transplant survival among the centers in Kansas, Missouri, Nebraska, and Iowa. Now in the year 2000, the Kidney Institute at KUMC is comprised of 34 collaborating faculty with over 100 research associates, and significant funding from the National Institutes of Health.
- The Kansas City Area Development Council and the Civic Council of Greater Kansas City established a Life Sciences Task Force which set

forth steps that must be taken to develop a "nationally known center of established, world-class life science companies, private and academic research institutions, and emerging, entrepreneurial companies." As part of this planning effort, the Life Sciences Institute was established to provide accountability, evaluation, oversight, resource allocation, collaboration, fundraising, lobbying and marketing. Five scientific/medical areas will be the focus of the Institute: human development and aging; cancer; cardiovascular diseases; neurological diseases; and infectious diseases. Fundraising will begin in September, 2000 once the business plan has been approved by the Kansas City Area Development Council and the Civic Council of Great Kansas City.

- Life sciences research and technology transfer will be an important part of the economic development of Kansas City over the next 10 to 20 years. Alliances that achieve use-directed fundamental research make an impact on the community in the most rapid manner. Kansas City has a good start in building valuable alliances among research organizations, foundations and civic institutions. For a research center to make an economic impact, it also needs capital, legal advice, and CEO's to mentor start-up companies. The Midwest Research Institute is preparing a strategic plan that will model the investment needed for R&D and also for education, technology transfer, and commercialization. It is important to create an infrastructure to support the creation of new companies that will add to the high technology job opportunities of the region.

MAKING RESEARCH A PART OF THE PUBLIC AGENDA

George E. Walker

Vice President for Research
and Dean of the Graduate School
Indiana University

Introduction

It is a pleasure to be with you at this year's Merrill Summer Conference. Since this is a working, interactive conference, I will try to present my remarks in a way that will stimulate later discussion and new ideas.

First of all, let's assume that those of us here today are a group made up of representatives from research universities or from federal, state, or private sector organizations. Let's assume also that we have fairly extensive knowledge about research universities and the potential of their research-educated students and faculty to make important contributions to the quality of life of citizens, start new businesses and enhance existing businesses, promote economic development, attract new companies (and hence jobs and tax base to individual states), and so forth.

Let us further assume that each of our institutions currently has experience partnering with industry and has already produced papers (distributed to appropriate stakeholders) that highlight the importance of research carried out on our campuses, and that these informational materials have been used to educate the state legislature, industry, boards of regents or trustees, and the general public.

Moreover, let's assume that each of the institutions represented here has active state and federal relations efforts to coordinate outreach with government agencies and legislatures, and an office (often the vice president for research or an arm's length foundation) to coordinate activities with industry. Probably the president's or chancellor's office coordinates activities involving boards of regents or trustees, alumni, a state higher education commission, and research promotion, perhaps with the help of a vice president for external affairs and a director of alumni relations.

Establishing vigorous, informed, cooperative efforts that promote the value of university research in all of these areas is a crucial first step that I will assume the institutions represented here have already taken but I will make some suggestions regarding strengthening and broadening these efforts.

My presumption is that you all agree with me that in terms of support, respect, and priority setting, university research is not yet where it needs to be on the public agenda. What we need to do is discuss additional steps we can take to strengthen research as a multifaceted benefit to society and therefore an essential part of the public agenda.

In my remarks, I will not quote statistics showing the benefits of research to stakeholders, although we need to use the quantitative measures and studies that are available. My comments will be divided into four parts:

- I. Background: Some simple questions whose answers may guide our discussion
- II. Practices that we have initiated in the past few years at Indiana University
- III. Successes and suggestions
- IV. Questions for future consideration and discussion.

I. Background

General Comments

The future belongs to those who can forcefully cooperate and meet important goals of the agenda setters. Success requires a long-term initiative that must be consistent, must survive the accountability/assessment test, and must avoid pitting different research institutions against each other and avoid pitting major stakeholders against each other. The efforts we make must be sincere. Success can be achieved through these means, and is being achieved every day at many research institutions. To use the example of my own institution, at Indiana University external grants and contracts funding will increase by nearly \$100 million this year.

But how exactly does this kind of success come about?

First, let's examine the role of faculty in bringing the research agenda to the public. Faculty members can play a vital role in advocating the importance of research because of their infectious enthusiasm and in-depth knowledge of their discipline. However, not all faculty are effective spokespersons for research and, quite frankly, not all research is going to be highly valued by a given public. We have to know what "sells" and focus on that. Let me quickly say, though, that this approach carries a caveat: we need to be alert to faculty backlash. Some faculty members may complain that certain research (particularly research of obvious direct importance to industry and economic development) gets too much attention, to the detriment of other research, teaching, and the academic mission in general. It's very important that there be appropriate hope in all disciplines. Good faculty morale is essential, and a sense of cooperation and interdependence contributes strongly to that. To offer again an illustration from Indiana University, the interdependence of research success across departments is highlighted by the fact that the humanities research centers care about the funding health of the Indiana University Cyclotron Facility ∇they know that "resources" generated by the Cyclotron are a significant source of funding for their own centers.

Now, here are a few preliminary, background questions that are important to address before we can fully understand the task of promoting the research mission of our universities:

1. Who is the public?
2. How does the public rate the importance of university research?
2. How do we know how the public rates research?
4. Why do we care?
5. Why do we need to pay special attention to research and research support?
6. How do we act when we make choices internally to support research?

1. Who is the public?

From a university's standpoint, the public may be said to include citizens; federal, state, and community elected and appointed officials; industries; university donors and alumni; and students and parents.

2. How does the public rate the importance of university research?

The public sees the benefits of research, but also suspects that research takes away from teaching and learning. In other words, the public has mixed views on the value of university research.

3. How do we know how the public rates research?

There are numerous marketing studies germane to the issue. Also, we can tell a lot from the actions and public statements of the various organizations and persons who have a stake in university research.

4. Why do we care?

We must care how the public feels about research because only with that attitude can we begin to improve the current situation, and establish university research as a high priority on the public agenda.

5. Why do we need to pay special attention to research and research support?

Answers to this may seem obvious, but let's take a look at them: Research is a major part of our mission. It facilitates learning—through the inspiration of teachers who are working at the forefront of knowledge and who bring their excitement into the classroom, and through the opportunity for students to become involved in research themselves. It provides many services to the state. It is essential to attracting and retaining outstanding faculty. It is crucial to the prestige of our universities. And, arguably, it is a significant financial resource for the university.

6. How do we act when we make choices internally to support research?

These are the actions we should bring into focus: First, we need to build on the faculty strengths we already have. Second, we must make the best use of our academic environment and administrative decisions to attract and retain outstanding faculty. Third, we need to build strength in areas that we have reason to think will be supported nationally. And fourth, we must ensure that state organizations and industry have genuine opportunities to provide input into our decisions regarding research **before** we go to them for resources.

II. Recent Initiatives at Indiana University

If you've already been singing a long time and you wish to sing better, you most often have to go back to the basics; for example, you may have to learn to breathe differently and develop stronger and more

disciplined breath support. If we want research to be a higher priority in the public sector, we not only have to present the positive arguments for research support, but we have to eliminate the perceived negatives and get the energetic support of members of the public to be our spokespersons. These members of the public can include undergraduates, citizen groups, industry, entrepreneurs, and powerful members of the legislative and executive branches. I would also include the trustees in this group. The university president's strong leadership, vision, and dedication to creating the right environment for the support of research is absolutely essential.

I'll mention here a few initiatives that Indiana University and other institutions have taken along these lines.

a. Programs for Undergraduates

1. President's Summer Undergraduate Research Initiative. This program is a widely available opportunity for undergraduate research using graduate students and faculty as mentors, and including opportunities to attend national conferences to report the research results.

We believe that in the future there will be increased funding from federal agencies for undergraduate research (which is tied in with the graduate student learning experience), and we intend to compete strongly for these funds.

2. Scholarship of Teaching. This faculty initiative supports and publicizes research and scholarship on teaching. "Scholarship" implies a reflective habit of mind; and in keeping with that outlook, this initiative is designed to improve disciplinary research as well as provide insights into teaching.

3. Marketing Strategy. A marketing strategy should be a cohesive set of efforts that will convince students that the prestige of the institution depends significantly on research, and that research of high quality therefore increases the value of their degree.

As a result of our marketing strategy over the past few years, Indiana University's undergraduate students have specifically requested that their tuition be increased an additional one percent, with that money being invested in hiring additional faculty to both teach and do research. The students monitor how this additional money is spent.

Undergraduates are excellent representatives to the trustees and to federal and state offices on the role of research in creating a more fertile learning environment.

b. Graduate Students

You may believe that graduate student support is a given and that no special efforts are needed for graduate students to be enthusiastic supporters of additional funds for research. I find that this is not entirely true. It is clear in the national news, and probably your experience as well as mine, that there are important issues to be addressed, involving faculty mentoring, training of graduate students as teachers, and fair compensation. The competitiveness of today's job market and special efforts to make students more successful in that market also are very important factors.

Initiatives we have used to earn graduate student trust and generate enthusiasm include day care; health insurance; a graduate placement center; a strengthened Graduate Student Organization (GSO); participation in the national Preparing Future Faculty program sponsored by the Pew Charitable Trusts, the Association of American Colleges and Universities, and the Council of Graduate Schools; more representation in faculty governance; and a graduate student presence on key university committees.

The GSO meets once or twice a year with the Board of Trustees to communicate their concerns and our successes. This has been an important and positive experience for both the Trustees—in their commitment of support for research and graduate education—and for the graduate students.

c. Trustees

Even those trustees who clearly understand the importance of the research mission must find assurance that support for research will not, for example, result in tuition costs getting out of hand, potentially making college inaccessible for lower and middle-income families. Many trustees will be concerned that research is draining resources, including faculty time, from undergraduate education. Strong support for research by undergraduate and graduate students at trustee meetings is therefore crucial. Sharing relevant data with trustees and keeping them apprised of initiatives is, in my opinion, essential.

Some worry that trustees will be tempted to micro-manage if they have access to too much information. But if trustees don't have information, they may think there is something to hide, or that the administration doesn't have the information needed to make good management decisions. Indiana University has developed an extensive database on graduate students that includes information on progress

toward degree and job placement, and we also maintain departmental data on faculty teaching and research productivity. These data are made available to the Board of Trustees when and as the President directs.

The Trustees were directly involved in our Strategic Directions program, which provided \$20 million in seed money for initiatives that were deemed valuable contributions to the university's missions and likely to be sustained in future years. The Trustees have also cooperated with the President in providing matching funds for endowed professorial chairs, as well as incentives for building a graduate student fellowship endowment. Individual trustees, as well as the Trustees as a group, have been very active in presenting the university's case to the legislature and to the executive branch. They have also consistently given new research initiatives the highest priority within the university. An example on our campus is the proposed \$80 million interdisciplinary Science Building.

d. Citizens, alumni, parents

One continuing initiative that has been successful for Indiana University is called Hoosiers for Higher Education (HHE). HHE is a large grass roots organization that recruits alumni to educate the general public about Indiana University and higher education issues, and mobilizes these volunteers to maintain contact with elected officials representing the district in which they reside. The point here is to organize, educate, and then use a large number of private citizens to carry the university research message among other key messages in higher education to others at the grass roots level.

e. Industry and venture capitalists

In addition to the usual partnerships with industry that arise from research or intellectual property transactions, universities also provide industry with a workforce of high quality. Further, a prestigious research university acts as a drawing card for attracting prospective employees to the state.

Some particular initiatives that we at Indiana University have found useful include:

IRLP. The Industrial Research Liaison Program provides business assistance and information services to Indiana's business and industrial communities, governmental units, and economic development agencies. These services include research and development assistance, proposal writing, and grant administration assistance; business and scientific information retrieval services; solutions to applied research problems; and opportunities for

increased collaboration between Indiana University faculty and economic development organizations.

ARTI. The Advanced Research & Technology Institute is a private, not-for-profit agent of Indiana University. In addition to the Indianapolis corporation headquarters, ARTI maintains offices in Bloomington and cooperates with faculty on all eight Indiana University campuses. By partnering through ARTI, Indiana businesses have access to the university's best strategists and scientists, cutting-edge laboratories, communication tools, and information technologies. ARTI helps put research and development to work in new and powerful ways that are both practical and economical.

Venture Capital Funds. Recently, a venture capital fund has been formed to invest in potential spin-offs of university research in the Midwest. The fund, already fully capitalized, is run by experienced and successful professionals in the venture-capital field, one of whom is a former vice president for finance at Indiana University.

We have decided to expand our economic development activities to include more opportunities for each of the Indiana University campuses to facilitate university partnerships with small and medium-sized businesses throughout the state and, when asked, to provide "white papers" for state policymakers.

f. State and federal elected officials and federal funding agencies

Indiana University has had an active on-going relationship with elected officials through our federal and state relations offices. I am sure your institutions do also. Our program is based on priorities set internally by a Federal Relations Committee, using a holistic approach that involves knowing the university's diverse strengths and priorities, and influencing federal legislation and agencies to fund programs that will strengthen both primary and emerging research areas. Program officers must know in detail that funds provided to Indiana University will result in excellent research, will be strongly leveraged by the university, and will most often result in sustainable programs so that a grant is not money wasted.

At the federal level, top university officials periodically visit the Indiana Congressional delegation in Washington regarding special requests for earmarks, most often involving research. We also ensure that university representatives are seen as national leaders in lobbying for more Congressional support for the federal funding agencies. This can best be done if our people have leadership roles in the national higher

education associations such as the Association of American Universities, the National Association of State Universities and Land Grant Colleges, the Association of Graduate Schools, and the Council of Graduate Schools. I remember testifying on behalf of the National Science Foundation and the National Institutes of Health before a House committee with the directors of those two agencies on either side of me. This kind of opportunity has significant long-term advantages for the universities and the agencies involved.

At the state level, we utilize the various public stakeholders to supplement our vigorous state relations efforts. In this, as in other arenas, cooperation among higher education institutions in the state is crucial. In particular, common goals and initiatives involving Purdue University and Indiana University are important to both institutions.

We also use as many opportunities as possible to talk with legislators, trustees, and industry leaders about the importance of funding the research university, and the centrality of research to state economic development and quality of life. An example of such an opportunity is our annual Smithsonian Program, which brings legislators, trustees, business owners, and university personnel together in Washington, D.C. The invitees learn of opportunities for Indiana business around the world, visit several trade-important embassies for meals and discussion, and meet with the Indiana Congressional delegation.

I should mention here that Indiana University has a similar broad-based approach to fund raising from private corporations, foundations, and donors. But that's another talk, and would be better presented by other members of our administrative team, in particular Curt Simic, President of the Indiana University Foundation.

III. Successes and Suggestions

I'll mention just a couple of the recent successes Indiana University has had at the state level:

Twenty-First Century Fund. This fund, created in January 2000 by Indiana Governor Frank O'Bannon, provides \$25 million per year to nurture the state's growing research and development sector. In the first round of funding, more than \$15 million was awarded to 12 groups that partner Indiana universities and researchers with Indiana companies. An important point is that the creation of the Twenty-First Century Fund was urged and promoted by an independent Health Industry Forum; many of the projects that have received funding to date involve research on new health-related treatments and technologies.

Proton Therapy Project. This project has received \$10 million from the state of Indiana and \$2 million from Congress. These funds will be used to create the Midwest Proton Radiation Institute, housed at the Indiana University Cyclotron Facility, to provide cancer treatment using advanced proton therapy techniques. This project was funded because of the efforts of external supporters who saw its benefit to citizens and its value as an economic development initiative.

IV. Questions for Future Consideration and Discussion

I suggest that the questions listed below are helpful no matter what stage an institution is at in its development of the research mission. We all need to keep them in mind on a continuing basis. The questions also serve as an excellent ground for productive discussion within and among universities:

1. What are your recent outstanding successes? Failures? What do you learn from these efforts in terms of strategies for the future?
2. How accountable are you to your stakeholders and potential champions?
3. How do you currently use your faculty, students, parents, grass roots organization, alumni, trustees, industrial and other private sector leaders, federal and state relations team, and key state and federal legislators to influence others?
4. What resource, organization, or new initiatives are needed internally and externally to make a still better case for research support?
5. Does your institution **sincerely** use current research and public funds so that additional requests will be greeted with a sympathetic initial response?
6. Does your university aggressively cooperate with potential stakeholders?

Conclusion

I hope these remarks and questions will stimulate our discussion. In summary, before we can expect research to be higher on the public agenda we need to know and respond to the public's agenda for us. We

must pay particular attention to the undergraduate learning environment and take the proper steps to improve it in tangible ways that allow stakeholders to see research as a positive contribution to teaching and learning (as opposed to a competitor to teaching). The understanding that we are mentors of the next generation of citizens whether we are teaching others in the classroom or in the research laboratory is crucial.

Of course, the reflective nature that is so necessary to teaching is also crucial in research and in cooperating with external stakeholders. The attitude of the faculty (the Ph.D. holders) as stewards of knowledge in their discipline (both in disseminating and creating new knowledge) could go a long way in creating a positive atmosphere in dealing with the improvement of the **public's** knowledge base and opportunities resulting from research. Then the public will be able and willing to "carry our water" more effectively than we could do ourselves and research will have a higher priority on the public agenda.

THE RESEARCH 1 UNIVERSITY: STRATEGIES AND PUBLIC AGENDA

Robert E. Barnhill
Vice Chancellor for Research & Public Service
University of Kansas

Prologue: Research Competitiveness

I would like to tie together several strands in this presentation on Strategies and Public Agenda for the Research 1 University. With his keynote address today, George Walker set us on a good course to discuss the meeting's topic, "Making Research Part of the Public Agenda."

First, I would like to cite the principal conclusion from a conference on Research Competitiveness. In April 1995, the American Association for the Advancement of Science (AAAS) convened some forty people at Kiawah Island, South Carolina. Included were experts in research policy such as Roger Geiger, Irwin Feller, Susan Cozzens, and Harry Lambright. The purpose of the meeting was to help EPSCoR states become more competitive in research. The AAAS invited two "outliers," that is, two people who had been successful in non-EPSCoR states, to pass around their secrets of success. Those two people were George Walker from Indiana University and me, representing Arizona State University. This was my first meeting with George and also with the national research policy experts. Along with my institutions, Arizona State University (ASU) and the University of Kansas (KU), I personally have subsequently profited from meeting George and the other research policy gurus.

We prepared manuscripts prior to the 1995 meeting which then became a published book (see references). Roger Geiger's pre-meeting manuscript described the overall research scene, focusing on federal expenditures. He mentioned that only five universities had made a considerable improvement in research competitiveness in the 1980's and early 1990's: ASU was one of the five. Geiger went on to say, "Presidential backing for strengthening research is a virtual prerequisite. In some cases, presidents have identified themselves with ambitious research goals; in others, presidents have more quietly backed the efforts of provosts or vice presidents of research (ASU)." Geiger also said, "An institutional commitment to research almost presupposes the organization of research administration under a single office. The office of the vice president for research does far more than standardize research accounting and offer administration support. It should become the initiator of and advocate for proactive policies."

After three days, the conferees agreed on one fundamental principle: **Leadership at every level is essential for institutional research competitiveness.** This includes leadership not only at the president/chancellor level, but also within the faculty and the rest of the university research community.

Prior Merrill Center Research Policy Meetings

Let me review for you the last three Merrill Center conferences on research policy.

- Mobilizing for Research Opportunities in the Next Century (1998)
- Building Cross-University Alliances that Enhance Research (1999)
- Making Research Part of the Public Agenda (2000)

The keynote speakers have been Michael Crow, Columbia University, Luis Proenza, University of Akron, and George Walker, Indiana University, respectively. Michael Crow, now the Executive Vice Provost at Columbia, explained the “niche” strategy whereby a university emphasizes a few areas of institutional expertise. Luis Proenza, formerly Vice President for Research at Purdue University and now President of the University of Akron, discussed “strategic intent” and its ramifications in collaborative efforts. George Walker, Vice President for Research and Graduate School Dean at Indiana University, discussed today the Indiana story of mobilizing “the public” to support research. I will take up each of these three themes in turn.

Setting the Stage for Success

The dawn of the new millennium is an exciting time for research in general and science in particular. It is an excellent time for organizations to take stock of their goals and resources, and their impact.

Universities have great stability and a long and honorable history. But it is important that institutions be able to move as quickly as possible. Each university must answer these questions:

- Can we remain relevant in today's fast moving world? Or will we be relegated to a genteel backwater role in American society?
- If we wish to remain, or become, relevant, how can we do it? What are reasonable goals and how can we achieve them?

Michael Crow estimates that in the near future there will be about 75 significant research universities in the United States. These select universities will obtain almost all the competitive federal funding.

Andrew Grove, CEO of Intel Corporation, has written the book, *Only the Paranoid Survive*, to which I will return in a few minutes. Let me paraphrase the book's title to: *Only the Flexible Will Thrive*. Only universities that are flexible in their approach and have clear goals and expectations will do well, or even have the chance of being among Crow's 75 universities.

At the 1999 Merrill conference, Luis Proenza introduced the key concept of "strategic intent," as examined in the book *Competing for the Future*. Strategic intent has the attributes of direction, discovery and destiny.

- *Direction*: "Most companies are over-managed and under-led." That is, "more effort goes into the exercise of control than into the provision of direction."
- *Discovery*: "Strategic intent should offer employees the enticing spectacle of a new destination or at least new routes to well-known destinations."
- *Destiny*: "Only extraordinary goals provoke extraordinary efforts." Thus, numerical goals are less energizing to employees (or researchers) than goals such as being "the best" in defined competitive areas.

Strategic intent goes beyond strategic planning. Strategic planning is a "feasibility sieve." Strategic intent goes beyond the feasible to what is barely possible, e.g., President Kennedy's vision of a space landing on the moon.

Successful Examples

Let me take you through three examples of strategic intent applied to public universities.

1. Arizona became a state, the forty-eighth, in 1912. It still feels like a frontier. A few of you know that I spent 11 pleasant years at Arizona State University. I want to discuss the example of the friendly rival down the road, the University of Arizona. From Roger Geiger's book, *Research and Relevant Knowledge*, "the same factors that have been identified in the advancement of other research universities—establishing centers of research excellence,

academic leadership, and the availability of resources—were vital to Arizona as well." In 1959, President Richard A. Harvill stated that "Arizona's role in the expanding research economy would be to concentrate on fields in which it possessed some natural advantage." (Clark Kerr has also used this phrase "natural advantages.") At the time, just after Sputnik in 1957, the University of Arizona had only \$1 million in federal funding and no nationally recognized departments. In the years that followed, two centers emerged, one in astronomy and one in anthropology. Each relied on natural advantages: astronomy on clear skies and nearby mountains for observatories; and anthropology on the presence of a large number of Native American tribal nations. (There are 21 tribal nations in the state.) In 1966, the corresponding two departments became the first University of Arizona departments to receive national recognition in reputational rankings.

Geiger discerns a pattern to establishing these university centers of research excellence:

- a natural advantage
- topics a little off the beaten academic path
- areas of excellence that have far-reaching effects on the rest of the university

Note especially Geiger's third point: "achieving these pockets of research excellence...overcame a kind of defeatist attitude that was prevalent on the campus."

2. Before going to ASU, I spent 22 years at the University of Utah, in Salt Lake City. Technology sectors in Salt Lake City account for some \$10 billion in annual revenues and five of the six key factors in the city's development as a technology center hinge on the University of Utah. One spin-off company—Evans & Sutherland Corporation—has helped created more than 150 computer and software companies. In 1965, David Evans came to the University of Utah to chair the Computer Science Department. In the 1970's, he brought Ivan Sutherland to the University of Utah with the strategic intent of forming the premiere computer graphics group in the country. Evans and Sutherland formed their company in the university's new research park. (Many of my own students in mathematics worked for the new company.) The University of Utah Research Park was itself a product of strategic intent. Wayne Brown, Dean of Engineering, worked with President David Gardner to inaugurate the Research Park. Their strategic intent was to develop a place where local entrepreneurship and expertise could flower. Evans & Sutherland became the anchor tenant of the new

park. The three elements of direction, discovery and destiny prevailed for all of these people relative to their respective goals.

3. I now turn to a more recent example, Arizona State University, where I served from 1986-1997. ASU is a large university in Phoenix, a metropolitan area with considerable high tech industry. However, ASU only formally adopted a research mission in 1980. At about the same time, C. Roland Haden, the new Dean of Engineering, met with local business people who wanted ASU to become a significant research university. Their goal was to stimulate economic development. "Engineering Excellence" was born from these meetings and sold to Governor Bruce Babbitt and other political and business leaders. Unlike many universities in the early 1980's, ASU was growing and thus received new science faculty positions to which excellent people were hired. This combination of Engineering Excellence and the emphasis on hiring scientists lifted the entire university (cf. Geiger's remarks above). At ASU, I served for five years as Chair of Computer Science and Engineering and thus worked within Engineering Excellence on the front lines. I then served for six years as the University's second Vice President for Research. During that time, ASU's external funding doubled and, in 1994, ASU became a Research 1 university for the first time in its history.

Strategic intent by top leadership, coupled with natural advantages and local expertise, can lead to research enhancement that lifts the entire institution. Lifting the entire institution is a phenomenon that occurred at all three of the universities I mentioned—when all the elements were in place.

Action Agenda

Only the Paranoid Survive, written by Andy Grove of Intel, contains useful advice. As I said earlier, for use in our discussions about universities, I've modified the title of his book to *Only the Flexible Will Thrive*. Grove discusses "strategic inflection points," which demarcate times of strategic changes in the performance of a company. These changes can be either positive or negative.

Positive strategic inflection points are reached more often if we apply strategic intent to our universities. Having goals that reflect our institutional missions can affect major changes in the output of our university research communities. In relation to this thought is the important topic of academic performance measures.

Performance Measures

Performance metrics are important because we will become what we measure. Thus we should select and promote measures that reflect values we think are important.

As an aside, several senior research officers of public universities are currently studying research and graduate education performance measures as part of our work for the Council on Research Policy and Graduate Education of the National Association of State Universities and Land Grant Colleges. The work is ongoing, and we believe it will have national significance. George Walker and I have both played leading roles in this work and would be glad to discuss it with you during the discussion session.

A "road map" can be a useful guide. By "road map" I mean a well thought out formal "action agenda" document. This concept is adopted from the Japanese semi-conductor industry where it has been used since the early 1980's when Japan became a threat to American dominance in that field.

Universities often do not set research goals or, if they do, the goals don't have quantitative measures. My counsel is to encourage setting goals that are both ambitious and multidimensional.

Performance measures are used to rank and rate universities nationally, as well as to provide accountability locally. Well-known rankings are published by *U.S. News and World Report*, the National Research Council on graduate education, the Carnegie Foundation and in the book by Graham and Diamond, *The Rise of American Research Universities*. The statistics collected by the National Science Foundation ("NSF numbers") provide rankings based on both federal research expenditures and on all research expenditures. There are recent studies by The Center at the University of Florida and by the Association of American Universities that use multiple dimensions of quantitative measurements.

If we would like to enlist our citizens' support of research, it is essential to have quantitative goals that are easily understandable by the public. This is another important reason for performance measures.

Tactics: Intra- and Inter-institutional

The University of Kansas provides an interesting case study for us today. When I returned to my alma mater in 1997, KU had reached a research equilibrium, wherein its national research ranking was fairly static

and **at the institutional level** little change had occurred within memory. State support of the university had apparently been mediocre for some time and, consequently, support for research was sparse. However, the faculty and the university appeared to be better than was indicated by the institutional ranking in research. In particular, KU had a group of entrepreneurial research centers with faculty eager to step up the pace.

We decided to inventory our intellectual capital on the four KU campuses. We did this by means of a call to the Deans and Center Directors to elicit faculty proposals for research attention. This was not a formal call for financial proposals, but rather a call for feasibility of "world class" research. Forty-seven proposals were submitted and a steering committee of Deans, Directors, and others looked for "mega themes," that is, for topics that met three major criteria: at least 50 faculty working in areas that have demonstrated, peer-reviewed strength, that are also of significance to our public. The steering committee was unanimous in selecting four megathemes: information technology, human biosciences, the human condition, and environmental science & engineering. What is "world class" research? In my opinion, a group is doing world-class research if every international meeting in their area must invite a member of that group to participate.

Next we inventoried the three research universities of Kansas: the University of Kansas, Kansas State University and Wichita State University. Partners in this process included the AAAS, KTEC (Kansas Technology Enterprise Corporation), EPSCoR, the Senator Pat Roberts Committee on Science, Technology and the Future, and KU's Merrill Advanced Studies Center. In due course, we determined four strategic initiatives in science and technology for the state:

- Information Technology
- Human Biosciences
- Agricultural Biotechnology
- Aviation

We are working at the state, regional and national levels to promote these initiatives.

Arrival at Destination

I list several means by which one can tell that an institution has arrived at a suitable research destination:

- High institutional rankings
- World class research areas
- Cash
- Fullest utilization of university community
- Value added to society

R&D Environment in the United States

Some background is necessary and helpful in understanding what is nationally possible.

Lester Thurow, MIT professor of management and economics, wrote the lead article in the June, 1999, *Atlantic Monthly*, entitled "Building Wealth: The New Rules for Individuals, Companies and Nations." Thurow writes, "A successful knowledge-based economy requires large public investments in education, infrastructure, and research and development." He quotes rates of return on R&D as: 24% for private rates, 66% for public rates. In the "public" rates of return, benefits accrue to the whole society. "Put simply," Thurow continues, "the payoff from social investment in basic research is as clear as anything is ever going to be in economics."

Some sound bites:

- 50% of economic progress since World War II is due to technology. This includes the fact that almost 3/4 of patents issued depend at least in part on publicly funded research.
- With regard to information technology, Alan Greenspan has stated that the "unexpected leap in technology is primarily responsible for the nation's phenomenal economic performance."
- The \$300 billion Internet economy currently employs 1.2 million people.
- President's Information Technology Advisory Council report:
 - 1/3 of USA economic growth
 - 1/3 of all corporate R & D
 - 55% of all venture capital
 - New startup every hour
 - 7.4 million jobs at salaries that are 80% higher than average

My own scientific career in Numerical Analysis and then Computer Aided Geometric Design causes me to think that information technology advances during the next few years will dwarf what has come before, in terms of ubiquitous computing and visualization possibilities. These advances will include such visionary topics as molecular level, fault tolerant computer architectures that resemble biological systems, as well as advances in brain imaging and gene therapy due to virtual reality and computational power. For an institution to become a research leader, it

must possess leadership that can utilize national trends such as these on the local level.

State Rationale for Research

Research universities provide unique cultural and economic advantages to society in general and to local communities in particular. Cultural opportunities include the advantages of a liberal education and all its corollaries. Economic impacts include the value added by the degrees to the graduates, as well as the economic ripple effect due to R&D dollars.

Graduates are the largest form of technology transfer from research universities. We have quantified the economic impact for our state: the annual income of the alumni of our three research universities who currently reside in Kansas is \$9 billion annually. About 1/3 of this total, or \$3 billion, is due to the increased salaries that our alumni earn because of their academic degrees. State taxes paid by these graduates is \$700 million annually, a figure that exceeds the annual state appropriation of \$400 million to the three universities.

We have built upon NSF methodology to create R&D numbers for the three Kansas research universities. The annually reported "NSF numbers" comprise research expenditures in science and engineering **only**. Our "enhanced NSF numbers" include expenditures in non-science and engineering fields and also in training projects for **all** fields. The U.S. Department of Commerce estimates that, in Kansas, \$1 million in R&D provides 40.6 jobs. The three Kansas research universities had \$236.5 million in "enhanced NSF" R&D expenditures in fiscal year 97, which implies that almost 10,000 (9,600) jobs are due to this source of funding. Moreover, the average salary in these jobs exceeds the average salary in our state.

A Poll of the Public

Everyone knows that the National Institutes of Health have received significant appropriations in recent years. An organization entitled Research!America has made many of the persuasive arguments that have promoted the NIH's budget. A few months ago I met with Mary Woolley, president of Research!America, and learned that they do state surveys and want to move beyond their original focus on biomedical science to the support of science in general. Kansas is an attractive state to Research!America because of the recent decisions centered on evolution. In February of this year, I called together my counterparts from Kansas State University, Wichita State University, and the Kansas Technology Enterprise Corporation (KTEC) to meet Mary Woolley. We decided to initiate a poll of the Kansas citizenry. At last week's meeting of his

statewide Committee on Science, Technology and the Future, we spoke with Kansas Senator Pat Roberts about this project. He expressed interest in this statewide survey, and assigned Keith Yehle, a member of his Washington staff, to work with us on disseminating the results of the poll.

A Tipping Point

Malcolm Gladwell's book, *The Tipping Point*, demonstrates by examples how changes by relatively few people can have a large impact. There are three rules for a tipping point: the Law of the Few, the Stickiness Factor, and the Power of Context. My considerable oversimplification of the book is the following:

The Law of the Few: The example of Paul Revere illustrates that some people have exactly the right connections for making a significant impact, whereas others in the same situation cannot because they do not have these resources.

The Stickiness Factor: Successful projects frequently have some feature, say, a snappy title or phrase, which makes people remember them favorably. The image "sticks" in their mind. My own advocacy example is "Selling the Endless Frontier." This echoes "Science, the Endless Frontier" from Vannevar Bush's letter to President Franklin Roosevelt encouraging federal support of research after World War II.

The Power of Context: "Environmental tipping points are things that we can change." Gladwell gives the example of fixing up a small portion of a run-down neighborhood. By this example, the neighborhood as a whole improves itself. My example would be the indifference of a legislature to university research.

Black Elk, Oglala Sioux

In the research arena, change is a necessity. Sometimes, especially in a millennial year, it is tempting to think that we have invented everything. I am always brought back to Earth when I turn to this late nineteenth-century saying by Black Elk, an Oglala Sioux elder:

"Little else but weather ever happened in that country other than the sun and moon and stars going over and there was little for the old men to do but wait for yesterday."

Let us not be like Black Elk's "old men." Rather, let us embrace change and use it to advance science and society in the 21st century.

References

Bush, Vannevar (1945). *Science - The Endless Frontier*. National Science Foundation.

Geiger, Roger (1993). *Research and Relevant Knowledge: American Research Universities since World War II*. Oxford University Press.

Gladwell, Malcolm (2000). *The Tipping Point: How Little Things Can Make a Big Difference*. Little, Brown and Company.

Graham, Hugh Davis & Diamond, Nancy (1997). *The Rise of American Research Universities: Elites and Challengers in the Postwar Era*. Johns Hopkins University Press.

Grove, Andrew S. (1996). *Only the Paranoid Survive: How to Exploit the Crisis Points that Challenge Every Company and Career*. Doubleday Publishing Company.

Hamel, Gary & Prahalad, C.K. (1994). *Competing for the Future*. Harvard Business School Press.

Stokes, Donald E. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation*. Brookings Institution Press.

Teich, Albert H. (Ed.) (1996). *Competitiveness in Academic Research*. American Association for the Advancement of Science.

Thurow, Lester (June 1999). Building Wealth: the New Rules for Individuals, Companies, and Nations. *Atlantic Monthly*.

GRADUATE RESEARCH PROGRAMS ENRICH UNDERGRADUATE EDUCATION

J. E. Leach
University Distinguished Professor of Plant Pathology
Kansas State University

Few of us would disagree that graduate education and research are inseparable, that is, high quality graduate education is built upon creative and productive research programs. What may not seem so obvious, especially to non-academics, are the tremendous contributions that graduate research and education programs make to undergraduate education. More frequently, we hear assumptions to the contrary, that is, graduate research and education negatively impact or distract from undergraduate education. For example, some suggest that associations between graduate students and undergraduates occur only when graduate students serve as teaching assistants in undergraduate classes, or that excellent researchers are mediocre teachers because they are too busy scrambling for research dollars. Here, I would like to provide examples that demonstrate how undergraduate education programs are enriched by graduate programs.

The Benefits of Research Experiences for Undergraduates

Our goal in graduate education is to provide the philosophical, theoretical, and technical bases that are needed to develop strategies, to solve problems, and to enhance our knowledge base. In other words, we strive to educate our students in the process and excitement of discovery. Graduate education provides students with skills in the scientific method, including hypothesis development and the technical and analytical skills needed to test that hypothesis. Graduate students are taught to collaborate to achieve research goals at many levels, i.e., the one-to-one interactions with their major professors or their advisory committee members, with other scholars in their department or research group, or with researchers at other institutions who are tackling the same research question.

How do graduate research and education impact undergraduate education? In first-rate research universities, graduate students constitute one part of the continuum in education offered to undergraduates. As part of their training to teach, graduate students not only serve as teaching assistants, but they also learn valuable skills by supervising undergraduate research projects. For example, at any given time in my

own laboratory, between three and five undergraduate students are involved in research at different levels, each supervised by a graduate student or postdoctoral fellow. These research experiences last for various lengths of time. For example, we frequently host undergraduates from the 1890's universities in the United States or from a university in France to perform summer research projects. Other students may be involved in one or more research projects throughout their undergraduate program. One undergraduate worked directly with a postdoctoral fellow to clone rice genes encoding an enzyme thought to be involved in targeted secretion of plant defense compounds. She started as a freshman and worked on the project throughout her undergraduate career. During the course of her project, she mastered many basic and advanced techniques required for molecular biology, and, by the end of her stay, she was training new lab members in these techniques. This well-trained and motivated student has just started a Ph.D. program at Oregon State University in Plant Molecular Biology.

Many of the undergraduate students start in the lab as dishwashers but soon become interested in what's happening around them and ask to do research projects. The funding for the projects is usually from external grants, but some students have had their own fellowship funds. For example, one of my undergraduate students was a Goldwater Scholar and another a Howard Hughes Scholar. Depending on the interests/skills of a student, projects vary from stand-alone to those in which the undergraduate assists a graduate student with his or her research project. Several projects have been so successful that the students have presented their work in the form of a paper or poster at a regional or national meeting or have earned co-authorship on a publication in a peer-reviewed, national journal.

Considering who the undergraduate student works with or interacts with in the laboratory, the training often goes beyond acquiring research skills; these students learn collaborative skills. Interactions between graduate students from other countries and "Kansas kids," who may have never been out of the state benefit both the undergraduate native and the graduate student. It is thrilling to watch prejudices melt and admiration build as research interactions progress. We have a responsibility to prepare our graduate and undergraduate students to function in a global economy; what better way than to build international friendships and collaborations early in their careers?

Spillovers from Research Technologies: Innovative Teaching Tools

Research programs can impact undergraduate education in other ways. Undergraduates are exposed to state-of-the-art equipment and technologies through classes as well as research experiences. Access to

such equipment and technologies can inspire researchers to develop innovative teaching technologies that impact both graduate and undergraduate students. For example, we recently experimented with the Internet 2 as a means for interactive, high quality teaching. In the fall 1999 semester, two colleagues and I collaborated to teach Molecular Plant-Microbe Interactions on three campuses (University of Nebraska, Oregon State, and Kansas State University) simultaneously. To deliver this graduate-level course, we used new interactive technologies made possible by the high-speed, high-capacity Internet 2. The Internet 2 can send more than 2.4 billion bits of information per second, a much faster rate than many phone modems that operate at 56,000 bits per second. The huge capacity of the Internet 2 makes it an ideal medium for sending high-quality video.

For many years, my colleagues and I have been concerned that in our shrinking and often small-sized classes, our students were missing out on the kinds of exciting exchanges that shaped our own graduate careers. Using the Internet 2 as our medium, our dream was to link our classes at the three universities into one high quality, fully interactive, real-time class. Each classroom contained microphones, cameras, and video monitors. For example, my classroom at Kansas State University had three monitors, two showing the University of Nebraska - Lincoln and Oregon State University classrooms, and one displaying the visual aides I was using. Initially, both students and professors were shy of the cameras, but it was amazing how quickly we adapted to talking to our colleagues on the television screens as if they were in the same room.

Our goal was to expose the students to the different expertise and philosophies of the three instructors while at the same time "meeting" and interacting with their future colleagues at the other universities. The class was a lecture/discussion format, with the three professors sharing responsibilities for presenting lectures and leading discussions. To help stimulate discussions, my colleagues and I were present during each lecture or discussion. A common website was developed to provide a venue for posting notices, handouts, and reading lists as well as for group threaded discussions.

From the very beginning, the instructors agreed that class discussion sessions were critical to the students' learning experience, so having real-time discussion capabilities with no delays or gaps in conversations was given the highest priority—and this component was the most taxing to our technology systems. The broadcast video engineers and the computer and network specialists worked for six months before the start of the class and were literally testing, experimenting, and writing software throughout the semester to achieve the high quality we demanded. This was a true collaboration between the engineers,

computer specialists, and instructors. And it worked. It was amazing how the technology became transparent during the heat of a discussion. After one particularly stimulating discussion in which the students from all three campuses participated freely, one engineer commented “we have landed.”

Although the course was not without its bugs, in general, the students and instructors agreed that the experiment was worth the effort, and that the technology offers great possibilities for teaching in the future. How we use that technology to provide high quality learning experiences for our graduate and undergraduate students or to advance our research fields is limited only by our imaginations.

Summary

The intertwining of graduate and undergraduate education and research programs benefits and enriches the learning experience for students at both levels. Graduate students learn to teach and advise, they learn from teaching, and together, the graduate and undergraduate students learn the excitement and process of research. Faculty research and teaching efforts also benefit from the continuum of training. Research productivity increases from their groups, and the energy of the interactions charges new ideas that can benefit both research and teaching. For example, development and testing of a novel teaching approach involving the Internet 2 for highly interactive discussion classes resulted from exposure to state-of-the-art research tools.

STRENGTHENING THE ROLE OF RESEARCH IN POLICY DECISIONS:

The Campbell Collaboration and the Promise of
Systematic Research Reviews

Harris Cooper
Professor of Psychology
University of Missouri - Columbia

In the past three decades, there has been a dramatic increase in the amount of social research available to policy makers. From drug abuse prevention to school desegregation, it is not uncommon to find dozens, if not hundreds, of studies that examine the effectiveness of social policies and programs. Policy makers look to these bodies of evidence in the hope that research will assist in making sound decisions about which programs to continue, expand, or abandon. Practitioners look to research for prescriptions about how best to carry out their work. Participants want to know that programs will have the desired effect. The public seeks evidence that tax and philanthropic dollars are being spent wisely.

The promise of evidence-based decision making in the social policy arena remains largely unfulfilled. In fact, skepticism, if not outright cynicism, exists about the value of research in creating social policy. Some of the barriers to the effective use of research are endemic to the policy arena. Other barriers reside within the research community. Advocacy groups on opposite sides of an issue point to studies that support their position but conflict with one another. Researchers producing disparate results ignore flaws in their own work while questioning the trustworthiness of other's findings. Both behaviors lead to diminished credibility for all research.

These episodes, and the resulting perception of a diminished value for empirical evidence in setting public policy, can be traced to at least three characteristics of social research. First, broad-based policies and programs are carried out in real world contexts. The complexities of setting introduce factors that influence whether or not a policy or program will produce the desired results. The important nuances of setting are difficult to recognize and even more difficult to represent within the confines of a single study.

Second, for both ethical and practical reasons, social research frequently will include design flaws. The flaws mean that explanations for the outcome of a study other than the effectiveness of the policy or program itself will remain plausible. Most typical among these design flaws are that program participants often cannot be randomly assigned to receive or not receive a treatment. This leaves open the possibility that preexisting differences between the treated and untreated participants account for outcome differences.

Third, the outcomes of single studies are probabilistic in nature, based as they are on samples drawn from populations. Therefore, variation in outcomes when many studies on the same topic have been conducted, in direction as well as the magnitude of treatment effects, is not surprising. Indeed, it is even expected. Often, this variation due to sampling uncertainty is mistakenly called conflicting results.

A solution to all three of these problems can be found in how individual studies are carried out. Additionally, after decades of neglect, social scientists now agree that a solution can also be found in how bodies of evidence are treated after multiple studies have accumulated (see Appendix A for a brief history of these developments). The influence of context on policy and program evaluations can be examined in research synthesis by comparing the outcomes of groups of evaluations that include different types of participants, settings, and treatment characteristics, even though no single study contained all the variations. Multiple studies can also be grouped according to the characteristics of their research designs. If studies with different design strengths and weaknesses lead to similar results, greater confidence can be placed in a review's conclusion than in the results of any single evaluation. If results are different, rival hypotheses can be precisely identified for testing in future study. Finally, by combining the results of multiple studies the general effect of a policy or program can be pinpointed much more precisely than in a single investigation. The expected variation about this midpoint can also be estimated.

In each instance, the use of proper procedures for the synthesis of multiple studies does more than simply ameliorate the problems currently associated with the use of research in policy making. Systematic review procedures transform the difficulties into strengths. Variation in the context, design, and sampling characteristics of individual studies are the source of consternation when studies are examined individually, serially, and narratively. When multiple studies, each limited in their representation of context, design, and sample, are treated as data points in a second round of scientific investigation they contribute jointly to more confident, general, and properly contextualized guides to decision making.

Because of the potential value of systematic research reviews in the policy domain, both the producers and consumers of reviews now agree they must think about what distinguishes good from bad reviews. Further, they agree that without high-quality reviews, consumers will question the value of research for assisting the development of effective public policy. *The issues now facing social scientists concern how to define high-quality reviews, how to train producers to carry them out, and how to disseminate reviews to those who might formulate and implement policy and practice based on their result.*

Efforts are underway to “raise the bar” regarding how both primary research and systematic reviews are conducted in the policy arena. In health care, the Cochrane Collaboration has become a recognized vehicle for the production and dissemination of high-quality systematic reviews of research. In social policy, the recent emergence of a parallel organization, the Campbell Collaboration, promises to bring the same kind of rigorous treatment of literatures to research on education, crime and justice, and social welfare.

The Cochrane Collaboration on Health Care

In 1979, Archie Cochrane, a British epidemiologist, noted that a serious criticism of his field was that it had not organized critical summaries of relevant randomized controlled trials (RCTs). In 1987, Cochrane found an example in health care of the kind of review he was looking for. He called this systematic review of care during pregnancy and childbirth “a real milestone in the history of randomized trials and in the evaluation of care,” and suggested that other specialties should copy the methods (Cochrane, 1989). In the same year, the scientific quality of many published reviews in medicine was shown to leave much to be desired (Mulrow, 1987).

The Cochrane Collaboration was developed in response to the call for systematic, up-to-date reviews of RCTs of health care practices. Funds were provided by the United Kingdom’s National Health Service to establish the first Cochrane Center. When the Center opened at Oxford in 1992, those involved expressed the hope that there would be a collaborative international response to Cochrane’s agenda. This idea was outlined at a meeting organized six months later by the New York Academy of Sciences. In October 1993, at what was to become the first in a series of annual Cochrane Colloquia, 77 people from eleven countries co-founded The Cochrane Collaboration.

The principles and products of the Cochrane Collaboration. The Cochrane Collaboration has evolved rapidly since the First Colloquium, but its basic objectives and principles have remained the same. It is an

international organization that aims to help people make well-informed decisions about health care by preparing, maintaining and ensuring the accessibility of systematic reviews of the effects of health care interventions. Detailed information on the Cochrane Collaboration can be found at <http://www.cochrane.org>

The Collaboration is built on the principles of joint effort, avoiding unnecessary duplication of effort, minimizing bias in review outcomes, ensuring relevance and access for people other than researchers, and continually updating and improving the quality of its work.

The core products of the Cochrane Collaboration are contained in the Cochrane Library, a set of electronic and web-based databases. The Cochrane Database of Systematic Reviews contains reviews that have been carried out by Collaboration review groups and that meet the standards set by the Collaboration's members. The Cochrane Controlled Trials Register, is an exhaustive reference database of randomized controlled trials of health care practices. The Database of Abstracts of Reviews of Effectiveness includes structured abstracts of systematic reviews completed outside the Collaboration that have gained approval after critical appraisal. The Cochrane Review Methodology Database is a bibliography of articles on the science of research synthesis. Also included in The Cochrane Library is a Reviewers' Handbook on the process of reviewing research.

There are several other unique aspects of the Cochrane Library. First, it contains comments and criticisms of its own work. Second, it remains a live document because review groups are constantly revising and updating their entries to reflect the results of new studies and improvements in review methodology. Thus, the quality of Cochrane reviews is enhanced by means of an iterative system through which successive versions of each review reflect not only the emergence of new data, but also valid criticisms, solicited or unsolicited, from whatever source. Successive versions of a particular review, together with any intervening criticisms, are archived electronically.

The organizational structure of the Cochrane Collaboration. Cochrane reviews are published electronically in quarterly issues of The Cochrane Database of Systematic Reviews. Preparation and maintenance of reviews is the responsibility of international collaborative Review Groups. Over 40 existing and planned review groups cover most of the important areas of health care. The members of these groups—researchers, health care professionals, consumers, and others—share an interest in generating reliable, up-to-date evidence relevant to the prevention, treatment and rehabilitation of particular health problems or groups of problems.

As they carry out their work, review groups employ a series of methods to assemble, appraise, and sometimes synthesize data from the trials that are relevant to their question. In doing so, they draw on the work of Methods Groups, which are created to organize and disseminate the work of methodologists who have come together to improve the validity and precision of systematic reviews. For example, collaborative review groups benefit from a Methods Group that developed high-quality, uniform methods for handsearching journals. Members from a number of Methods Groups have played major roles in the creation and maintenance of the Review Manager software that helps reviewers organize, prepare, analyze and present their systematic reviews.

The work of the Cochrane review groups also is facilitated in a variety of ways by the work of Cochrane Centers that advise on organizational policy and facilitate training and communication. Review groups are also assisted by field panels that monitor reviews to ensure that concerns of particular stakeholders are represented in reviews (e.g., child health). A consumer network also exists within the collaboration.

The Campbell Collaboration on Public Policy

The inaugural meeting of the Campbell Collaboration was held in Philadelphia, Pennsylvania, on February 24 and 25, 2000. Patterned after the Cochrane Collaboration, and championed by many of the same people, The Campbell Collaboration aims to bring the same quality of systematic evidence to issues of public policy as the Cochrane does to health care. It seeks to help policy makers, practitioners, consumers, and the general public make informed decisions by preparing, maintaining, and promoting access to systematic reviews of studies on the effects of public policies, social interventions, and educational practices.

The Campbell Collaboration was named after the American psychologist and methodologist, Donald Campbell, who drew attention to the need for society to assess more rigorously the effects of social and educational experiments. These experiments take place in education, delinquency and criminal justice, mental health, welfare, housing, and employment, among other areas.

Over 80 people from North America and Europe attended the inaugural meeting. In addition to general sessions, the meeting began the process of developing review groups. Attendees interested in education, crime and justice, and social welfare, met in breakout groups to define their scope and begin the process of building an organizational infrastructure. Similar breakout groups met to discuss organizational needs concerning primary research and systematic review methods, and

software and dissemination. Review groups in other areas are expected to emerge in coming years. The Campbell Collaboration web site is: <http://campbell.gse.upenn.edu>

Much time was spent examining ways in which the Cochrane and Campbell Collaborations could cooperate so as to share scarce resources and avoid duplication. This issue was especially salient to the incipient Methods Group because of the considerable overlap in methods used by medical and behavioral scientists. The Methods Group established a working committee of four members that will be joined by a similar group from the Cochrane Collaboration to look at ways to integrate activities, where appropriate. The author of this paper was appointed to convene the methods working committee and represent the methods groups on the Campbell Collaboration Steering Committee.

Implications for Policy

Currently, the use of research in the formation and evaluation of public policy can be described as marginal, at best. Causes for this lack of use include the public perception that research results are often equivocal. This inconsistency has its roots in complex settings, suboptimal research methodology, and misinterpretation of research findings on the part of researchers, policy makers, practitioners, and the public.

The Campbell Collaboration is an emerging international organization that aims to help make well-informed decisions by preparing, maintaining, and disseminating high-quality, systematic reviews of research on topics related to public policy, beginning with education, crime and justice, and social welfare.

By supporting the production of trustworthy reviews and by disseminating results in an accessible fashion, the Campbell Collaboration will play a crucial role in improving the quality of evidence-based decisions in the public policy arena.

References

Campbell, D.T. & Stanley, J.C. (1966). *Experimental and Quasi-Experimental Designs for Research*. Chicago, IL: Rand McNally.

Cochrane, A.L. (1989). Forward. In I. Chalmers, M. Enkin & Keirse, M. (Eds.). *Effective Care in Pregnancy and Childbirth*. Oxford, England: Oxford University Press.

Cook, T. D. & Campbell, D.T. (1979). *Quasi-Experimentation: Design and Analysis Issues for Field Settings*. Chicago, IL: Rand McNally.

Cooper, H. M. (1979). Statistically combining independent studies: A meta-analysis of sex differences in conformity research. *Journal of Personality and Social Psychology*, 37, 131-146.

Cooper, H.M. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research*, 52, 291-302.

Cooper, H. & Hedges, L.V. (1994). *Handbook of Research Synthesis*. New York: Russell Sage.

Cooper, H. M., & Rosenthal, R. (1980). Statistical versus traditional procedures for summarizing research findings. *Psychological Bulletin*, 87, 442-449.

Feldman, K.A. (1971). Using the work of others: Some observations on reviewing and integrating. *Sociology of Education*, 4, 86-102.

Fisher, R. A. (1932). *Statistical Methods for Research Workers*. London: Oliver & Boyd.

Glass, G. V. (1976). Primary, secondary, and meta-analysis of research. *Educational Researcher*, 5, 3-8.

Glass, G.V. & Smith, M.L. (1979). Meta-analysis of research on class size and achievement. *Educational Evaluation and Policy Analysis*, 1, 2-16.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. Orlando, FL: Academic Press.

Hunter, J.E., Schmidt, F.L. & Jackson, G.B. (1979). *Meta-Analysis: Cumulating Research Findings Across Studies*. Beverly Hills, CA: Sage.

Jackson, G.B. (1980). Methods for integrative reviews. *Review of Educational Research*, 50, 438-460.

Light, R.J. (Ed.). (1983) *Evaluation Studies Review Annual, Vol. 8*. Beverly Hills, CA: Sage.

Light, R. J., & Pillemer, D. B. (1984). *Summing Up: The Science of Research Reviewing*. Cambridge, MA: Harvard University Press.

Light, R.J. & Smith, P.V. (1971). Accumulating evidence: Procedures for resolving contradictions among research studies. *Harvard Educational Review*, 41, 429-471.

Mulrow, C.D. (1987). The medical review article: State of the Science. *Annals of Internal Medicine*, 106, 465-468.

Olkin, I. (1990). History and goals. In K. W. Wachter & M. L. Straf (Eds.). *The Future of Meta-Analysis*. New York: Russell Sage.

Pearson, K. (1904). Report on certain enteric fever inoculation statistics. *British Medical Journal*, 3, 1243-1246.

Rosenthal, R. (1984). *Meta-Analytic Procedures for Social Research*. Beverly Hills, CA: Sage.

Rosenthal, R., & Rubin, D. (1978). Interpersonal expectancy effects: The first 345 studies. *Behavioral and Brain Sciences*, 3, 377-415.

Smith, M. L., & Glass, G. V. (1977). Meta-analysis of psychotherapy outcome studies. *American Psychologist*, 32, 752-760.

Appendix: A Brief History of Systematic Review Methodology

In 1904, Karl Pearson conducted what is believed to be the first statistical synthesis of research. Having been asked to review the evidence on a vaccine against typhoid, Pearson gathered data from eleven relevant studies and for each study he calculated a statistic called the correlation coefficient. He averaged these measures of the treatment's effect across two groups of studies distinguished by the nature of their outcome variable. Based on the average correlations, Pearson concluded that other vaccines were more effective (Pearson, 1904).

In 1932, Ronald Fisher, in his classic text *Statistical Methods for Research Workers*, noted that:

... although few or [no statistical tests] can be claimed individually as significant, yet the aggregate gives an impression that the probabilities are lower than would have been obtained by chance. (Fisher, 1932, p.99).

Fisher then presented a technique for combining the p-values that came from independent tests of the same hypothesis. His work would be followed by more than a dozen papers published prior to 1960 on the same topic (cf., Olkin, 1990).

This early development of procedures for statistically combining results of independent studies largely went unused. However, beginning in the 1960s, social science research experienced a period of rapid growth. By the mid-1970s when Robert Rosenthal and Donald Rubin undertook a review of research studying the effects of interpersonal expectations on behavior they found 345 studies that pertained to their hypothesis (Rosenthal & Rubin, 1978). Almost simultaneously, Gene Glass and Mary Lee Smith were conducting a review of the relation between class size and academic achievement (Glass & Smith, 1979). They found 725 estimates of the relation, based on data from nearly 900,000 students. Smith and Glass also gathered assessments of the effectiveness of psychotherapy. This literature revealed 833 tests of the treatment (Smith & Glass, 1977). Likewise, John Hunter and Frank Schmidt uncovered 866 comparisons of the differential validity of employment tests for black and white workers (Hunter, Schmidt & Hunter, 1979).

Each of these research teams realized that for some topic areas, prodigious amounts of empirical evidence had been amassed on why people act and feel the way they do and on the effectiveness of psychological, social, educational, and health care interventions. These

researchers concluded that the traditional systematic review of research simply would not suffice. Largely independently, the three research teams rediscovered and reinvented Pearson's and Fisher's solutions to their problem.

In discussing his solution, Glass coined the term meta-analysis to stand for "the statistical analysis of a large collection of analysis results from individual studies for purposes of integrating the findings" (Glass, 1976, p. 3). Shortly thereafter, other proponents of meta-analysis demonstrated that traditional review procedures led to inaccurate or imprecise characterizations of the literature, even when the size of the literature was relatively small (Cooper, 1979; Cooper & Rosenthal, 1980).

Rosenthal (1984) presented a compendium of meta-analytic methods covering, among other topics, the combining of significance levels, effect size estimation, and the analysis of variation in effect sizes based on a set of techniques involving assumptions tailored specifically to the analysis of study outcomes.

Another text that appeared in 1984 also helped elevate the research review to a more rigorous level. Light and Pillemer (1984) focused on the use of research synthesis to help decision-making in the social policy domain. Their approach placed special emphasis on the importance of meshing both numbers and narrative for the effective interpretation and communication of synthesis results.

In 1985 with the publication of *Statistical Procedures for Meta-Analysis*, Hedges and Olkin (1985) helped to elevate the quantitative synthesis of research to an independent specialty within the statistical sciences. This book, summarizing and expanding nearly a decade of programmatic developments by the authors, not only covered the widest array of meta-analytic procedures but also established their legitimacy by presenting rigorous statistical proofs.

Simultaneous with the development of meta-analysis procedures, several attempts were undertaken to frame the research review in the terms of a scientific process. In 1971, Feldman wrote, that systematically reviewing and integrating the literature of a field "may be considered a type of research in its own right—one using a characteristic set of research techniques and methods" (Feldman, 1971, p.86). In the same year, Light and Smith (1971) presented a "cluster approach" to research synthesis that was meant to redress some of the deficiencies in the existing strategies. They argued that if treated properly the variation in outcomes among related studies could be a valuable source of information, rather than a source of consternation as it appeared to be when treated with traditional reviewing methods.

Two papers that appeared in the *Review of Educational Research* in the early 1980s brought the meta-analytic and review-as-research perspectives together. First, Jackson (1980) proposed six reviewing tasks "analogous to those performed during primary research" (p. 441). His paper employed a sample of 36 review articles from prestigious social science periodicals to examine the methods used in syntheses of empirical research. His conclusion was that "relatively little thought has been given to the methods for doing integrative reviews" (p. 459).

Cooper (1982) drew the analogy between research synthesis and primary research to its logical conclusion. He presented a five stage model of the review that viewed research synthesis as a data gathering exercise and, as such, applied to it criteria similar to those employed to judge primary research. Cooper argued that, similar to primary research, a research review involves problem formulation, data collection (the literature search), data evaluation, data analysis and interpretation (the meta-analysis), and public presentation. For each stage, Cooper codified the research question, its primary function in the review, and the procedural differences that might cause variation in reviews' conclusions. Also, Cooper applied the notion of threats-to-inferential-validity introduced by Campbell and Stanley (1966; also see Cook & Campbell, 1979) for evaluating the utility of primary research designs to research synthesis. He identified numerous threats to validity associated with reviewing procedures that might undermine the trustworthiness of a research synthesis' findings.

During and after the years that the works mentioned above were appearing, the use of meta-analysis spread from psychology and education through many disciplines, especially social policy analysis (Light, 1983) and the medical sciences (see *Statistics in Medicine*, 1987, Volume 6, Number 3). In 1994, the first edition of *Handbook of Research Synthesis* was published (Cooper & Hedges, 1994).

HIGH TECH, LOW TECH, RIGHT TECH

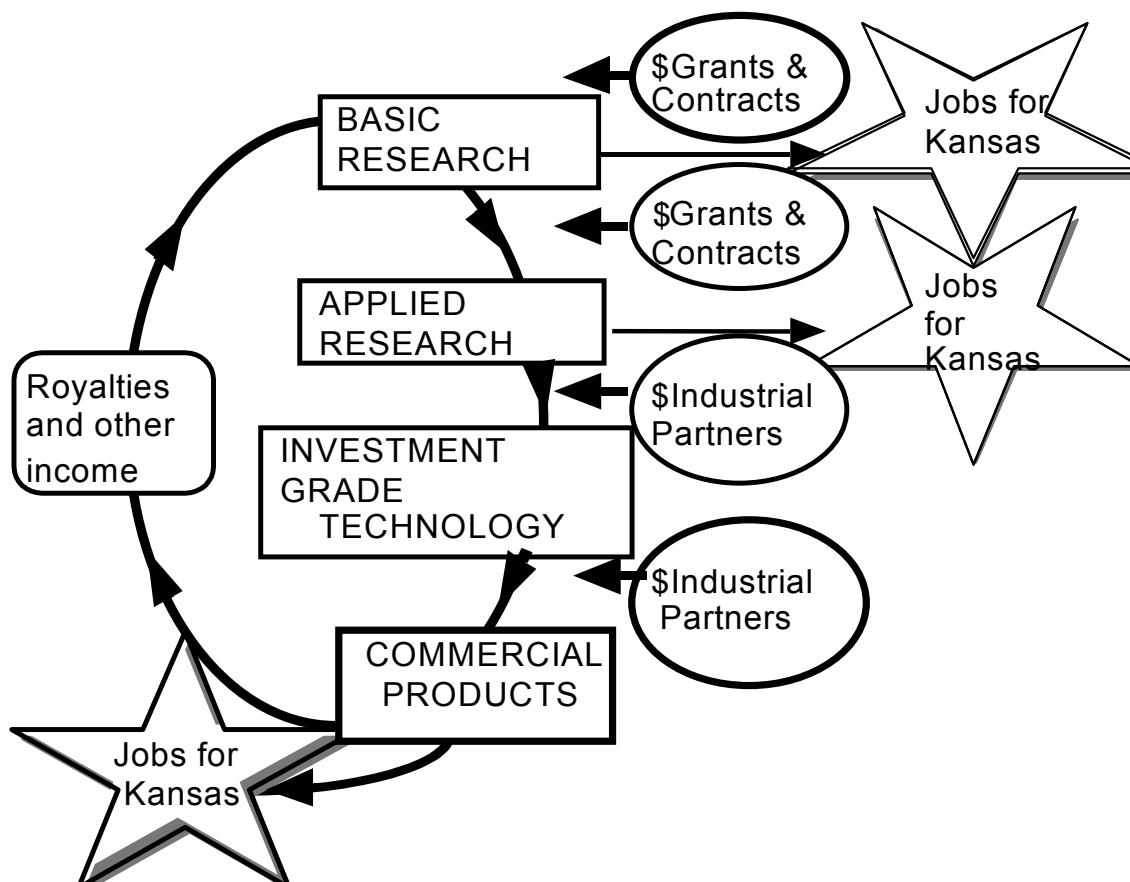
Valentino J. Stella

University Distinguished Professor of
Pharmaceutical Chemistry
University of Kansas

Around 1980, I helped discover the new antiseizure drug, fosphenytoin. It took almost 16 years for this drug to undergo clinical trials and to be approved by the FDA. Because of our naiveté at the time, we did not file for worldwide patent protection. Only patent protection in the United States was granted, and the compound was licensed to a company at a low royalty rate. Also, the licensing agreement did not have milestone payments and a due diligence clause, which contributed to the delay in reaching the market place, i.e. the University could not place any pressure on the companies involved to “move things along.” Thus the health benefits to society were delayed and the financial benefits to the University were less than they could have been.

The University of Kansas and other universities have become more savvy at technology transfer and licensing. State and State/private economic development units such as KTEC (Kansas Technology Enterprise Corporation) have helped support applied research allowing promising university-based research concepts to be advanced to “commercial grade” quality. Thus technologies can be moved beyond concept to potential commercial reality, increasing their value and hopefully the economic impact to the State. Also, because of our past experiences, we have learned what our intellectual property is worth and have developed the expertise to negotiate more favorable agreements.

We have helped launch three new companies over the last seven years. The bases for the companies have been technologies developed in the Center for Drug Delivery Research at the Higuchi Biosciences Center. It is our hope that these three companies will prosper and contribute significantly to the Kansas economy by providing high paying, technology-based jobs. With each new company we launch, we become smarter at optimizing the return to the State and the University. One of the goals of KTEC and the Centers of Excellence can be best defined by the cycle shown on the following page.



To be successful, the University, and each of these companies, had to protect their intellectual property by filing patents in a timely manner. This leads to a bit of a dilemma, that can be described as “Publish AND Perish.” I would like to quote verbatim from an “Opinion” article I wrote in the *Lawrence Journal World* in 1993.

“Publish **AND** perish. What heresy! Traditionally, universities have existed to generate and disseminate knowledge. They encourage publication through the tenure, promotion and merit salary processes, in which quantity and quality of publications plays a major role; thus the often-quoted cliché “publish **OR** perish.” However, in some fields or areas of research there are occasional, valid reasons to delay publication of information on novel technologies until patents or copyrights can be filed.

The state, nation and society might be the losers if information about promising new technologies developed at universities is made public prior to receiving patent or copyright protection. Unprotected technology is unlikely to ever be developed and used to the benefit of society. It's a simple case of economics. Let me explain by using examples in my own field, pharmaceutical sciences.

To develop a new drug and obtain approval by the FDA, a company must invest a minimum of around \$250-500 million, and the process takes 8 to 12 years. The drug must achieve annual sales of more than \$250-500 million/year over the five to nine years remaining in the 20-year patent life. This allows the company to recoup its investment, continue its product line through research and development of other drug entities, and cover the cost of products that fail to reach the market. In the unlikely event that a company were to take unprotected technology through the regulatory process to gain FDA approval, generic companies would be free to produce the product at a fraction of the cost and risk. They would not have to spend the \$250-500 million in R&D and regulatory costs. The sponsoring company would not cover its costs and would lose any economic benefit even though they might be first with the technology.

It just does not make economic sense to invest in a new drug or technology unless a strong worldwide patent protects it. As a result, few companies or investors will negotiate with inventors for rights to a new pharmaceutical technology if it is unprotected.

While patent protection is essential for commercialization, its real value lies in the fact that it enables development of a new drug or technology, which might save lives or enhance the quality of life. The drug's therapeutic benefits might allow individuals to return to the work force, thus lowering health care costs and reducing the direct and indirect financial burden to society. Additionally, university-based research often focuses on cures and treatments for more obscure diseases that may not be big money makers but may be commercialized under the "orphan" drug act.

There are also financial benefits to the university and society for a protected technology. First, the university is in a much stronger position to negotiate a favorable agreement with potential developers of the new technology. The university and state will profit by the creation of a revenue stream that can be put to creative uses in research and scholarship or general enhancement of the university mission. The developer profits, thus creating new jobs at the research, sales and manufacturing levels. And finally, as part of the negotiations for rights to the technology, leverage can be put on the developer for some or all of the technology to be developed locally, thus creating jobs in the geographical area.

There are some negatives to patenting. The cost of filing and defending a worldwide patent could easily rise above \$125,000, with additional annual maintenance fees required. This is above and beyond the cost of the research itself, which in the case of many technologies can

be very high. Such costs are not trivial, thus discouraging universities and inventors unless they have a sure winner. And when can you be certain that you have a sure winner?

Delaying publication until patents are filed conflicts with one of the principle aims of academic institutions, which is the sharing of new knowledge in a timely manner. Pressure to publish from the tenure and promotion standpoint and excitement about the discovery of new knowledge often lead faculty inventors to share their findings immediately rather than waiting to file patents or copyrights. The inventor may gain in prestige through early publication, but society loses when promising new technology is never developed because it is not protected prior to publication. How would you feel if you knew that someone discovered a potential cure for cancer or AIDS, but it could not benefit society because lack of patent protection made it too economically risky to develop?"

As more of us are asked to balance basic with applied research we need to be aware of the need to protect our intellectual property in a timely manner. Universities must continue to find ways to support the protection of intellectual property while not losing sight of their greater goal of generating and disseminating new knowledge.

THE UNIVERSITY OF KANSAS PREMIE
NEUROSCIENCE RESEARCH PROGRAM:

Towards Universal Newborn Sensorimotor Screening and Habilitation

Steven M. Barlow

Communication Neuroscience Laboratories
Department of Speech-Language-Hearing
University of Kansas

Incidence and Cost

Nearly 450,000 babies are born prematurely into the world each year in the United States. Of this, approximately 25,000 babies are classified as "extremely premature" or micropremies (27 weeks gestational age [GA] or less). Simply stated, these babies are born too soon and are thrust into an environment using a partially developed nervous system, immature lungs and respiratory system, skin too thin and fragile to be handled or subjected to the dehydrating effects of ambient air, and emerging anatomy.

Concerning the financial impact on the family and society, medical care costs approach \$750,000 for a single micropremie in the neonatal intensive care unit (NICU). The first month of care in the NICU for micropremies is an especially critical time period, with close involvement of a comprehensive team of medical care specialists. During the first month, these costs approach \$65,000 per week. This translates to more than \$15 billion annually to care for the micropremies until they reach term or 40 weeks gestational age. In the United States, the pooled costs among all preterm babies (micropremies + premies) is estimated at \$200 billion annually and rising.

Another factor that deserves consideration is the fact that post term costs are much higher for premies during the first three years of life (infancy through preschool) compared to babies born at term. Many neurological problems are not discovered using traditional diagnostic tools until toddler, preschool, and elementary school years. It has been estimated that approximately 1:5 preterm babies will eventually manifest profound impairments. This translates to nearly 80,000 babies per year contributing to a pool of nearly a half a million pre-kindergarten children with severe-profound impairments (learning disability, pervasive

developmental delay, sensory perception and integration disorders, sensorimotor dysfunction, cognitive impairments, literacy, language, and speech disorders). This estimate is limited to those children with salient, distinguishable disorders. The number of children with mild-moderate impairments is presumed to be much greater, perhaps an order of magnitude or more. The difficulty gauging the scope of impairment among young children is masked by developmental variability compounded with relatively insensitive diagnostic screening tools available to clinicians.

Obviously, the key is early identification. However, traditional wisdom has relied on a "wait" and "see" approach, due in large part to the lack of quantitative methods for assessing brain-behavior relations in NICU babies. This approach carries significant risk. The human brain undergoes dramatic changes during fetal development that extend well into the second decade of life. There are in fact a number of important critical periods that are dependent upon combinations of timing and experience to establish primary neural pathways for handling the barrage of sensory flow and eventual output to effector organs such as muscles and glands. There are also salient forms of stimulation that the baby needs to experience on a regular basis to form functional neural circuits. Certain classes of neurons also manifest endogenous (internally generated) forms of activity, the disruption of which can have serious ramifications on brain development. And finally, spontaneous or self-generated activities serve to trigger activity-dependent refinement of pathway formation and synaptic efficacy. Disruption of any of these processes can produce or contribute to significant neural delay. Fortunately there are potent mechanisms of neuroplasticity that afford the developing nervous system significant potential to recover or reorganize following periods of nutritive deficiency or insult to the developing brain.

The Goals and Objectives of the KU Newborn Neuroscience Program

During the past decade, a new approach and corresponding technology has been developed with the mechanisms of neuroplasticity in mind for premature infants at risk for brain insult, including: 1) objective, noninvasive assessment of functional neural status of centrally patterned orofacial and respiratory control, and 2) incorporation of neuroplasticity mechanisms of activity dependent change and multimodal coincident stimulation in a regimen for habilitating developing neural pathways in the premature infant (Barlow, Dusick, Finan, Coltart, Biswas, & Denne, 1999; Barlow, Dusick, Finan, Coltart, Biswas, & Flaherty, 2000; Barlow, Finan, Bradford, & Andreatta, 1993; Barlow, Finan, & Andreatta, 1997; Finan, 1998, Finan & Barlow, 1996, 1998). This second step provides neonatal specialists and developmental neurophysiologists with a set of intervention tools for inducing the developing nervous system to form preferred patterns of synaptic connectivity at a time in the baby's life when salient

stimulation is crucial for pathway formation. The NICU experience, while effective in maintaining crucial life support functions of the fragile premie, nonetheless represents a significant period of sensory deprivation. With the face and nose taped and intubated, self-generated orofacial movements and autogenic stimulation of mechanoreceptors and nerve endings in skin and muscle that "register" the consequences of such patterned motor output is severely limited. It is hypothesized that this form of sensory deprivation, combined with pre- and perinatal trauma to the nervous system, contribute to the constellation of long-term of neurobehavioral, sensory aversion, and motor control deficits observed in early years of development. Appropriate oral experiences may be critical in the final weeks of gestation, and their interruption may impair fragile syntheses of central neural representations of functions (Bosma, 1972).

The ACTIFIER Technology

Combinations of funding from the National Institutes of Health, and corporate sponsorship (Gerber, Neuro Logic, RC Electronics) have been utilized during the past decade to fuel the science and technologic development of a new instrument and protocol capable of efficient, noninvasive sampling neuromotor activity, reflexes, and orofacial pattern generation in premies during sucking in the NICU. The research referenced in this report reflects the participation of an extensive team of scientists, medical specialists, and students at all levels of their training careers (Table 1).

TABLE 1. KU Newborn Neuroscience Program Research Team

Don S. Finan, PhD	University of South Carolina Speech Physiology/Neuroscience
Amitava Biswas, PhD	University of Texas El Paso Engineering/Neuroscience
Esther Thelen, PhD	Indiana University - Developmental Psychology
Rick Konopacki, MSEE	University of Wisconsin Servo Dynamics/Engineering
Anna Dusick, MD	Indiana University School of Medicine Neonatology/Dev. Pediatrics
Shirley Coltart, MSRN	Indiana University School of Medicine Neonatology
Preston Garraghty, PhD	Indiana University - Neural Plasticity
Carol Boliek, PhD	University of Arizona Developmental Physiologist
Kathy Weatherstone, MD*	KU Medical Center Neonatology and Perinatal Medicine

* In consultation for research team recruitment

Trigemino-facial Reflex Modulation. Indexing the excitability of brain pathways, including brain stem and cerebral cortex, during non-nutritive suck is achieved with a specially designed instrument known as an *actifier*. The actifier consists of a latex baglet (Gerber NUK neonate nipple), a pacifier shield instrumented with 8 Ag/AgCl surface electrodes (3 mm diameter) for sampling electrical activity from lip muscles, and an array of four servo linear motors that provide natural stimulation of mechanoreceptive fields roughly corresponding to the "hairy skin" quadrants of the upper and lower lip. Each linear motor is under precise computer control and can be operated under position or current feedback with adjustable tracking forces. The timing of the brief and gentle mechanical stimulation is indexed to the baby's own suck pattern so that the skin tap occurs at the same phase of suck generation. All components of the actifier that come into direct contact with the infant's mouth are gas sterilized (ethylene oxide) prior to each test session.

The relatively innocuous nature of this natural form of mechanical stimulation makes it possible to assess perioral reflex excitability in the context of a naturally occurring, patterned oromotor output in about 3 minutes. All biological signals, including EMG, suck pressure, and stimulus related signals are digitized by a personal computer in real-time at 100-microsecond dwell time for each channel.

All instrumentation, including signal conditioning, servo controllers, microprocessor, and support electronics for the actifier stimulator assembly can be wheeled cribside in the NICU for each test session. The mobility of this neonate orofacial laboratory station makes it possible to complete recordings cribside or adjacent to an isolette while maintaining the baby's connection to the physiologic monitors.

Non-nutritive Suck. The actifier also permits physiologic evaluation of suck status. These tests occur at cribside approximately 15 minutes before a feeding with the infant alert. Following a brief examination of neurologic state, the infant is positioned and settled comfortably in the arms of the attending physician or research nurse. A sterile baglet assembly (non-nutritive nipple) is coupled to the actifier and positioned in the baby's mouth. The data acquisition computer is triggered by the baby's spontaneous suck to sample all physiological signals related to the non-nutritive suck. This protocol is usually completed within 2 or 3 minutes. Data on the mechanics of the suck provide important information on the functional status of the orofacial system. Physicians and pediatric nurses use this information to make key decisions about feeding readiness.

Neonatal "Electricians." The role of early oromotor experience will be tested in future studies at the University of Kansas and affiliate neonatal intensive care units (Indiana University School of Medicine, University of Arizona) to assess the brain's plasticity in establishing new patterns of connections to facilitate oromotor development. The pattern of electrical activity and competitive interaction between adjacent nerve terminals are primary determinants of development and stability of synaptic connections (Garraghty, Kaas & Florence, 1994). In essence, **"neurons wire together, if they fire together"** (Sporns, 1994). One such technique used in motor physiology to recruit populations of neurons to fire synchronously is known as entrainment. Entrainment of rhythmic motor outputs is a powerful experimental approach for revealing moment-to-moment influences of mechanosensory inputs on motor control. Entrainment is defined as the synchronization of an endogenous oscillator (neural circuits that produce patterned output, i.e., walking, running, chewing, sucking) to an external pacemaker (Pavlidis, 1973; Glass & Mackey, 1988; Kriellaars, Brownstone, Noga & Jordan, 1994). In the current application, the external pacemaker is the actifier. The nipple of the actifier is coupled to a hydraulic motor that can be programmed to produce very rapid and periodic changes in the shape and size of the nipple. The human neonate suck is one such rhythmic motor pattern that has recently been demonstrated to be significantly influenced by an entraining actifier nipple (Finan, 1998). Term infants are known to match or entrain to the "pulsing" nipple of the actifier. The potential for re-wiring the human neonate brain using highly controlled and patterned mechanosensory input is enormous. Entrainment techniques will be offered to premies in the NICU setting with confirmed oromotor disturbances to induce synchronous firing of neural circuits in brain stem and suprabulbar structures. This is expected to induce terminal sprouting and the creation of new functional connections that underlie oromotor and respiratory patterning. Daily regimens of mechanical entrainment is predicted to improve the overall functional status of orofacial and respiratory systems that are involved in sucking, and quite possibly improve long term outcome for other sensorimotor skills involving these muscle systems (vocalization, speech, gesture).

Highlight of Experimental Findings on Premies and Term Infants

1. The actifier technology permits non-invasive assessment of functional brain-behavior relations and biomechanics during non-nutritive suck production in the premature infant.
2. Computerized measures of orofacial sensorimotor function can be obtained routinely and reliably in less than 5 minutes of actual computer-controlled recording time. Efficiency is paramount when

- attempting to record sensorimotor behavior in neonates where vigilance is at a premium.
3. Non-nutritive suck dynamics change predictably as a function of maturation (age & experience) including longer, stronger, and more uniform suck burst patterns that appear correlated with changes in the neural integrity of trigeminal and facial cranial nerve systems.
 4. The actifier reflex protocol permits objective indexing of the speed of neural transmission through brain stem and cortical pathways using highly controlled, innocuous mechanical stimulation delivered to the surface of the upper and lower lip during non-nutritive suck. As the neonate matures, the speed of neural transmission in the brain stem increases thereby improving the capacity for sensorimotor integration. Variants of this protocol can be used to determine functional participation by cortical circuits during suck, thus indirectly assessing the "health" of select cerebral pathways.
 5. Oromotor, and recently respiratory entrainment appear to show great promise as tools for synchronously activating large populations of pathway specific neurons in order to reinforce the probability of desired patterns of motor output.

Future Directions

Research efforts will include an expanded research team and a set of experimental questions designed to map the dynamics of neural modulation between brain stem and cerebral systems in the premies during non-nutritive suck, nutritive suck, and patterned respiratory activity. Populations will include medically stable preterm infants as well as babies with suspected ventricular hemorrhage, respiratory distress syndrome, and genetic syndromes affecting brain function.

Concurrent experiments on the efficacy of entrainment therapy in the NICU will be conducted with systematic tests of modality type and multimodal entrainers applied to infants with known oromotor control problems. Parallel experiments in an animal model (fetal rat pup) will permit quantitative assessment of changes in brain connectivity at the level of synaptic arborization, efficiency, distribution, and typing in treated populations. The goal in these types of animal experiments is to identify the salient stimulation parameters that induce desired mechanisms of neuroplasticity in a developing brain.

Special efforts will be directed to develop a series of longitudinal outcome studies to identify links between early brain insult (hemorrhage and nutritive deficiency) and later appearing impairments (communication,

cognitive, learning, and sensorimotor including speech, locomotion and manipulation).

Summary

Collaboration is essential for the type of research program described in the current report where the target application transcends the initial working idea from the engineering workbench to cribside in the neonatal intensive care unit. It is a team effort, involving the expertise of dozens of professionals including hardware and software engineers, mechanical design specialists, machinists, biomechanists, electrophysiologists, statisticians, pediatric nurses, developmental pediatricians, neonatologists, undergraduate and graduate students, and post-doctoral research fellows. Research team building involves recruitment of talented individuals among several disciplines (departments) both within a university system, and frequently, establishing cooperative arrangements among two or more universities. I have found that what motivates such a diverse set of team members is the pursuit of knowledge and the altruism that drives us to solve a complex problem that degrades the human condition.

To gain access to clinical test sites, the principal investigator must convince the host site that the question under study is significant and bears direct relevance to patient care in their facility, with little or no risk to the test population. In the current report, we are interested in early detection and remediation of developmental or acquired neurological conditions in premature infants that are presumed to contribute to a constellation of developmental disorders that are manifest during toddler and preschool years. Thus far, the neonatal intensive care units have accommodated our research protocols with great enthusiasm. Medical directors of the NICU's and participating physicians have become strong advocates of the ACTIFIER technology and neurophysiological test protocols used with the premies under their care.

Biomedical research costs money, and principal investigators are responsible for generating grant applications to support innovative research programs. Without extramural support, research programs languish and progress is slow. The University of Kansas Premie Neurosciences Research Program represents the programmatic evolution of a research line into human neurologic disorders that began at Boys Town National Institute in the 1980's, moved on to Indiana University throughout the 1990's with concentration on pediatric sensorimotor neurophysiology and premie neurological monitoring in the neonatal intensive care unit, and now to the University of Kansas in the new millennium where we will accelerate the exploration of mechanisms of brain plasticity in newborns at-risk for brain injury. Funding has been provided

by multiple sources including the National Institutes of Health (NIDCD, NICHD), and corporate sponsors (Gerber, Neuro Logic, RC Electronics). Additional funding sources are needed to expand the KU Premie Neurosciences Research Program to include multi-institutional participation by regional NICU centers in the United States. This will help to increase the size of the test populations, and improve statistical power in determining the most efficacious methods of brain monitoring and therapeutic stimulation in premies as sensorimotor systems proceed through critical periods of neural refinement.

Literature Cited

Barlow, S.M., Dusick, A.M., Finan, D.S., Coltart, S.I., Biswas, A., & Denne, S. (1999). Neurophysiological monitoring of the orofacial system in premature infants. *Pediatric Research*, *45*, 339A.

Barlow, S.M., Dusick, A.M., Finan, D.S., Coltart, S., Biswas, A., & Flaherty, K.J. (2000). Neurophysiological monitoring of the orofacial system in premature and term infants. *Journal of Medical Speech-Language Pathology*, Invited paper, *in press*.

Barlow, S.M., Finan, D., Bradford, P.T., & Andreatta, R.D. (1993). Transitional properties of the mechanically evoked perioral reflex from infancy through adulthood. *Brain Research*, *623*, 181-188.

Barlow, S.M., Finan, D.S., & Andreatta, R. (1997). Neuronal group selection and emergent orofacial motor control: Towards a unifying theory of speech development. In W. Hulstijn, H.F.M. Peters, & P.H.H.M. van Lieshout (Eds.), *Speech Production: Motor Control, Brain Research, and Fluency Disorders*. (pp. 529-546). Elsevier, Amsterdam.

Bosma, J.F. (1972). Form and function in the infant's mouth and pharynx. In: J.F. Bosma (Ed.), *Third Symposium on Oral Sensation and Perception*, Charles C. Thomas Publisher, Springfield, Illinois (pp. 3-29).

Finan, D.S. (1998). Intrinsic dynamics and phase-dependent mechanosensory modulation of non-nutritive sucking in human infants. Unpublished Doctoral Dissertation, Indiana University.

Finan, D.S., & Barlow, S.M. (1996). The actifier and neurophysiological studies of orofacial control in neonates. *Journal of Speech and Hearing Research*, *39*, 833-838.

Finan, D.S., & Barlow, S.M. (1998). Mechanosensory modulation of non-nutritive sucking in human infants. *Journal Early Human Development*, *52*, 181-197.

Garraghty, P.E., Kaas, J.H., & Florence, S.L. (1994). Plasticity of sensory and motor maps in adult and developing mammals. In V.A. Casagrande and P.G. Shinkman (Eds.), *Advances in Neural and Behavioral Development*, Vol. 4, (pp. 1-36), Ablex, Norwood, NJ.

Glass, L., & Mackey, M.C. (1988). *From Clocks to Chaos: The rhythms of Life*. Princeton, NJ: Princeton University Press.

Kriellaars, D.J., Brownstone, R.M., Noga, B.R., & Jordan, L.M. (1994). Mechanical entrainment of fictive locomotion in the decerebrate cat. *Journal of Neurophysiology*, 71, 2074-2086.

Pavlidis, T. (1973). Entrainment of oscillators by external inputs, In *Biological Oscillators: Their mathematical analysis*. London: Academic, 71-98.

Sporns, O. (1994). Selectionist and instructionist ideas in neuroscience. In O. Sporns and G. Tononi (Eds.), *Selectionism and the Brain*, New York: Academic Press.

MISSOURI RESEARCH PUBLICATIONS: ILLUMINATING THE SCIENCE AGENDA

Jack O. Burns
Vice Provost for Research

Charles E. Reineke
Editor, *Illumination* Magazine
University of Missouri - Columbia

Across the nation, scientists and scholars are constantly working to expand the boundaries of human knowledge. In fields as varied as astronomy and industrial engineering, molecular microbiology and the fine arts, academic insights and discoveries enrich and improve the lives of millions of Americans.

As public institutions, our research enterprise is dependent upon the continued good will of these Americans—on fellow citizens who understand and appreciate the many benefits university-based research has to offer. Most of us acknowledge that the development of an effective research communication strategy is key to fostering and sustaining this support. Yet, as Marilyn Stokstad aptly noted in these pages last year, few of us have such strategies in place. We should, and here's why.

Even as funding for research in science and technology increases, so does scientific literacy fade. Interestingly enough, public apathy is not to blame. Surveys conducted every two years by the National Science Foundation show, in fact, that learning about science and technology ranks highly on the personal agendas of most citizens. Nevertheless, that desire to learn is often frustrated by a lack of information. "More than two-thirds of the American public believe that science is important; however, of those surveyed, only one in nine believes that he or she is well-informed about science and technology. Even more significant, only one in four can claim to be scientifically literate," wrote former director of the National Science Foundation and current presidential science advisor, Neil Lane after the 1997 survey.

Keeping the public in the dark is clearly not in anyone's best interest. It is, after all, a perilously short journey from ignorance to indifference and, ultimately, to antipathy. For years, for example, the vast majority of the American public neither understood, nor were encouraged to explore, the social and environmental implications of research into

biotechnology and genomics. Today there is an intense public interest in these areas. Sadly much of this interest is negative, driven by fear of the unknown.

In the absence of fair and accurate public information, many cutting edge research areas face a similarly harsh judgement. Over the long term there is even a danger that the current consensus in support of publicly supported scientific research, a consensus that has remained more or less intact since the end of World War II, could crumble.

Thoughtful science reporting is crucial if we are to avoid such pitfalls. But from whom? We believe most of us agree on the importance of urging both print and broadcast reporters to tell our stories—professional media organizations have the reach and credibility necessary to deliver huge audiences. Unfortunately, in recent years it has become clear that we should not rely too heavily on traditional media for providing the type of science and technology education deemed crucial by the National Science Foundation and others.

Much of television and press reporting is, in fact, uniquely ill-suited to tackling scientific research topics. Reporters working under deadline pressure seldom have the time or inclination to embark upon in-depth treatment of complicated scientific subjects. Deadline reporting is, moreover, intensely results oriented. Our experience at the University of Missouri—home of one of the world's great schools of journalism—has shown that science and technology reporters seldom attempt to explain that error, as much as discovery, is an integral part of the scientific process. Thus the plethora of apparently contradictory stories that only serve to further alienate already frustrated news consumers.

Public relations departments are the traditional information outlets on university campuses, and many do an excellent job. But their role is circumscribed by their mission; i.e., to ensure that professional media representatives get the story and get it right. Despite the name, today's public relations professional usually deals only with the public by proxy.

Because of the limitations described above, more and more public research universities, the University of Missouri - Columbia among them, have decided to take our message directly to non-academic audiences. At the center of our strategy in Missouri is *Illumination*, a full-color, 32-page research magazine that for the last four years has worked to bridge the information gap between campus researchers and the public. Publishing our own magazine has a number of advantages.

First, we are not dependent upon advertising dollars and circulation numbers. Thus we are free to engage our readers with challenging stories

that might not fit a traditional marketing niche—stories that explain, educate and even entertain a portion of that “two-thirds of the American public” who want to learn more about science.

By publishing our own magazine we can be assured that our stories will get into the hands of people who care about them. From lawmakers, influential donors and business leaders, to sponsoring agencies and prospective students, *Illumination* demands the attention of those with an interest in MU’s community of research. In addition, *Illumination* serves as a powerful vehicle for providing public recognition to individual scientists and scholars. Important contributions made by our faculty often do not become part of the public agenda without a little prodding. The magazine allows us to call attention to the value of work that might otherwise slip under the radar screen of people in the media and public relations.

Finally, along with other publications from the Office of Research—a quarterly newsletter, an annual report on grants and contracts, periodic updates of our Master Plan for Research and Technology Development, and an interactive presence on the World Wide Web (www.research.missouri.edu)—*Illumination* helps to build a sense of community among the hundreds of scientists and scholars working on the MU campus. Scholars and scientists often complained that, despite an interest in the activities of their colleagues, they themselves had little understanding of the work of other MU faculty. Our magazine has changed that.

All of this is not meant to suggest that a magazine alone will create a public fully conversant in the language of science and technology. However curious and sympathetic they may be, non-academic audiences—among them members of the target audiences described above—are a busy, impatient group, seldom willing to tolerate even an overview of complex subjects. Attracting and holding their interest is a huge challenge.

But now is the perfect time to do it. Never before in our nation’s history has science and technology accomplished so much in so little time. The process of scientific discovery has always been a quest to expand the boundaries of human knowledge. Today those boundaries are not so much expanding as exploding. These are exciting times at public research universities. Sharing that excitement with the people who keep us in business should be among our highest priorities.

WHEN THE PUBLIC AGENDA CLASHES WITH RESEARCH

Thomas H. Rosenquist
Director of Research Development
University of Nebraska Medical Center

In November of 1999, the *Omaha World-Herald* ran a page one article, an exposé as it were, about a research project at the University of Nebraska Medical Center (UNMC) that utilized embryonic neurons obtained from elective abortions, at a clinic in the suburban Omaha town of Bellevue. This work was sponsored by a research grant from the National Institutes of Health, and had been ongoing for about two years at the time the article was published. The use of these cells had been considered by a subcommittee of the UNMC Institutional Review Board for the protection of research subjects, although the tissue is considered to be exempt, and the review was elective; and the grant had been accepted by the University of Nebraska Board of Regents, as required by law. The use of these cells for research purposes was legal by the laws of the United States of America, and the State of Nebraska. The research was addressing a major, dreaded, incurable neurodegenerative disorder. Nevertheless, the publication of the article caused a sensation that preoccupied and disrupted the administrations of both the medical center and the university system as a whole, for several months. Several important lessons were learned by UNMC from this experience. Three of the most important lessons for other institutions are outlined below.

Lesson 1: Some research issues are explosive, divisive and dangerous.

The article about UNMC fetal cell research resulted in an immediate polarization of the people and organizations of the state. Polls reported that the people of the state were profoundly divided among supporters and opponents of the work. The University of Nebraska Board of Regents voted unanimously to support UNMC, while members of the Nebraska unicameral legislature, the majority of whom declared their opposition, began to discuss the development of a law to ban the work. A bill introduced to the Nebraska legislature that would have banned fetal cell research was withdrawn in March of 2000 because of a skillful filibuster by an Omaha legislator who supported the bill. However, it is highly likely that the legislature will activate the debate in the next legislative session.

The *Omaha World-Herald* published scores of letters condemning the work, as well as fewer letters supporting the work; the *World-Herald* also published a series of editorials that urged the legislature to keep “hands off” this and other research activities of the University. The governor of Nebraska announced his unequivocal opposition to the research, while the president of the University system was as unequivocally supportive. The *de facto* debate between these two leaders was publicized widely; their pictures and a description of the debate were carried in *Science* and other national publications.

When it became associated with this issue, UNMC entered the abortion war, where, we were to find, there is no compromise and no holds are barred. Anti-abortion and right-to-life groups entered the fray with a passion. The university has learned that these groups include members to whom this issue is nothing less than total war, wherein all's fair, including lying, disinformation, and harassment. It is well-known that these tactics have extended to assault or even murder in some cases, although not yet in the present case. Others in the anti-abortion movement may be more law-abiding, but are no less passionate on the issue. Their tactics against the university have included lawsuits, requests for federal audits of research activities, and political activism in support of regents and legislators who oppose the research.

Responses similar to those experienced by UNMC for fetal cell research also may be anticipated for other controversial research issues, including the use of mammals in research, and the creation of transgenic animals or plants.

Lesson 2: A university or medical center that decides to conduct controversial research needs to be fully prepared.

There are several levels of preparation that need to be addressed. First, the university needs to recognize and fully understand the degree to which some research may trigger a negative response among a vocal, passionate, and possibly violent segment of the population. Some opponents may be positioned to impact negatively upon the resources of the university. For example, citing the UNMC experience, the governor and key legislators; potential donors also could have been perturbed. The UNMC experience has not yet shown a way to permit the faculty to pursue legitimate but sensitive research, while mollifying the opponents of the research. Indeed, it may not be possible for a university to do so. However, it will be critical for the university entering this interesting arena, to understand the potential results.

Second, all regulatory issues pertaining to the sensitive research need to be considered scrupulously, and addressed completely. If the

typical research project is reviewed twice, issues such as human fetal cell research and genetically engineered animals or plants need to be reviewed six times.

Third, the university and the investigators need to be prepared **well in advance** to respond to the public release of the story. Immediately upon the release of the story, the university needs to be able to provide a strong, cogent, convincing and completely documented response that includes all of the following: the high value of the work to the people of the state; the degree to which the work is legal, ethical and moral; a list of other universities around the country who do similar work; and a detailed history of approval for the work at the university, state and national levels. If possible, the university should be prepared to show that it is aware of the sensitivity of the issue, and has been exploring alternative ways to obtain the same key research results.

Lesson 3: A university must be aggressive in assuring the integrity, independence, and objectivity of its research enterprise.

A university must assure that her researchers are able to pursue their legitimate research in an environment of academic freedom, without the imposition of political, religious or other biases. Most important, the university must work to assure the safety of the faculty and their families.

RESEARCH: MAKING IT A BLIP ON THE PUBLIC'S RADAR SCREEN

James A. Guikema
Associate Dean of the Graduate School
Kansas State University

Some Myths To Unload

There is an old proverb: the only person who really enjoys a change is a baby with a wet diaper.

I began my life at Kansas State University in 1981, when I joined the Division of Biology as a young assistant professor. The goals and expectations of my career were simple and well-defined: I would shape the young Kansas undergraduate in my classroom, and the citizens would be grateful. I would, through scholarship, publish in the best journals, and my path through the landmines of the academic landscape would be successful. In short, my future depended upon the classic linkage between the state/federal funding agencies and my success in attracting the resources to do my scholarship, coupled with my ability to transition that scholarship into creative experiences for the K-State graduate and undergraduate community. The contention here is that, in the past two decades, times have changed.

It is time to unload some myths that colored my early years as an assistant professor. As to the first myth—the public perceives that science, *per se*, is always used to foster the public good. Examples of science-gone-awry, especially when compliance procedures were not observed, have made recent headlines. These are times when research should **not** be on the public's radar screen. As a corollary to this myth—the University enjoys strong support for research and scholarship among the Kansas taxpayers. This "myth" has proven true in the past, and I am **not** yet willing to give it up. I sincerely hope that current initiatives demonstrate to our legislative community that Kansans continue in their resolve to support a strong university research base.

A second myth—federally-funded research and development programs are a growth industry. In recent days, there are indications that the federal attitude toward human health research has warmed significantly. However, the indicators from 1970 to 1997 show that the total

federal sponsorship of the research endeavor, when viewed as a percentage of the total effort, has declined (Figure 1).

A third myth we must abandon∇Universities should never look to industry for funding to support scholarship. Many rationales have been used in the past to support this contention, such as, industry will not let us publish, and this would be suicide for our graduate students; and industry funding is tainted by preconceived notions of expected outcomes. In fact, however, protection practices for intellectual property are in place on our campuses, and partnerships between universities and industries (and their philanthropic foundations) can be vigorous. As the federal percentage of research sponsorship has declined during the past decades, corporate sponsorship has increased (Figure 2). The total FY 1998 sponsored research expenditures funded by industry were \$2.4 billion, a 9% increase from that in FY 1997 (AUTM: *FY 98 Licensing Survey*).

A final myth that needs to be put to rest∇Universities, by themselves, can effectively place the blip of research on the public's radar screen. We are currently viewed by the public as our own special interest group. Unfortunately, this view extends to the legislature, and often to the Kansas Board of Regents. At a past Merrill Conference, an executive director of the Board noted that there was no effective mechanism to bring research issues before the Board. Happily, this has been changing.

Making it Happen: Universities in Partnership

There is an old proverb: "Nothing is impossible for the person who does not have to do it."

The current era has become the "information age." Information is now the currency of our economy, with informational advances touching the fabric of the Kansas agriculture, aviation, telecommunications, and biomedical industries. The Kansas universities should be, and are leading the charge to increase knowledge in these areas. Yet, how can we effectively take our message∇that university research deserves state-wide investment∇to the Kansas taxpayer? We take the message by building partnerships and having our partners help validate the message.

We encourage partnership between science research and science education. This is a potent alliance. K-12 educators have an impact on society. At Kansas State University, the Division of Biology currently has a \$1.8 million grant from the Howard Hughes Medical Institute, which creates partnerships between biologists and budding young educators who wish to teach biology. This grant facilitates two-year experiences for science educators in their sophomore and junior years. The young educators receive hands-on opportunities to perform the scholarship of

science, to recognize its value, and to build a reservoir of knowledge that they will pass on with enthusiasm to their students, and in some way, to their students' parents. Likewise, the University of Kansas was recently awarded a special "cross-cutting" grant from the National Science Foundation. This was the first year that such grants were offered. Graduate students, who are studying the sciences at KU, will be placed in K-12 classrooms. We believe that by reaching the K-12 students, we also reach their parents.

A second potent partnership must be forged between the research universities and the governing bodies that oversee them. The Board of Regents has been charged with this responsibility, yet research and scholarship has taken a back seat to the education of the undergraduate masses. There are strategies that can help bridge this perceived gap between undergraduate education and research. The gap itself exists because of a misperception. We must emphasize that the best education occurs within a creative environment, and our brightest students learn by doing, not by listening. The organization of Named and Distinguished Professors has brought this concept to the Board's attention.

Finally, the universities must form partnerships with the economic communities, to emphasize and re-emphasize the importance of university research for the Kansas economy. The mainstream agricultural commodity groups in Kansas understand this and have been an historic voice for research at Kansas State University. Their voices, however, have been diminished by economic forces beyond their control, yet their voices will rise within the next decade, if food-production estimates are accurate.

The Kansas Technology Enterprise Corporation (KTEC) has been beneficial as an economic voice urging the research universities to showcase strategic technologies supported by their campuses. From the perspective of Kansas State University, we have a potent mandate to continue our efforts on several fronts. In order to address our economic needs, we can continue to fuse the study of agriculture with exciting advances in biotechnology and with research on the devastating effects of drought and disease. Because our state ranks high in red meat production and we value food safety and security, we have a mandate to continue university research on production processes and security. In a world where animal diseases are also diseases that can affect humans, university research is vital. The KTEC message, from the Kansas State perspective, emphasizes the importance of agricultural biotechnology to our state.

Summary

There is an old proverb: “The sight of the gallows clears the mind.”

Is it a good thing or a bad thing, that university research is a blip on the public’s radar screen? As an individual, I would like to turn off the surrounding radar, but this is a wrong-based view at best. As an administrator who is concerned about others, I want that radar turned on. University research, like every other form of human endeavor, must be a public concern. In an information age, how can this concern be anything but positive? Only if we opt for the wrong partners.

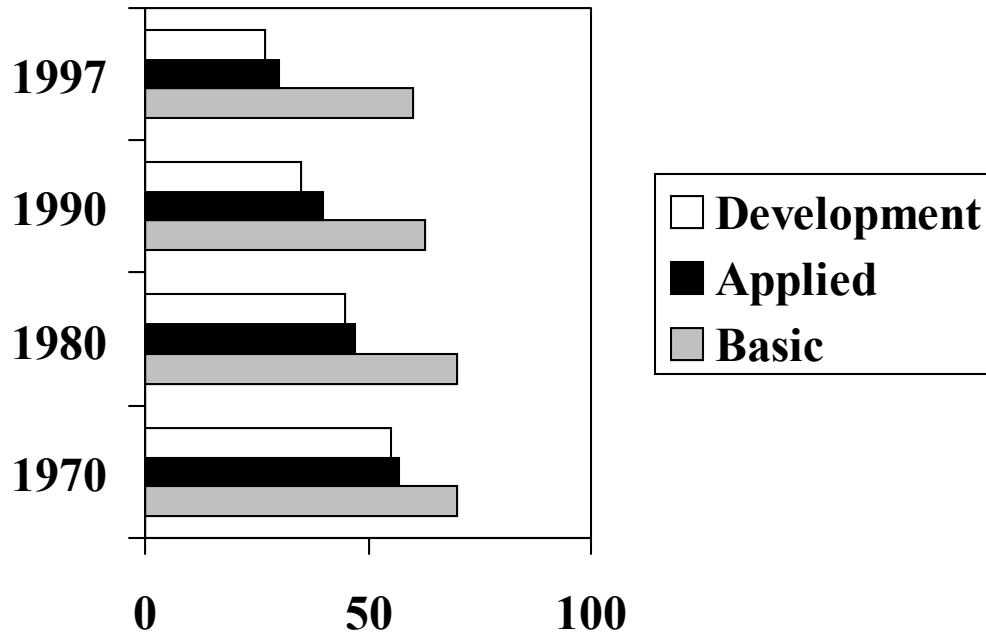


Figure 1. The federally-funded share (percentage) of the total U.S. funding of basic research, applied research, and development. From the National Science Foundation, *Science and Engineering Indicators*.

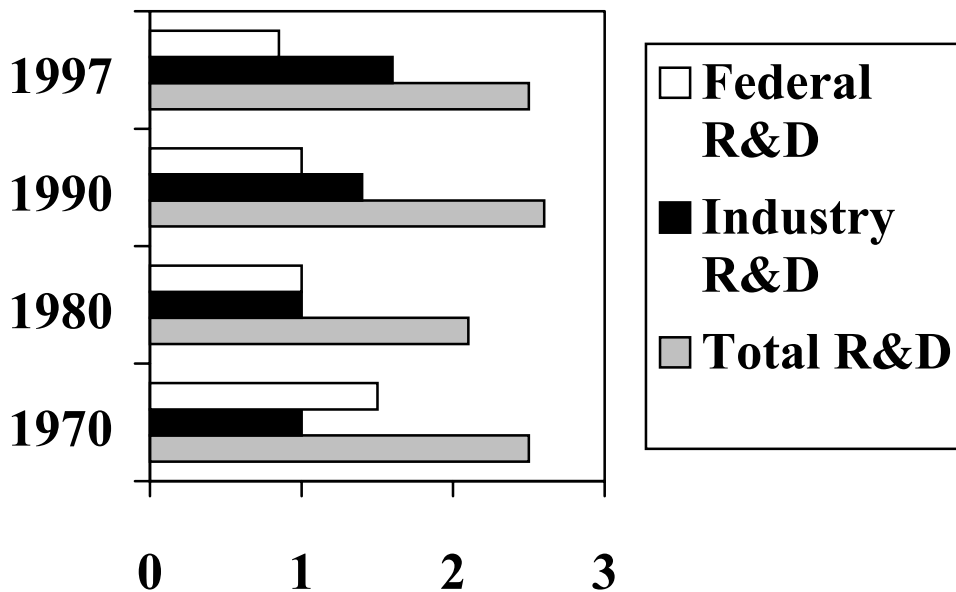


Figure 2. U.S. research and development funding as a percentage of the gross domestic product, by source.

MAKING RESEARCH PART OF THE PUBLIC AGENDA:

AN ENGAGED UNIVERSITY

Brady J. Deaton
Provost
University of Missouri - Columbia

Building a public agenda for the university must begin with undergraduate students. This is true for research as well as teaching and outreach. To invigorate the general education of undergraduates, the University of Missouri has pioneered the integration of teaching and research. The Hesburg Award received by the University in 1997 called particular attention to this strength.

A great deal of the literature regarding student affairs and undergraduate education continues to express concern about the quality of undergraduate education offered at the major research universities. For example, a 1993 report of the Wingspread Group sponsored by the Johnson Foundation focused on the quality of undergraduate education, but its general warning is also applicable to the research role of public universities. The following warnings emanated from the conference:

- A disturbing and dangerous mismatch exists between what American society needs of higher education and what it is receiving.
- The American imperative for the 21st century is that society must hold higher education to much higher expectations or risk national decline.

In most of our states, our higher education coordinating bodies are promoting the concept of a “seamless web of public education.” In doing so, the research role of our major public research universities becomes a singular responsibility of the institutions represented at this conference. In order to be successful, research must be made part of the public agenda. This can be achieved most effectively when we:

1. See research as part of an integrated educational whole. It begins with undergraduate students and, indeed, must incorporate K-12

linkages between the university and primary and secondary education.

2. Develop a culture of openness, sharing, listening, and willingness to be convinced by legislators, public agencies, and interest groups. That culture of openness must be maintained between and among campus administrators and research scientists, among scientists themselves, and with the public. The importance of sharing data on the university with key stakeholders, particularly legislators, cannot be over emphasized.
3. Create a sense of importance and urgency in individual researchers and research teams. It is more fun to be on the cutting edge, to share problems with sympathetic colleagues, and to produce quality results. We must celebrate the successes on our campuses and with each other. Scientists must be encouraged to search for the competitive edge, for that frontier of knowledge that is ultimately the greatest reward for researchers. This can be illustrated in so many ways. For example, our Dean of Arts and Sciences, at the major awards banquet for that college on our campus, cited the scientific accomplishments of Dr. Jerry Atwood, the Chair of our Chemistry Department, who has recently created the smallest molecule yet known. This organic molecule has an empty space within it with potential applications for medicine, organic wiring for information technology, and unlimited implications in a vivid imagination. Dean Schwartz called attention to this significant accomplishment, which had already been featured on the cover of *Science Magazine*; and pointed out its implications for targeted medical treatments, biological information systems, etc. He then unveiled a rendition of this molecule painted by a local artist. This was displayed before a crowd of over 500 people and illustrated a true celebration of knowledge.

As we seek to make research part of the public agenda, it may be useful to recognize that we are now into a third generation approach for building research systems on most of our campuses. Within this context, the first generation consisted of hiring good scientists, the best scholars, and providing them with the best support and facilities possible, including a “creative” work setting, leaving them alone, and watching them prosper. We found that, indeed, this formula led to the prospering of many scientists, but with less benefit to society than expected.

A second generation approach incorporated a more systematic quantification of the relative costs of individual projects, monitoring progress against specified objectives, particularly in the private sector. We found that each project may have great merit under this scenario but

the collective effort wasn't always that attractive. Perhaps the most important shortcoming of this kind of research was in the field of agriculture and natural resources wherein production-oriented research failed to capture the social and environmental externalities associated with agricultural practices. This has become particularly important today with our national and global concern about water quality and other environmental challenges.

A third generation approach characterizes much of what we are doing, or seeking to promote, at the University of Missouri and, I suspect, in many other universities. A major goal is to design a purposeful and strategic web of interlocking research activities, focusing on interdisciplinary and multidisciplinary approaches to key scientific issues. Our challenge is to design a process, which itself is exciting, and leads to innovative and invigorating research findings.

This third generation research model challenges traditional approaches and requires constant monitoring and adjustments to achieve scientific breakthroughs. The ancient Greek philosopher, Heraclitus, said, "You cannot step twice into the same river; for fresh waters are ever flowing in upon you." Higher education and research incorporates processes of continual change. Our processes for faculty development must keep up with these changes and promote intellectual growth and creativity as well as instill new technical skills in our researchers.

Burton Clark identified five critical characteristics of an innovative university poised to address the challenges of the 21st century. These characteristics include the following:

- An institutional sense of direction
- Entrepreneurship
- Reconciliation of administrative and professional values
- The integration of research, teaching, and extension/outreach
- Diversified institutional funding

As universities become more innovative, a number of assumptions and "sacred precepts" of the academy will be called into question. Among these are the following:

1. A changing concept of tenure and increasing diversity of types of appointments. Only 45% of faculty at the Harvard Business School are in tenure or tenure-track positions. A full 30% of the faculty on the University of Missouri campus are in non-regular (i.e. non-tenure track) positions. Public accountability and public perceptions continue to challenge the basic structure of higher education and require reassessment of faculty responsibilities. The question

arises as to whether this will impede the quality of our faculty and the role of doctoral faculty on our campuses.

Management processes in higher education become more complex as the rights and responsibilities among regular and non-regular faculty are not shared evenly. Jealousies arise about preferential access to resources, and the overhead burden of committees and governance tend to be more concentrated on regular tenure-track faculty.

2. The use of internal versus external resources becomes more complex. Internal seed capital is often used to leverage outside funding. We are now initiating a comprehensive campaign to generate additional private funds to supplement public funds, grants and contracts, and other sources of funding. We are undertaking a strategic planning process to ensure that we develop an optimal mix of resources to achieve our mission.
3. We must be able to encourage appropriate partnerships and linkages with the private sector. Industry links must be consistent with university values and mission
4. Intellectual property rights are being addressed once again, and conflicts will continue to emerge under the complex relationships currently being developed in most research universities.
5. Continuing challenges arise over the control of indirect cost returns. Major public research universities have the responsibility to be accountable to the public to show that we care about the public trust and that we are responsive to the needs of the state and federal supporters of our research role.

As research becomes increasingly important on the public agenda, the University's responsibilities will grow to ensure that the needs of the public are met. University administrators and researchers will also face public scrutiny to ensure that our responsibilities to society are effectively carried out. We all should welcome that challenge, and grow stronger as we respond.

References

Clark, Burton R. (1996). Case Studies of Innovative Universities: A Progress Report. *Tertiary Education and Management*, 2, 52-61.

Gappa, Judith M. (1996). *Off the Tenure Track: Six Models for Full-Time Nontenurable Appointments*. Inquiry #10 Working Paper Series, Forum on Faculty Roles & Rewards. American Association for Higher Education. Washington, D.C.

Wingspread Group on Higher Education (1993). *An American Imperative: Higher Expectations for Higher Education*. The Johnson Foundation, Inc.

PUBLIC PERCEPTION:
SEEING OURSELVES AS OTHERS SEE US

Marsha R. Torr
Vice Chancellor for Research
University of Nebraska - Lincoln

The theme for this meeting is certainly most timely and I am pleased to participate in such a discussion with universities that have so many issues in common with us in Nebraska.

Universities and scientists have struggled for some time with how we might do a better job of informing the public about the worth of public research universities and the central role of research. We continue to do this less well than we would like and we continue to be surprised—and even amazed—by the interpretations of what we do and how we do it.

At the University of Nebraska - Lincoln we have recently taken a step toward improved public relations by forming what we call our Institutional Marketing Team. Its purpose is to help shape a more coordinated image. This effort links our administration, public relations people, deans, and alumni association. To our key audiences we convey messages that go beyond Husker football and distill the importance of our academic and research mission. Of course the extent to which this is successful depends on the message and how we present it.

One of the greatest difficulties in life is to get a glimpse of how others see us. It is difficult for individuals to step back and try to look at themselves, and it is even more difficult for institutions to do this—particularly institutions that have a public mission and public sources of support.

The public perception of the value and role of a public university may be rather different from the view that we within the institution have of our purpose—hopefully with large areas of overlap. However, we see ourselves as being so much more than we are given credit for and we often end up feeling under-appreciated and misunderstood.

What does the public expect of its research universities? The education of its citizens tops the list. However, we must consider several issues in this respect. There is not always an appreciation of competition universities experience. Students today have many options, are very mobile, and will vote with their feet. There is not always an appreciation of

the competitive nature of the job market—which is driving students in their choice of institution. Universities see themselves as magnets for talent and improving the quality of that talent is always a goal, yet there can be a backlash against our search for the "brightest and best." Availability is often seen by the public as more important than quality. So what is good enough? And we know that quality requires resources far beyond those the states are providing

So, there is not a good appreciation of what we do, how it benefits the state, or why it costs what it costs. This is particularly true for those of us who are in land grant institutions where there is a historic sense of ownership in the institution by the agricultural interests. We find ourselves in institutions that have gone through significant changes in our funding base. In many cases it is only a few decades ago that our institutions received 60-80% of our resources from the state. At the University of Nebraska - Lincoln this is now down to 31% and is still high by comparison with many public research universities for which the average may be in the mid-20%. Yet a large portion of our public has no understanding of the fact that we must now turn to other sources of revenue to put in place the laboratories and research fellowships and computing infrastructure and faculty and libraries that we must have to meet the basic needs of the state in education. Our own faculty in many cases do not understand this, so we have certainly failed to explain our fiscal needs and sources outside the institution. We must explain to the public that sponsored research allows us to enhance the quality of the institution.

Another important public expectation is that the university should be a source of expert, unbiased assessment of issues. Of course we arrive at this level of competence through the same means by which we build the faculty and research resources that establish the caliber of the learning at an institution. And so credibility and objectivity are amongst the institution's most important assets. Once credibility and objectivity are lost, the image of the research university is badly damaged. Independent, valuable opinion does not come easily or cheaply. We have not explained this well.

A third expectation is that the research universities will enhance economic development in the region—a factor that is very true but often oversold or sold on the wrong elements. In our enthusiasm to promote ourselves as "economic engines" we risk making bad deals that verge on using tuition funds to underwrite corporate welfare or that place our objectivity at risk.

Some years ago I was with NASA and worked with the leadership team of a shuttle mission. Because one of the payload specialists was a Belgian, after the mission concluded the astronauts, the mission manager

and I were invited to Belgium to have lunch with the King and Queen. At lunch we were discussing the falling fortunes of NASA and its difficulty in holding the interest of the public even though it was doing very challenging and innovative things. The public had tired of NASA and took it for granted. Whereupon the King said, "Well Coca Cola would know how to solve this—they would bring in a good advertising company." We are somewhat in that situation. Much of what we do is very good—indeed remarkable—and interesting, but **how do we keep it fresh and interesting to our supporters?** This is the challenge.

The public does get interested in what we do—but often in ways we do not like. There are issues in which the public university plays a central role that can take on a life of their own and actually spin out of control. We see this in research areas such as genetically modified foods (GMOs), fetal tissue research, and evolution. Public response to GMOs has taken turns that were not anticipated a few years ago. Yet, with our unbiased credibility as our currency, I hear my own faculty and administrators saying things like: "We just have to do a better job in explaining why GMOs are OK." Why do we have to do a better job in explaining this—who are we representing? Do we really have the answers yet? Is there an answer? It seems to me we could be framing the discussions without being forced into an advocacy position.

Right now there is so much at play in the public arena that we are unconsciously staging a backdrop that will inform public opinion in many areas. We are well beyond the few anecdotes and into a broad spectrum of publicity that if not understood and managed, will set the public agenda for us. And research is right at the center.

In seeking to inform the public about what we do, we need to assess and understand our audience. I recommend a book that recently came out called *Sleeping with Extra-Terrestrials: The Rise of Irrationalism*. The author ponders the fact that the achievements of research in the past few decades have been staggering and everyone has been impacted. Yet while books by Gould, Sagan and others do not make it onto the best-seller lists, pseudo-science does; Deepak Chopra's *The Quantum Alternative to Growing Old* and anything on alien abductions sell well. One may suggest that in talking about what we do, we should use strange and wonderful terms. Consider the possibilities just in my own field—Physics—where we are in a world of space warps, worm holes, strings and superstrings, and things have names like Truth, Beauty, Charm and Strangeness. Perhaps we have led people to believe that anything strange can happen. The author concludes that we have allowed others to usurp (or hijack) our language and, unhindered by our constraints, they use it to develop logic-free concepts that intrigue the general public. A person described as a "postmodern theologian" explains how angels are

like photons and move at the speed of light. Otherwise intelligent people are buying these books. Academics have the "real thing" and stammer about it.

We do not really understand our audiences or how to talk to them. Can we learn from issues that excite people?

And we are at some risk of sending the wrong message. Two pillars of the university—on the one hand the drive for quality (and hence the pursuit of dollars to build that quality) and, on the other hand the university's role as the state's/nation's unbiased source of assessment—are at risk of being on a collision course. Hence the public's willingness to support and sustain the universities may falter. At that collision point is the research enterprise.

There are many issues that must at the very least be confusing to the public. And these developments are enabled by very rapidly changing technologies—the outcomes of which will be on us before we have had much chance to map the trends. We see examples of this in the GMO debate, in concerns about ethical aspects of biological research, and in the fears expressed by people like Bill Joy who speaks to the potential for uncontrolled destruction latent in new technologies about 20 years away.

But there are simpler matters, such as the appearance of universities making substantial money from public investment—as in drug development—and then private corporations making even bigger money by selling products that only some can afford, many of which were developed in our public institutions with public funds and intended for the public good. These circumstances cultivate perceptions that are not understood. Another relevant issue involves the ownership and sale of data sets vs. immediate, universal availability of information—and with universal access, the potential for massive public good and harm.

We must ask ourselves: Are our institutions at risk of losing the high ground? We have traditionally presented unbiased, in-depth assessments of complex issues. However, we now experience tremendous pressure to find dollars that will build quality, cutting-edge programs, coupled with a tremendous drive to enter and explore and manipulate the unknown. How do we find ways to cover the costs of objectivity? Of course, we are entering the unknown at such speed that there is little time to assess the landscape ahead. Once the public confidence is shaken, it takes decades to reclaim what has taken a century to build. Is our moral authority at risk?

On the other hand, who else can provide guidance through this new landscape? We must do it to the best of our abilities. And our ability to do it will depend on how well we tackle the topic of this meeting.

THE EPSCoR CHALLENGE:
PARTNERSHIPS IN RESEARCH

Thomas N. Taylor

Roy A. Roberts Distinguished Professor of Botany
University of Kansas
Director of Kansas NSF EPSCoR

As many of you know, Ted Kuwana has served as the Project Director of Kansas NSF EPSCoR since its inception in 1992. After a short stint as Associate Director, I became Project Director in February of this year. Much of what I'll talk about today has been accomplished on Ted's watch, but I am pleased to offer a summary of where we are, and perhaps a few reflections of where Kansas NSF EPSCoR is headed and what lies ahead.

EPSCoR, the Experimental Program to Stimulate Competitive Research, is based on the premise that universities and their science and engineering faculty and students are valuable resources that can potentially influence a state's development in the twenty-first century much the same way that agricultural, industrial, and natural resources did in the twentieth century. EPSCoR's goal, therefore, is to identify, develop, and utilize a state's academic science and technology resources in a way that will support wealth creation and a more productive, fulfilling way of life for a state's citizenry. Begun in 1978 by the National Science Foundation (NSF), EPSCoR helps scientists in traditionally rural states to build a better research program and become more competitive in science and technology. The NSF EPSCoR Office actively cooperates with state leaders in government, higher education, and business to establish productive, long-term partnerships. In each EPSCoR state, the NSF's role is to stimulate local action that will result in lasting improvements to the state's academic research infrastructure and increased national R&D competitiveness. EPSCoR increases the R&D competitiveness of an eligible state through the development and utilization of the science and technology (S&T) resources residing in its major research universities. EPSCoR achieves its objective by:

1. stimulating sustainable S&T infrastructure improvements at the state and institutional levels that significantly increase the ability of EPSCoR researchers to compete for federal and private sector R&D funding; and

2. accelerating the movement of EPSCoR researchers and institutions into the mainstream of federal and private sector R&D support.

How Did Kansas Become an EPSCoR State?

In 1991, Kansas was invited to join EPSCoR. An alliance of Kansas business people, government officials, and university faculty wrote a proposal to create an NSF EPSCoR program in Kansas. The proposed program would link faculty members at the University of Kansas, Kansas State University, and Wichita State University in cooperative projects; share major equipment resources; fund junior faculty to increase competitiveness for federal grants earlier in their careers; and stimulate formation of research partnerships among the university, state and the private sectors. After merit review of this proposal, NSF awarded Kansas a Phase I Infrastructure Program for 1992-1995. Since then, Kansas has received two additional infrastructure awards: Phase II from 1995-1999, and Phase III from 1999-2002.

Why Is Kansas an EPSCoR State?

EPSCoR is restricted to those states that have historically received lesser amounts of Federal R&D funding and have demonstrated a commitment to develop their research bases and to improve the quality of science and engineering research conducted at their universities and colleges. In 1989, Kansas ranked 33rd among the states receiving federal R&D support. Kansas received less than one-half of one percent of all federal research dollars awarded to colleges and universities. In 1991, Kansas received \$20 per capita in Federal R&D dollars while the national average was \$38 per capita. In 1996, on a per capita basis Kansas received \$31 while the U.S. average was \$46. Another way of expressing this is that nearly \$40 million in federal taxes for R&D was lost, sent to states on the East and West Coast corridors. So as to dispel any illusion that there is a coastal influence, our neighbor Colorado has federal obligations of \$75 per capita, or nearly \$280 million compared to our \$80 million! Although accurate per capita data are not available for all states, in 1997 the total federal R&D obligations (and that includes obviously more than the National Science Foundation) for the period 1991–1996 changed in Kansas from \$20 to \$31 per capita. The national average for the same time period changed from \$36 to \$46 per capita. Regardless of the math used, at this rate it will take us a long, long time to get to a sufficient level in R&D dollars. The key is obviously research proposals that are highly meritorious and funded, since individual research proposals are the bedrock of research programs.

How Has EPSCoR Helped Kansas?

Since entering the NSF EPSCoR program in 1992, Kansas EPSCoR has grown to include programs from: the Department of Defense, the Department of Energy, the Environmental Protection Agency, the National Aeronautic and Space Administration, and the National Institutes of Health. The Kansas NSF EPSCoR program has effectively changed the research paradigm by fostering inter-institutional, inter-state, and regional research projects. For example, a project headed up by Rob Denell at Kansas State University (KSU) used various model systems to increase knowledge about human development and disease, processes by which cells transmit signals regulating growth and development, mechanisms that regulate cell death during normal development, and the manner in which this mechanism is regulated by viruses during infection. This program resulted in the yearly Sunflower Developmental Genetics Symposium, which includes invited speakers chosen for their potential to interact with and mentor Core Members of the project. In addition to increasing research competitiveness and collaboration, Core Members' laboratories helped train 88 undergraduate students, 37 graduate students, and 15 postdoctoral scholars. The 14 faculty members on this project published 60 papers in 23 peer-reviewed journals or as book chapters, and generated more than \$6 million in extramural funding with grants from NSF, NIH, the March of Dimes, the American Cancer Society, the Muscular Dystrophy Association, and the Council for Tobacco Research. Thus, NSF EPSCoR helped generate more than \$25 million in new funding.

Another example is the project headed by Dr. Chu that partnered the University of Kansas (KU), KSU, and Wichita State University (WSU) to form the Kansas Center for Advanced Scientific Computing (KCASC). KCASC is a statewide interdisciplinary research infrastructure with three objectives: 1) to establish a mid-range multiprocessor supercomputing system for supporting advanced computational research in the sciences and engineering; 2) to foster advanced computational technology in interdisciplinary research by supporting interdisciplinary activities; and 3) to enhance the computational technology in Kansas to nationally and internationally competitive levels. In August 1999, NSF awarded \$593,435 to KCASC, which it combined with \$300,000 from KU to install 64 SGI Origin2400 processors with 16 GB memory and 200 GB disks. The need among KCASC researchers to access additional supercomputing resources helped stimulate development of the Great Plains Network, a regional high-bandwidth network linking six EPSCoR states with the national grid. Faculty associated with KCASC have received more than \$5.1 million in funding for their research.

Still another project, headed by Bob Zeigler at KSU, is the Great Plains Cereal Biotechnology Consortium, consisting of the Land Grant universities of Kansas, Nebraska, and Oklahoma. The Great Plains states produce a major portion of the world's cereals. Thus, global food security as well as the regional economy depends to a significant extent on the sustainability and economic viability of cereal grains production—primarily wheat, maize, and sorghum. Each university has specific and complementary strengths in the different cereals, and each has invested substantially in establishing plant biotechnology capacity. Consortium members will invest in their existing areas of strength. This will avoid duplicating thin coverage at each university and will create complementary foci of excellence in cereals biotechnology in the region.

A research program that has united the faculty across the campuses of KSU, KU and WSU involves the area of complex fluid flows. The three campuses will be joined by an active Internet link. The proposed research meets critical needs in materials processing, aviation, environmental air quality, and the chemical process industry. These areas are bound together by the common physics underlying all complex fluid flows and the need for an interdisciplinary effort to fully understand the ramifications. The program will be guided by an advisory committee of industrial and governmental scientists and administrators. The next time you are sitting out on the runway on an airplane with stale air, waiting to take off, you will have some appreciation for the research being done on complex fluid flows. Some of the cutting edge research involving air circulation through aircraft is an outcome of this program.

Another area where NSF EPSCoR has greatly helped to stimulate research is in the development of human infrastructure. Kansas NSF EPSCoR Faculty Start-Up initiatives are helping to fund seven new positions. At KU, the Department of Chemistry is recruiting a senior distinguished Professor and a junior faculty member in bioanalytical mass spectrometry. The Department of Physics and Astronomy, in an effort to rebuild its condensed matter physics program, has hired a new faculty member who will complement existing expertise in superconducting electroceramics. At WSU, the Department of Mathematics and the National Institute for Aviation Research have jointly hired a junior faculty member with expertise in numerical analysis and scientific computing, and the Department of Chemistry has hired a mass spectrometrist. KSU has recruited two junior faculty members, one in molecular plant biology and one whose expertise is in fungal biology, and one senior person in plant taxonomy and systematics.

Kansas NSF EPSCoR has also participated in the acquisition of a high performance computer at WSU that will make it possible for the faculty to perform leading edge research and write nationally competitive

research proposals. Wichita has a significant concentration of aircraft manufacturers (Boeing, Cessna, Raytheon, and Learjet) that are increasingly employing advanced computational programs. With the addition of a high performance computer, WSU will be able to assist these and other businesses and industries in solving complex problems and providing a trained work force. At the recent statewide EPSCoR conference held in Manhattan, Dr. Alexander, who headed up this equipment purchase, indicated that the time on this computer is saturated, further attesting to its multi-dimensional value. Kansas NSF EPSCoR also assisted in the purchase of a mass spectrometer for the Chemistry Department at KU for protein microcharacterization.

Another Kansas NSF EPSCoR initiative that has been a very special success is the First Award program. Newly hired faculty are asked to submit a research proposal to Kansas NSF EPSCoR in parallel with a proposal submitted to a program in the National Science Foundation. The EPSCoR proposals are competitively reviewed much like the *ad hoc* review program employed by the National Science Foundation. Our EPSCoR program provides rather quick turnaround time for proposals up to \$40,000 for a single year; the intent is to jumpstart new investigators so as to make their programs immediately competitive. These funds are often earmarked for undergraduate assistance, graduate students, and postdoctoral fellows in order to increase data acquisition, which is such an important part of NSF proposals today.

The First Award program in Kansas has provided approximately \$1.6 million to 44 faculty. These 44 faculty have generated an impressive \$21.2 million in external awards, with another \$20 million pending at this time. This past October, ten additional First Awards were provided to investigators at KU, KSU, and WSU. Average EPSCoR awards are approximately \$40,000; and in the competition for First Awards that will take place this fall, those funds will be elevated to \$50,000 dollars.

Kansas NSF EPSCoR has supported several special initiatives. One project involved the powerful Access Grid, which is changing the face of research, collaboration, and education. August 1-3 the University of Kansas hosted the Alliance Chautauqua Conference 2000, which showcased the Alliance Access Grid, including its ability to link powerful computers into a virtual machine room and to bring people together into virtual workspaces. Kansas NSF EPSCoR co-sponsored this three-day event together with the National Computational Science Alliance and KU. This program not only highlighted emerging new grid technologies and access grid visualization, but also focused on bioinformatics, computational materials science, Internet 2, chemical engineering applications, and real-time storm prediction and severe weather modeling.

The Science Workshop for Minority High School Students is another project that combined the strength of several EPSCoR programs. Co-sponsors were the Nebraska, Oklahoma, and South Dakota EPSCoR programs and the Brown Foundation. The purpose of the workshop was to encourage high school minority students to pursue careers in science, mathematics, engineering and technology, and to learn about educational opportunities at the state universities in the region. More than 150 high school students attended science lessons on DNA fingerprinting, the physiology of fitness, the analysis of particulates, laser ICP probing of rocks, tornado hazards, and physics and astronomy while their teachers discussed issues of common interest. Students enjoyed a college fair with information about universities in the region, a tour of the University of Kansas Natural History Museum and Biodiversity Research Center, and entertainment by the New Dawn Native American Dancers.

Kansas NSF EPSCoR has also sponsored strategic planning workshops. The value of strategic planning was underscored when Dr. Joe Heppert and colleagues were awarded a Hewlett Grant for \$240,000 and an NSF DUE award of \$2.4 million for K-12 teacher training in the sciences. Heppert was funded under a Phase II Planning Grant to engage statewide stakeholders to plan and develop these proposals. Kansas EPSCoR in turn contracted the Institute for Public Policy and Business Research (IPPBR) at KU to conduct strategic planning workshops. Of the three NSF EPSCoR grant proposals submitted in February 1999, two selected for funding had enlisted IPPBR for assistance.

Kansas NSF EPSCoR has paid for faculty travel to funding agencies. The program has arranged air transportation for five faculty to attend the February 9, 1999, Oklahoma NSF EPSCoR Regional Workshop in Materials Science. In addition, the program has fostered industry-university research partnerships. One high-profile industry/university partnership is the information technology program at KU that was initially funded by EPSCoR, later partnered with SPRINT and now has several industrial components. The program now generates several million dollars a year. The program has provided editing assistance to faculty writing proposals, and it has funded large infrastructure-building research projects.

Despite the impressive successes enjoyed by Kansas researchers and the NSF EPSCoR program, there is still much to be accomplished. We continue to experience barriers to research in EPSCoR states. These include: 1) faculty recruitment, development, and especially retention; 2) graduate student quality and quantity; 3) R&D infrastructure and institutional change; 4) recognition and reputation; 5) technology transfer; and 6) state support for higher education and S&T development.

Because success in research, at least within the sphere of university programs, requires well-trained researchers that are capable of writing successful fundable grants, faculty retention in EPSCoR states is of critical concern. The Kansas First Award program, for example, provides faculty with an early competitive edge in competitions for regular NSF grants. These early-career faculty now can be easily lured to more established universities that possess the infrastructure and lack research barriers. As a department chair, I can relate a scenario that is taking place as I speak. I have a faculty member who has two offers in hand, one from the University of Rochester, the other from Penn State University. We will need to provide a \$90,000 piece of equipment as just one of several items necessary to retain this bright and highly motivated scholar, who in the years to come will greatly contribute to the research mission in the state of Kansas—if we are able to retain him.

Finally, next year at this time we will be preparing the Phase IV grant proposal to the National Science Foundation EPSCoR program. This new round of grants will be up to \$3 million per year and will require a \$1.5 million per year match by the state. I am hopeful that our program will be successful, and that the potential \$13.5 million that will flow through the EPSCoR program to Kansas researchers will further enable us to increase our R&D competitiveness and to continue to enhance the partnership between universities, the private sector, and the state's citizenry.

In summary, Kansas NSF EPSCoR has: changed the research paradigm by fostering inter-institutional, inter-state, and regional research projects; assisted in the development of human infrastructure; funded multi-user equipment; provided start-up funds to faculty early in their careers (FIRST Awards); supported special initiatives; sponsored strategic planning workshops; funded faculty travel to funding agencies; fostered industry-university research partnerships; provided editing assistance to faculty writing proposals; and funded large infrastructure-building research projects. With the continued partnership that has been developed and nurtured among the state, universities, and federal government, EPSCoR in Kansas is making a significant imprint on the overall research enterprise of the state.

Table 1. Funds Awarded to Kansas NSF EPSCoR
1992-1999
in Millions of Dollars

Date	Program	NSF Funds	KTEC Funds	Other Funds	Total Funds
1992-1995	Phase 1	4.48	4.5	~2.0	10.98
1995-1999	Phase 2	5.25	5.06	~2.0	12.31
1999-2002	Phase 3	3.00	2.25	3.52	8.77
1994-2001	EPSCoR Grants (7)	4.455	1.437	1.085	7.077
1998-1999	Co-Funded Proposals (12)	5.32			5.32
TOTAL		22.505	13.247	8.605	44.357

STATE POLICY AND UNIVERSITY RESEARCH:

A PANEL DISCUSSION

William R. Docking
Chair, Kansas Board of Regents

Thank you for the opportunity to meet with you today. This is a particularly important occasion for me because I believe our future will be largely determined by our collective research success. That puts our future in the hands of those of you at our research universities. There is no more important job than yours.

I have been asked to comment on the relationship between state policy and university research, especially from the perspective of the Board of Regents. To begin, I should offer a bit of context on the Kansas Board of Regents for those of you from our neighboring states. The Board is comprised of 9 members who are appointed by the Governor within parameters that tend to minimize political and geographic divisions. The Regents serve as the governing board for the state's six public universities—The University of Kansas, Kansas State University, Wichita State University, Pittsburg State University, Emporia State University and Fort Hays State University. As of July 1 of last year, the Board is also responsible for supervising and coordinating the state's 19 community colleges, 11 technical schools and a municipal university. In addition, the Board administers Kansas' state financial aid programs, Adult Basic Education program, and GED testing program.

I have been very public in my belief that university governance continues to be our central and most important role. That said, however, you can see from this list of responsibilities that there are many issues competing for the time and attention of the Board. Moreover, only three of the state universities (KU, K-State, and WSU) are designated as doctoral degree-granting, research institutions. Thus, the time and energy available to devote to research is necessarily limited.

Over its 75 years of existence, the Board has developed a fairly decentralized governance model, relying on institutional leadership to operate the universities in the most efficient and effective manner within the policies set by the Board. By its very nature, research is a "local" activity that does not easily lend itself to specific direction by the Board. Where many people would expect the Regents to offer specific guidance on the articulation of general education courses among the 37 public institutions in Kansas to ensure easy transfer between schools; few, if any,

would see us playing a similar role in specifying the nature and format of individual research projects across institutions.

If research is one of our most important activities, but we agree that it is largely a "local" issue, then what role should the Board of Regents play in the process? I would offer the following three broad responsibilities:

1. Determine institutional direction
2. Provide institutional support
3. Stay out of the way

Determine institutional direction. As stewards of the public trust, the Board is responsible for ensuring that the state's research efforts are effectively focused to meet the needs of the state. In large measure, this is accomplished through determination of institutional missions. In Kansas, for example, the University of Kansas has primary responsibility for medical education and research and Kansas State University has responsibility for agriculture and food science. Much is made about unnecessary duplication in public higher education and Kansas is no exception. By clearly defining missions, the Board works to minimize unnecessary duplication. Missions are reflected both in the programs offered at a university and the focus of those programs. For example, we are fortunate in Kansas to have three engineering schools, one at each of the three research universities. Over the years, however, the Board and the institutions' leaders have worked to ensure that those schools complement each other. As a result, the University of Kansas is known for digital communications, Wichita State University for aeronautics and Kansas State University for agricultural engineering. Compliance with university mission is monitored in many ways, with one of the more important being the approval of new academic programs. The Board has a rigorous program approval process, but it is most rigorous for doctoral programs. So, for example, the University of Kansas would likely have great difficulty receiving approval for a new degree in grain science and especially a doctoral degree. Given the Board's role in determining budgets, we also have considerable influence over legislative funding requests for new research centers and initiatives.

In addition to formal means for monitoring compliance with institutional mission, there are many informal mechanisms. In most cases, Board members are fully aware of any major campus initiatives well before they become reality. This is because no university president wants to surprise his or her Board with some bold, but unacceptable, idea and, in many cases, the president needs to enlist the support of Board members to ensure the success of the project.

Provide institutional support. The second broad responsibility that the Board of Regents has with respect to research is to ensure that campuses and their scientists have the resources necessary to be successful. Much of that support, of course, comes in the form of the basic state support provided to the universities. Perhaps as importantly, however, is the nature of policies the Board provides for utilizing those funds. The policy that comes to mind first in this regard is our insistence, for many years, that faculty salary increases be distributed based on merit, rather than equally distributed across the board to all faculty.

In addition to its base support, the Board can also play a role in providing more focused research support. A prime example is the Partnership for Faculty of Distinction Program enacted this year by the state legislature. This program uses state matching funds to encourage the creation of endowed professorships by private donors. While a case could be made for similar matching programs in other areas (e.g. scholarships), investing in world-class faculty holds the greatest promise for enhancing the quality of our institutions and advancing our research agendas. The Regents supported this measure, quite frankly, because Kansas is not keeping up with the competition. Many other states, including our neighboring states Missouri and Oklahoma, have long had in place programs to leverage private resources and the results have stimulated private giving and the creation of endowed and distinguished chairs.

Another program of pride for Kansans is the Kansas Technology Enterprise Corporation, or KTEC. KTEC is a quasi-public corporation established by the state of Kansas to promote advanced technology economic development. KTEC supports basic research through a variety of programs including five KTEC Centers of Excellence located at state universities:

- Advanced Manufacturing Institute at Kansas State University
- Center for Design, Development and Production at Pittsburg State University
- Higuchi Biosciences Center at the University of Kansas
- Information and Telecommunication Technology Center at the University of Kansas
- National Institute for Aviation Research at Wichita State University

The five Centers conduct innovative research and provide technical assistance with the overlapping aims of creating new companies,

strengthening existing companies and serving as expert resources to the communities and the state at-large. Viewed as part of a research and commercialization continuum, the Centers are investments in the early stages of the research pipeline and act as more immediate consultants and developers for modernizing manufacturing processes. Viewed from the perspective of the Board of Regents, these Centers are an excellent means of assisting the state of Kansas while enhancing the missions of our institutions.

From these two examples (Program for Faculty of Distinction and KTEC), it is clear that the role of the Board of Regents in enhancing research often takes the form of partnering with the legislature and the business community. In particular, I want to point out the key role of the legislature and the leadership of Representative Ralph Tanner, Chair of the House Education Committee and an important advocate for education and research, in creating the Partnership for Faculty of Distinction Program.

Stay out of the way. The third role for the Board of Regents in the research process is setting broad system-wide policies and staying away from the specific work of the academics. The very nature of the research enterprise demands freedom to experiment in the fullest sense of the word. Our faculty and scientists should, and do, have the freedom to explore and research without concern that the Board of Regents will attempt to steer or shape the direction of their efforts. As public servants, we recognize that science should be relevant to the needs of society as it enters the 21st century. Our role in making that a reality is to provide an environment where the right **types** of research for our state can be undertaken, and then we must have confidence in those responsible for research, like many of you, who will find the specific answers needed to improve our future.

This is not an easy role to play, for the Board sits at the interface of two distinctly different timeframes. The public's timeframe demands a speedy solution to very real societal problems, while the scientific timeframe differs in that ideas are conceived decades or even centuries before their products become reality. As a result, the Board must act as both an advocate and cheerleader when dealing with research.

In closing, I want to emphasize that the Kansas Board of Regents is committed to the primary role that research plays at our universities and will continue to advocate for its support.

STATE POLICY AND UNIVERSITY RESEARCH:

A PANEL DISCUSSION

Kim A. Wilcox
Executive Director
Kansas Board of Regents

During the past two days, we have heard about several state and federal programs that are designed to support university research. These programs reflect the fact that research and discovery have fundamental importance to society and that it is in our collective interest to support these activities. At the same time, the specific forms of these programs reflect the reality of the give-and-take in the political process. They also reflect the financial limitations that any state faces when implementing policy or initiating new programs.

I believe that we have an opportunity to reaffirm the relationship between public policy development and research, and to rethink the potential breadth of that relationship. As a beginning point, we should recognize that the relationship between state policy and university research is bi-directional, in that:

- Research should inform public policy
- Policy decisions often direct/fund research

If research is truly in our collective best interest, then we should work to ensure that the outcomes of research result in changes in society. One of the most fundamental means for realizing social change is the legislative process, so it follows that there should be reasoned mechanisms in place for ensuring that scientific results yield legislative results. It is striking, in fact, how the term “results” is used differently by scientists and by legislators. On-campus, the question: “What were your results?” might produce a response such as: “A small, but significant effect for the experimental conditions; more importantly, however, we believe that the stimuli we produced for the second experiment have great potential as a general diagnostic measure.” Needless to say, the same question, “What were your results?” will yield a VERY different response on the floor of the House of Representatives. There, the primary measure of import is the creation of new laws, and more specifically new laws that reflect the priorities of specific legislators.

In Kansas, we have had some success in developing mechanisms for moving research into the public policy arena. Good examples include the Kansas Geological Survey, the Institute for Public Policy and Business Research at the University of Kansas, and the Agricultural Research and Extension programs at Kansas State University. On the other hand, Kansas Technology Enterprise Corporation (K-TEC) is an excellent example of legislative action directly affecting (and stimulating) research. One might ask why it is that with these, and similar programs in place, one of the primary and chronic complaints leveled at the academy is that we are out-of-touch and that our work is unrelated to the “real world.” While at the same time, legislators routinely face criticism for making decisions in an information vacuum. Why is it that these two natural allies (researchers and policy makers) haven’t taken better advantage of a partnership to correct these complementary criticisms? To begin the discussion, I would offer the following points for your consideration:

- There is a mismatch between areas of legislative interest and the visibility of the programs for informing decision-making.
- There is only a limited overlap in the organizational models of the academy and the legislature.
- Legislative, university, and research timelines are inherently different.
- There is an inherent tension between the “independence” of research and the “public” nature of policy decisions.

There is a mismatch between areas of legislative interest and the visibility of the programs for informing decision-making. In Kansas, and in many other states, the legislature is increasingly concerned with a small set of human service issues: providing social services to those most in need (SRS waiting lists), criminal justice (new Juvenile Justice Authority), health (Medicare/Medicaid, access to prescription drugs, tobacco abuse, uninsured children, abortion) and education (K-12 funding formula, higher education). Indeed, the current state budget devotes approximately 85% of its funds to education and human services, compared with 0.8% for agriculture and natural resources. Yet we have failed to bring together legislators and university scientists whose research involves human services, despite the successful collaborative model of the Geologic Survey and the Agricultural Extension. Similarly, K-TEC promotes research in four targeted areas that are important to the future economic vitality of the state, but there is no parallel unit targeting issues that dominate the legislative agenda. This state of affairs can be viewed as a mismatch, or simply an incomplete system, where our research results are not equally available to policy-makers across all topics and issues. We in

the academy should recognize the need to increase the visibility of existing programs across the **full range** of academic and societal topics. At the same time, the legislature should encourage the development of mechanisms to link scientists and their work with ongoing policy discussions.

There is only a limited overlap in the organizational models of academe and the legislature. Universities are organized by discipline and the organization is realized as departments, centers, colleges, etc. The legislature is organized by topic (e.g. education, agriculture, utilities, etc.) and by activity (e.g. appropriations, calendar) and this organization is realized as committees. Putting aside the differences in what is included within categories of the same name (e.g. education) in the two groups, there are many more disciplines in universities than there are topic-related committees in the legislature. Moreover, the natural scientific tendency to work in “interdisciplinary” fields risks exacerbating the mismatch between the two systems. Thus, to link policy and research, we must devise mechanisms that bridge existing structures in both domains.

Legislative, university, and research timelines are inherently different. If “Timing is everything!” then we face serious challenges if our goal is to enhance the linkage between research and policy development. Science is a long-term process that builds directly and systematically on previous efforts. Individual scholars accept that their work may take months or years to come to fruition. And while they realize that something might happen tomorrow that would cause them to drop what they’re doing and pursue some new idea or project, they expect to spend most of their lives focusing on similar topics and issues.

Institutions, in support of research, build administrative processes, physical plants, and infrastructure that are designed to serve the long-term purposes of the university. Institutional leaders invest in research clusters or departments with an acknowledged research strength and not in individual scientists and their agendas. A new electron microscope, for example, is purchased with the expectation that a group of scientists will use the instrument for various experiments (the details of which cannot even be predicted at the time of purchase) for several years into the future, and the investment is made with the belief that enough interest in related topics will persist to justify the purchase.

The legislature, by contrast, operates on a fixed calendar, which is determined *a priori* and separate from the nature of the topics to be discussed. In Kansas the timeline is no more than 90 days/year, regardless of the issues. As a result, all of the work and deliberations necessary for making any decision must fit within this time scale. Even ignoring the real constraints imposed on this process by the politics of the

body, this 90-day time limit creates a compelling need to “generate results” and inevitably leads to hurried decisions and/or legislative “game-playing” with deadline extensions. Similarly, the topics to be addressed by the legislature are only partially under the control of the body. Many issues are thrust upon them by events outside of their control. In addition, the composition of the membership itself is not stable, which enhances the volatility of the environment and the press for action.

The following table highlights the differences among these three partners in research and policy development.

	Personnel	Topics	Timeline
Researchers	stable	stable	volatile
Institutions	stable	stable	stable (long)
Legislature	volatile	volatile	stable (short)

There is an inherent tension between the “independence” of research and the “public” nature of policy decisions. To be effective, science must be independently driven and free from political pressure. Generating legislation is a political process. In our bi-directional relationship, any attempt by the legislature to direct research activity (even through mechanisms like K-TEC) runs the risk of sacrificing scientific independence. The primary means of minimizing the risk is to ensure that the relationship is crafted on the broadest terms, nominally by area of activity or broad research topic. As the focus narrows, the risk for inappropriate or unacceptable political influence increases markedly. While legislators must often make very focused decisions (especially regarding budget issues), they, like most citizens, are ultimately concerned with the long-term success of the state and its citizens. Fundamental research can certainly play an important role in informing short-term decisions that effect long-term goals.

In summary, I believe that we have not done a good job of making university experts and their research available to the legislature. That failure has been to the detriment of both groups. Serious consideration should be given to creating mechanisms that bridge this divide. While that process must include discussion among all parties, the universities should take the lead in this effort.

EVOLUTION OF THE KIDNEY RESEARCH PROGRAM AT THE UNIVERSITY OF KANSAS MEDICAL CENTER

Jared J. Grantham, M.D.
Distinguished Professor, Medical School
University of Kansas

Evolution is a “hot” topic in Kansas this year and there is no better place to see the impact of evolutionary pressures on organ development than in the kidneys. It seems appropriate, therefore, to consider kidney evolution in a related context, i.e. the emergence of a comprehensive program in renal research and patient care at the University of Kansas Medical Center.

In the beginning. In 1952, Paul R. Schloerb, M.D. became the first investigator to initiate studies on body fluid and electrolyte metabolism at the University of Kansas Medical Center (KUMC). His coming was the equivalent of the birth of the first living organisms in the ancient seas. Prior to this there was no identifiable renal research program at the University of Kansas although two unwitting contributions to the body of knowledge were made in the first half of the 20th century.

At the turn of the century Marshall Barber, a University of Kansas microbiologist, invented a glass micropipette and micromanipulator that he used to capture a single bacterium from a broth culture. He was the first to unequivocally prove Koch’s postulates underlying the germ theory by injecting a single anthrax bacillus into an animal and reproducing the disease. In the middle of the century Barber’s pipette found even wider application in the study of kidney tubule physiology by A.N. Richards in Philadelphia and a host of others. Today a minor refinement of Barber’s pipette is the major device used to transfer DNA from one cell into another, the cornerstone method for cloning experiments.

In 1939, Homer Smith, a renal physiologist from New York, delivered a series of lectures at the University of Kansas that later became the foundation of his popular book entitled “From Fish to Philosopher.” In this book he elucidated the extraordinary parallels between the evolution of the kidney from protovertebrates to man and the development of the kidney in the embryos of all mammals. Indeed, renal ontogeny recapitulates phylogeny. Smith advocated that the evolution of the kidney was the central development that permitted mammals to live on land rather than in the seas, a hypothesis that has been forcefully supported

through the years by experimental evidence. It is ironic, indeed, that vociferous debate on the role of evolution in the ascent of man has been rekindled in a state with an academic and fossil record used by scientists throughout the world in support of the theory of evolution.

Emergence of Renal Physiology and Nephrology at KUMC. In 1965 Lawrence Sullivan, Ph.D. arrived on the KUMC campus to begin the first modern studies of renal tubular function. He was joined one year later by Darrell Fanestil, M.D. who developed the first dialysis and transplantation program in the State. In 1969 Jared Grantham, M.D., Donald Tucker, M.D. and Dennis Diederich, M.D. were recruited to the Nephrology Division in the Department of Internal Medicine. In 1970 Dr. Fanestil left the university and Dr. Grantham became Director of the Division of Nephrology. In 1974 Billy Hudson, Ph.D. joined the Department of Biochemistry and instituted studies of the renal biomatrix.

Renal research discoveries at KUMC. The diversity of research in the early days led to further differentiation and advancement of the renal research program. In 1972 Dr. Grantham discovered that the renal tubules of mammalian kidneys secreted as well as reabsorbed solutes and water. This finding formed the basis of a series of experiments demonstrating that in patients with polycystic kidney disease, cysts were in fact gigantic, distended renal tubules that secreted fluid into an expanding cavity. In 1983 Doctors Diederich and Weigmann developed a novel method for anticoagulating the blood of patients undergoing hemodialysis. In 1985, Dr. Hudson isolated and determined the chemical composition of the alpha 3 and alpha 4 chains of Type IV collagen from the glomerulus of animal and human kidneys. These proteins were subsequently shown to be instrumental in the pathogenesis of two renal diseases, Goodpasture Disease and Alport Disease. Also in 1985, James Calvet, Ph.D. joined the renal research effort and discovered that polycystic kidneys aberrantly expressed growth regulating genes called proto-oncogenes, thereby placing polycystic kidney disease in the context of a neoplastic disorder. All of these discoveries served as important points of departure for the subsequent understanding of renal biology and disease.

National and international recognition of renal research at KUMC. By 1985 the annual NIH direct costs budget for investigator-initiated research exceeded \$1,000,000 and University of Kansas was recognized nationally as one of the leading renal research centers in the country.

In 1982 Dr. Grantham teamed with Mr. Joseph Bruening to create the Polycystic Kidney Research Foundation, headquartered in Kansas City, Missouri. In 1999, the PKRF was responsible for directly funding nearly \$2,000,000 in national and international grants and in influencing

federal support for PKD research to the extent of an additional \$10,000,000 per year.

In 1989 the Journal of the American Society of Nephrology was founded by Dr. Grantham and Dr. Sullivan. Upon completion of their editorial terms in 1996, the journal had the highest impact factor of over 30 titles in nephrology and urology throughout the world.

In 1998 Doctors Grantham, Hudson and Calvet successfully competed for a five year NIH Program Project Grant for studies of "Chronic Progressive Renal Diseases." This was followed by the recruitment of Dale Abrahamson, Ph.D., an expert in kidney development research, to be the Chair of Anatomy and Cell Biology. In 1999 Doctors Grantham, Calvet, Maser, Peterson, Buechner and Lu were chosen in a stiff competition to be one of the Magnet Centers for Polycystic Kidney Research by the National Institutes of Diabetes, Digestive and Kidney Diseases. In 2000 Tom DuBose, M.D., an authority in disorders of acid-base balance, became the Chair of Internal Medicine.

Research training and clinical care programs in Nephrology. The propagation of species depends upon a healthy reproductive system. Since 1969 KUMC has trained 50 nephrologists, 18 of whom spend significant amounts of their time in renal research in several universities. Seventeen nephrology trainees practice in Kansas, seven in Western Missouri, three in Nebraska, one in Iowa and 18 others elsewhere. The University of Kansas Medical Center has also graduated many renal researchers with Ph.D. degrees and postdoctoral fellowships obtained in the Departments of Biochemistry and Molecular Biology, Anatomy and Cell Biology and Molecular and Integrative Physiology.

KUMC has the highest 3-year success rate for kidney transplant survival among all of the transplanting centers in Kansas, Missouri, Nebraska and Iowa. Four of the KUMC staff nephrologists have been chosen *Outstanding Doctors of America*.

The Kidney Institute at the University of Kansas Medical Center. In 2000 a new order arose on this campus, the Kidney Institute. The Kidney Institute is a magnificent collection of scholars and trainees pursuing research programs in polycystic kidney diseases, progressive renal diseases including diabetic nephropathy and Alport Syndrome, and disorders of kidney development and metabolism. The Institute is comprised of 34 collaborating faculty investigators including 15 clinicians and 19 basic scientists. Over 100 research associates, graduate students, fellows and support staff are directly associated with the Institute. The annual total direct costs budget of the Institute in 2000 is \$4,761,976, the majority of which comes from the National Institutes of Health.

The future of the Kidney Institute. The emergence of the Kidney Institute at the University of Kansas Medical Center exemplifies the survival of the fittest in a challenging environment. The highly differentiated Kidney Institute at the University of Kansas Medical Center is a model of interactive research by talented, imaginative and successful scientists and clinicians who work toward a common goal of high excellence in renal research and patient care. The Kidney Institute is positioned to grow by the addition of exceptionally talented clinicians and researchers who will flourish in this strong growth environment.

KANSAS CITY AREA LIFE SCIENCES INSTITUTE

William G. Brundage
Executive Director

The Life Sciences Initiative is an economic development initiative. If Kansas City is to prosper in the future, it has to address the infrastructure requirements of the 21st Century. Today, economies are regional and if a region does not possess a significant "technology" infrastructure within the next five to ten years, it will not be in a position to compete. The Kansas City Area Development Council and the Civic Council of Greater Kansas City established a Life Sciences Task Force which determined that the Life Sciences could provide this region with a competitive edge. A tectonic shift has occurred in the world economy. Strong arms and legs, a good work ethic, a central location, a low cost business climate, and access to materials and transportation will no longer be sufficient for a region to compete. Rather, competitive advantage will be defined by a combination of traditional factors that equate to financial capital, and non-traditional factors—expertise and knowledge—that equate to intellectual capital. The regions that succeed in balancing this new equation will prosper into the future by expanding their economies and creating new value, wealth, capital, and profit through marketing products of the mind.

The Life Sciences Task Force determined that in order to attain its vision of Kansas City as "A nationally known center of established, world-class life sciences companies, private and academic research institutions, and emerging, entrepreneurial companies in a community recognized for its opportunity and attractive quality of life," the community will have to do the following:

- Make a major financial investment in Kansas City's institutions of higher education.
- Build the physical and organizational support structure for life sciences entrepreneurs.
- Develop, finance, and commercialize intellectual products in Kansas City.
- Attract the brightest scientific talent and the best, young entrepreneurial companies that can be found.

This past Spring the sponsoring organizations created the Life Sciences Institute and assigned it the following functions:

- Accountability
- Evaluation
- Oversight
- Resource Allocation
- Collaboration
- Fundraising
- Lobbying
- Marketing

The first order of business was to develop a business plan, which will be completed by the end of August. This plan is concentrated around the following focus areas:

- Human Development and Aging
- Cancer
- Cardiovascular Diseases
- Neurological Diseases
- Infectious Diseases

Plans for commercialization, economic development, and educational support will be included. Our goal is to develop a ten-year investment strategy that will enable the Area's research institutions to collectively attain \$500 million annually in Research and Development expenditures.

How do we determine Kansas City's niche? The competition is considerable and we will not be able to compete in every field. In order to make the best possible investment decisions, we are employing the following: an external Scientific Advisory Committee and a process called "business dynamics modeling." The Committee will advise us on the science and where they believe we can be competitive. The business dynamics modeling will show us what it will take to achieve the goal of \$500 million in annual R & D expenditures.

The business plan will be presented to the boards of directors of the Kansas City Area Development Council and the Civic Council of Greater Kansas City for approval on September 8, 2000. Fund raising will begin shortly thereafter.

NEW ALLIANCES

James Spigarelli,
President and CEO
Midwest Research Institute

Midwest Research Institute (MRI) has been in existence since 1944. One of the main objectives of our founding fathers was for MRI to make a positive economic impact on the Kansas City region. For the first ten years of operation MRI served as a research arm for many local companies, but we changed direction in the late 60's and early 70's as federal funding increased. By the early 80's the federal government funded about 90% of our contract research. We have reversed that trend and now have about 30% of our contract work funded by private industry.

In 1977, we won the contract to manage the Solar Energy Research Institute, which later became the National Renewable Energy Laboratory for the Department of Energy. This is the premier laboratory for the federal government's funding of basic and applied research in renewable energy and energy efficient technologies. To win this contract initially we had to bid with a state. At that time, Kansas and Missouri didn't show much interest in furnishing a location for this laboratory, so it became located in Golden, Colorado. Today there is more awareness about the importance of research, development, and technology transfer to the economic health of a community. I'm confident that if the same opportunity presented itself today, the result would be much different, and the 1,000 high tech jobs that are located in Golden would be located somewhere in the Kansas City region.

The Kansas City Area Life Sciences initiative is an example of the value many groups place on research and technology in terms of the regional economy. This alliance includes research institutes, universities, and research hospitals along with civic organizations such as the Civic Council and the Kansas City Area Development Council. Today, Kansas City is creating its own roadmap to draw upon its strengths. Life sciences research and technology transfer will be an important part of its economic development over the next 10 to 20 years.

The kind of research that will make Kansas City successful is not described by a linear research model. Instead, use-directed fundamental research is what we need. Pasteur was interested in understanding fundamental issues, but he also wanted to apply the results for the good of society as quickly as possible. This is the goal in medical research. For

example, researchers want to understand the mapping of the human genome and to make this knowledge work for the good of people. In Kansas City, if we receive public money, there will be pressure to realize an economic impact as quickly as possible. Alliances that achieve directed fundamental research make an impact on the community in the most rapid manner. We must talk about research in this way.

We have some unique advantages in Kansas City. Whatever we do, we must take these specific strengths into account. We must form alliances thoughtfully and according to criteria that will enhance our possibilities of success. If an alliance does not bring researchers together and make it easier for them to conduct research, it is not worth forming. There are several important criteria: 1) the leaders of the organizations must believe the alliance is important, 2) the organizations must have complementary core competencies, 3) there must be a market/societal need and clients for the core competencies, and 4) an effective infrastructure must be created. Recently MRI has formed several alliances that meet these criteria. For example, we are working with researchers and administrators at the University of Kansas Medical Center and at the Lawrence campus to define common areas of research and to develop an infrastructure that fosters collaboration between our institutions. We have a head start because we have carried out joint research projects in the past. We also have formed an alliance with Children's Mercy Hospital in Kansas City to develop new medicines for children. We formed this alliance because MRI has the analytical chemistry researchers and the instrumentation to complement the clinical and basic research capabilities at Children's Mercy. Both kinds of institutional alliances are designed to achieve synergies in breadth and quality of research and to remove institutional barriers that would hinder our work together.

The momentum created by the Kansas City Life Sciences Institute helped in forming these alliances and will make future alliances much easier. But research alliances are just part of what is necessary to make the Kansas City Area Life Sciences initiative work. William Brundage spoke about a business plan. We are preparing a strategic plan that will model the investment needed not only for R & D but also for education, technology transfer, and commercialization. We must create an infrastructure to support the creation of new companies that will add to the high technology job opportunities in our region.

The McKinsey group did a study for the city of Houston. Houston has about \$400 million in funded life sciences R & D annually, compared to San Diego, which has about \$250 million in funded life sciences R & D. Yet, there were only three venture capital deals in Houston last year compared to about 70 in San Diego. If you don't have the capital, legal

advice, and the CEO's to mentor start-up companies, you don't have the infrastructure in place to make an economic impact.

The Kansas City Area Life Sciences Institute represents a “grand alliance” among research organizations, foundations, and civic institutions. It will create synergistic collaboration, an infrastructure, and a source of funds to help each organization achieve what they couldn't achieve individually, and to help the community realize a strong, technology-based economy and better health care for its citizens.

CONFERENCE PARTICIPANTS 2000

Keynote Speaker

George Walker, Vice President for Research
and Dean of the Graduate School
Indiana University

University of Missouri

Jack O. Burns, Vice Provost for Research
Harris Cooper, Professor of Psychology
Brady J. Deaton, Provost

University of Kansas

Steven M. Barlow, Professor of Speech-Language-Hearing
Robert E. Barnhill, Vice Chancellor for Research
Sally Frost Mason, Dean, College of Liberal Arts and Sciences
Jared J. Grantham, M.D., Distinguished Professor, Medical School
Donald F. Hagen, M.D., Executive Vice Chancellor, Medical Center
Robert Hemenway, Chancellor
Kathleen McCluskey-Fawcett, Associate Provost
Marlin Rein, Director of Budget & Governmental Relations
Mabel Rice, Director, Merrill Center and Distinguished Professor
Stephen R. Schroeder, Director, Institute for Life Span Studies
Valentino J. Stella, Distinguished Professor, Pharmaceutical Chemistry
Thomas N. Taylor, Distinguished Professor of Botany
Steve F. Warren, Director,
Mental Retardation & Developmental Disabilities Research Center

Iowa State University

William Lord, Interim Vice Provost for Research and Graduate Dean

Kansas State University

James A. Guikema, Associate Dean of the Graduate School
J.E. Leach, Distinguished Professor of Plant Pathology

University of Nebraska

Thomas H. Rosenquist, Director of Research, Medical Center -Omaha
Marsha R. Torr, Vice Chancellor for Research - Lincoln

Kansas Board of Regents

William R. Docking, Chair
Kim A. Wilcox, Executive Director

Other Participants

William Brundage, Executive Director, Kansas City Area Life Sciences

James Spigarelli, President and CEO, Midwest Research Institute

Ralph Tanner, Kansas House of Representatives, District 10

Keith Yehle, Legislative Assistant to Senator Pat Roberts

Heather Wingate, Chief of Staff to Senator Sam Brownback

Bob Woody, KU Counsel in Washington, D.C.