BUILDING CROSS-UNIVERSITY ALLIANCES THAT ENHANCE RESEARCH

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TABLE OF CONTENTS
MASC Report No. 103

Introduction..... 1
Mabel L. Rice, Director
Merrill Advanced Studies Center

Executive Summary 3

KEYNOTE ADDRESS.....15
Luis M. Proenza, President
University of Akron
Clusters and Collaborations in the New Research Economy—Creating Strategic Intent among Universities

RESPONSE to the Keynote Address 31
Robert E. Barnhill, Vice Chancellor for Research & Public Service
University of Kansas

PANEL OF RESEARCHERS

Bikram S. Gill, Director **.....39**
Wheat Genetics Resource Center, Kansas State University
Wheat Genetics Resource Center: Pioneering Center without Walls

George S. Wilson, Professor of Chemistry & Pharmaceutical Chemistry **.....43**
University of Kansas
The Benefits of Collaboration to Graduate Education

PANEL OF VICE CHANCELLORS FOR RESEARCH

Jack O. Burns, Vice Provost for Research **.....49**
University of Missouri - Columbia
Mission Enhancement at the University of Missouri

P.B. Swan, Vice Provost for Research & Advanced Studies **.....53**
Iowa State University
Managing Intellectual Property Arising from Research

R.W. Trewyn, Vice Provost for Research **.....59**
Kansas State University
Graduate Education and Research in the Year 2000: Fashioning Horizontal Flexibility in a Vertical World

PANEL OF RESEARCHERS

Roberta Johnson, Director **.....69**
Hall Center for the Humanities, University of Kansas
Interdisciplinary Research in the Humanities:
Recipes for Elephant and Rabbit Stew

Don Steeples, Professor of Geophysics **.....75**
University of Kansas
Increasing Research Flexibility with Endowment Funds
(In Defense of Research by Serendipity)

Marilyn Stokstad, Professor of Art History **.....81**
University of Kansas
Is Anyone Out There Listening?

Special Presentation

David E. Shulenburger, Provost **.....87**
University of Kansas
Eliminating the Scholarly Communication Crisis: From Here to NEAR

PANEL OF DEANS AND CHAIRS

Marc A. Johnson, Dean of Agriculture **.....95**
Kansas State University
Agricultural Biotechnology: Competitiveness through
Multi-State Collaboration

Roger A. Sunde, Chair **.....99**
Nutritional Sciences, University of Missouri - Columbia
Nurturing Multi-Disciplinary Nutritional Sciences on the Eve of the
21st Century

Andrew J. Blanchard, Director of Research **.....107**
College of Engineering, University of Missouri - Columbia
A Business-Oriented View of the Academy

Sally Frost Mason, Dean **.....113**
College of Liberal Arts & Sciences, University of Kansas
The Dean's Role in Fostering Collaborative, Multi-Disciplinary Research

PANEL OF RESEARCHERS / ADMINISTRATORS

Kim A. Wilcox, Executive Director **119**
Kansas Board of Regents
Of Baseballs and Foul Balls: The Context for Research in the Kansas Board of Regents Office

Charlotte R. Bronson, Professor of Plant Pathology **125**
Iowa State University
Marshalling Forces in a Competitive Research Environment—Some Slippery Issues

Bruce Harmon, Deputy Director **133**
Ames Laboratory, Iowa State University
"Herding Cats"—A New Inter-Institutional Science Network

PANEL OF CHANCELLORS

Richard L. Wallace, Chancellor **137**
University of Missouri - Columbia

Robert Hemenway, Chancellor **141**
University of Kansas

List of Conference Participants 145

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 third in a series of regional conferences on the topic of research in public universities, sponsored by the Merrill Advanced Studies Center. We hosted "Building Cross-University Alliances That Enhance Research" on July 26-28, 1999 in the retreat center at Valley Falls, Kansas. The gathering included thirty-two administrators, senior faculty scientists, and guests from five research institutions: the universities of Kansas (including the Medical Center), Kansas State, Nebraska, Missouri, and Iowa State University. The keynote speaker was Dr. Luis Proenza, President, University of Akron. Senator Pat Roberts was represented by his legislative assistant, Keith Yehle.

This year's topic followed naturally from the two previous topics. In 1997, the conference focused on pressures that hinder the research mission of higher education, with special consideration of the complexities encountered by public research universities. In 1998, our attention turned to how best to compete for new resources. Discussions focused on ways to enhance individual and collective productivity. In particular, our keynote speaker of that year, Dr. Michael Crow, encouraged the represented universities 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. A corollary recommendation was to cover research areas cooperatively with other institutions.

In 1999, we turned our attention to an explicit examination of cross-university alliances for the enhancement of research endeavors. In order to broaden the perspectives, we expanded the number to five major regional universities, representing the four-corner states of Kansas, Nebraska, Iowa, and Missouri. The research areas represented were also chosen for diversity, including biomedical science, grain science, chemistry, biology, physics, engineering, art history, and literature. The participants included persons who participate in direct research endeavors, those who direct multi-investigator and multi-university collaborative efforts, academic deans, research administrators, provosts, and chancellors.

The following collection of papers captures the energetic, enthusiastic, and lively nature of the dialogues that took place at the conference, beginning with the keynote address of Dr. Luis Proenza, who encouraged the participants to think in terms of “strategic intent” and described important precedents in university-industry cooperation and cross-university alliances. Subsequent contributions addressed the correlated issue of the measurement of academic performance, and a variety of observations bearing directly on research productivity, research training, dissemination of research findings, and the forging of new alliances and competitive coalitions. It is with pleasure that I encourage you to read each of the following contributions for a sense of the diversity of issues involved in research endeavors and the basis for collaborative institutional arrangements.

I would like to end this section with appreciation to Robert Barnhill, who is on the Board of Directors of the Merrill Advanced Studies Center, for his thoughtful recommendations, and to Joy Simpson, who assisted with the arrangements for the conference, and the compilation, editing, and production of this document.

EXECUTIVE SUMMARY

KEYNOTE ADDRESS

Luis M. Proenza
President, University of Akron

- There are seismic rumbles of change, yet scientists are embroiled in a climate of pessimism, believing research cannot be done another way.

- Worldwide, Research & Development is a $410 billion industry, 90% of which is dominated by 7 countries with the U.S. claiming 44%. Of the $180 billion in U.S. market share, 60% is derived from industry. 13% is claimed by academia, and this money is increasingly distributed among a larger number of colleges and universities.

- It is useful for an institution to look carefully at its research "portfolio" and to assess its academic research competitiveness. It is important to look at clusters of strength in the institution and to pinpoint emerging opportunities. Through focus and differentiation institutions gain strength. No university can be truly comprehensive today.

- There is no single model to define a research university.

- The concept of "strategic intent" is valuable because it asks you to state what you want to be in a powerful and ambitious way. See the book *Competing for the Future* by Garn Hamel and C.K. Prahalad.

- There are many models of mergers and coalitions in academia. In the early part of the 20th century, many normal schools became parts of large universities. Just this year, Radcliff merged in to Harvard. In 1969, Indiana University's school of medicine and Purdue's school of engineering, among other programs, formed a consortia based at a single campus in Indianapolis. In Massachusetts, five institutions have formed a consortia so that students from any of the schools may enroll at the other schools for no extra charge.

- In terms of university-industry cooperation, Purdue and Caterpillar have a productive relationship that includes exchange of personnel and training of students. This is accomplished through an overarching agreement that does not require negotiation for individual projects.

- Tim Ferguson in *Forbes,* May 31, 1999 described the nature of the change in the U.S. economy: "[in the past] proximity to water or rail mattered a lot. Today, proximity to a university campus matters a lot."

- We can expect research universities to lead efforts that involve a "cluster made out of brainpower." For example, Georgia began positioning itself as the economic New South in the late 1960's when Governor Busbee added 400 faculty positions at just one university, followed by R & D investments under Governor Harris in 1984 which resulted in the Georgia Research Alliance under Governor Miller. In just six years, the Alliance has attracted 22 eminent scholars to Georgia; accelerated growth in intellectual properties; encouraged business-friendly technology transfer systems; and between 1990 and 1997 increased sponsored research at Georgia's universities from $400 million to more than $700 million.

RESPONSE TO THE KEYNOTE ADDRESS

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

- Strategic intent goes beyond strategic planning; it extends to what is barely possible, such as Kennedy's vision of our landing on the moon.

- Research enhancement can lift the entire institution. As an example, the University of Arizona on the eve of Sputnik had only 2 doctoral programs in arts and sciences and less than $1 million in separately budgeted research. Today it ranks in the top 10 public universities in research funding. In 1959, President Harvill provided leadership and focus by directing research toward areas in which Arizona possessed some natural advantage. In two years, the centers for astronomy and anthropology arose and in 1966 became the first departments to receive national recognition in reputational rankings.

- Lester Thurow, a professor at MIT, has said that "a successful knowledge-based economy requires large public investments in education, infrastructure, and research and development." He also stresses that the rates of return on Research and Development are far greater in the public arena, with benefits accrued for the whole society.

- A principal reason that academic performance measures are important is that we will become what we decide to measure. We should select and promote measures that reflect the values we believe are important.

- At the June 1999 NASULGC CRPGE forum, a view emerged that rankings are valid for perhaps the top 20 universities, but for universities in the middle, relatively small changes in the data or the criteria can produce dramatic differences in the rankings.

- Graham and Diamond in their book *The Rise of American Research Universities* suggest that reputational rankings are an artifact of the past. In the Knowledge Age there are no adequate peer reviews for the multitude of research universities where interdisciplinary work is flourishing. They suggest two main categories (federal research obligations & journal publications) with three sub-categories (publications in top-rated sciences & top-rated social science journals and top awards in the humanities). They suggest a per faculty capita approach, as opposed to the National Research Council graduate study reputational rankings that use aggregate numbers and therefore favor large departments. At the June NASULGC forum Graham also suggested these criteria: journal citation density, top-journal approach, research funding and outcome measures for doctoral graduates such as first jobs taken after graduation.

- The National Science Foundation counts only science and engineering in its report. In compiling its data, Kansas added the excluded disciplines and expenditures from training grants. These adjusted totals will be used by Kansas to measure research performance in the future.

PANEL OF RESEARCHERS

Bikram S. Gill
Wheat Genetics Resource Center
Kansas State University

George S. Wilson
Chemistry/Pharmaceutical Chemistry
University of Kansas

- The secrets of collaboration distilled from studies of successful teams are: select the right people; have a clear mission; provide adequate resources; communicate accomplishments; inculcate a strong belief in the project and the urgency to complete it before anyone else. In graduate education, the advantages are: access to unique experts and resources; an opportunity for students to try their wings; access to different perspectives on a research problem; experience in managing collaboration; exposure to different research environments; and experience communicating and problem solving. Barriers to success can involve: who is in control; who gets the credit; intellectual property issues; conflicts in management style; ineffective communication; lack of definition of the experimental plan.

- An example of collaboration is the Wheat Genetics Resource Center which was established at Kansas State University (K-State) in the 1980's. Its purpose is to conserve genetic resources of wheat, promoting its utilization in wheat improvement through basic and applied research, and it also sponsors the training of students and visiting scientists. This is a successful center because it is investigator-driven; it nurtures grassroots participation and shared vision with producers, consumers, administrators and legislators.

- A proposed collaborative project could be developed by K-State and the University of Kansas (KU) to conserve native prairie in one of the last remnants of contiguous prairie in the nation. This could be called the Prairie Genetics Conservation Center. It could draw on the Konza Prairie/Agronomy group at K-State for ecological and range management research, the Wheat Genetics Resource Center, and the KU scientists for conservation and genetics research. This center could work to conserve and enhance prairie genetics here and abroad.

PANEL OF VICE CHANCELLORS FOR RESEARCH

Jack O. Burns	**P. B. Swan**	**R. W. Trewyn**
Vice Provost	Vice Provost	Vice Provost
University of Missouri	Iowa State University	K-State University

- By following the model by which American businesses have transformed successfully in the 1990's, universities will also successfully adapt and change. Centers and institutes create flexibility in a "vertical" institution. Universities must listen to the employers of students—an often overlooked "customer" of education. Employers want students who can solve real-world problems in teams.

- Kansas State University has a new graduate certificate program that is geared toward the part-time student and the student who wants the flexibility of coursework in an additional area, but is concurrently enrolled full-time in another degree program. The military graduate student recruitment program capitalizes on K-State's strengths in food safety, environmental remediation, etc.—military concerns in the next century. The University has also removed impediments to the transfer of technology from university research labs to the private sector, and has developed procedures that allow faculty to participate in federal grant awards that fund innovative business start-ups.

- The University of Missouri is focusing on its regional strengths and opportunities to excel through a four-year funding package allocated by the General Assembly of Missouri. The goals of Mission Enhancement are to: increase research productivity and extramural funding; achieve national prominence and improve program rankings in selected academic areas; improve graduate program quality; enhance service to the state of Missouri; and improve undergraduate program quality with enhanced undergraduate research experiences and exposure to more senior faculty in the classroom. In the first full year, 125 new faculty positions have been approved and four broad areas of academic enhancement have been chosen: Life Sciences, Connections, Quality of Life, and Global Information Access. Global Information Access will include creation of a new multi-disciplinary program in electronic commerce that involves the faculty from business, law, journalism, political science and apparel management.

- The Heartland Research Consortium is an example of multi-institutional collaboration with a focused strategy. It involves 10 Midwestern research universities that will launch an international conference on Genetically-Modified Organisms in fall 2000 with co-sponsorship by the American Association for the Advancement of Science. Strategic alliances between universities in the heartland enable everyone to achieve a competitive advantage by leveraging resources.

- Public universities must make their knowledge and expertise available; when new knowledge leads to a potentially useful product or to a better manufacturing process, it is developed and protected as intellectual property so it can be commercialized and made available to the public. Universities invest in intellectual property programs to: facilitate collaboration, meet federal requirements (Bayh-Dole Act), protect the value of the research and the rights of the inventors, and protect the interests of public investors in the university. Only a few universities make money and this is momentary. The best time to agree on the basis for management is when the contract is being written on the research, even if the outcome of the research is uncertain.

PANEL OF RESEARCHERS

Roberta Johnson	**Marilyn Stokstad**	**Don Steeples**
Hall Center for Humanities	Art History	Geophysics
University of Kansas	University of Kansas	University of Kansas

- Cross-disciplinary marriage rarely occurs between equals. It may be an elephant and rabbit stew. Rather than advocate blendings, flavorings could make a valuable difference in the humanities scholar's project or the way he/she conducts career-long research. Interactions between people from different fields is worth promoting. The Hall Center for the Humanities provides a venue for faculty from across campus and for off-campus people to come together to share current research and to dialogue. It is a challenge for humanities faculty to meet scientists and medical professionals, especially when the work is carried out in Kansas City. A Four-State Institute for Ethics could address ethical issues in medicine and other areas of human endeavor and could lead to major break-throughs on issues of contemporary debate.

- Scholars know how to share information rapidly with those who want to know, but the important question is how to communicate with a wider audience. We cannot function without public support. Because the academic community relies on in-group-speak for scholarly communication, and media-types for external communication, public response wanes. Combining images and words is effective for rapid, accurate dissemination of information. Visual images are long lasting. Bright and creative people in the arts and humanities can be communicators for the university.

- There are many ways of doing science. Jack Oliver defined two valuable methods: science by synthesis and science by serendipity. He states that "no one style of doing science is superior or should be exclusive." Funding from the National Science Foundation is difficult to obtain unless a proposal has an explicit, testable hypothesis. Yet, when scientists follow the scientific method, they may become married to the hypothesis, making it difficult to admit a failed experiment or causing them to follow a research track far longer than it is valuable. Endowed research funding can enable scientists to explore high-risk research that may result in valuable breakthroughs.

ELIMINATING THE SCHOLARLY COMMUNICATION CRISIS

David E. Shulenburger
Provost, University of Kansas

- We have experienced ten years of annual compounded increases in the price of scholarly journals in excess of 10%, especially in science, technology and medicine. To purchase the same proportion of published serials and monographs as a decade ago, the University of Kansas acquisitions budget would have had to increase by 250%. Instead, it increased only about 50%. Because this situation reduces the availability of information to scholars, it threatens to reduce the universities' contribution to both basic and applied research.

- We must find a way to make information permanently accessible to scholars and the public in a useful fashion. Solutions must deal with ultimate ownership of scholarly communication, i.e., copyright, and only in that instance will we have found a solution.

- I propose that when a manuscript is prepared by a U.S. faculty member and is accepted for publication by a scholarly journal, a portion of the copyright of that manuscript shall be retained for inclusion in a single, publicly accessible repository, after a specified time following publication in the journal. Only the exclusive right to journal publication of the manuscript would pass to the journal and the author would retain the right to have the manuscript included in the National Electronic Article Repository (NEAR) 90 days after it appears in the journal. NEAR would index manuscripts by author, title, subject and name of the journal and see to it that articles are permanently archived. NEAR could be funded by universities through "page charges" per article included, by federal appropriation, by a small charge levied on each user upon accessing articles, or by a combination of these methods. Since all scholarly journal articles would pass into the public domain in 90 days, individuals, libraries, agencies and businesses would choose to subscribe only to those journals where timely access justified the cost. The amount by which prices fall will vary inversely with the rate at which the value of the information contained in the journal deteriorates over time.

PANEL OF DEANS AND CHAIRS

Roger A. Sunde
Chair, Nutritional Sciences
University of Missouri

Marc A. Johnson
Dean of Agriculture
Kansas State University

Sally Frost Mason
Dean of Liberal Arts
University of Kansas

Andrew J. Blanchard
Director of Research, Engineering
University of Missouri

- Universities cannot rely solely on direct allocations of state and federal resources for growth. In states with smaller university scientific infrastructural investments, collaboration may be essential to create critical mass and to be competitive nationally. We must recognize that other institutions are better at some things while our own is better at others, and when we join forces, both prosper.

- Kansas State University participates in the Great Plains Cereals Biotechnology Consortium with the University of Nebraska, Oklahoma State and the Nobel Foundation in Oklahoma. Together, these institutions have 80 faculty who competitively seek grants as one entity. This has enabled the development of relationships overseas and has strengthened research programs that may be able to reduce the $700 million annual loss of potential grain yield in Kansas, Oklahoma and Nebraska—an issue that is fundamental to the world's food supply.

- Research centers can reach across departments, colleges, universities, states, and nations to gather together talented faculty. Centers are designed to be less bureaucratic and tend to enhance faculty fulfillment while avoiding the question of changing departmental structures. Substantial seed money results in quick organization and a quick product, and enables the preliminary work for building excellent proposals.

- The University of Kansas has received several Department of Education Title VI grants for National Resource Centers (NRC's). Three NRC's have been in existence for over a decade: Russian and East European Studies, Latin American Studies, and East Asian Studies. Humanists and social scientists at these centers have created an excellent collaborative environment where faculty participate in genuine multi-disciplinary work and are rewarded with promotion, tenure, merit salary, travel, etc.

- Deans can be instrumental in facilitating multi-disciplinary efforts by ensuring that the college-level promotion and tenure committee gives full

credit for the work done by faculty who are appointed jointly. A dean is also instrumental in committing new faculty lines, start-up monies and matching dollars for major equipment and infrastructure.

- The Plant Biotechnology Center at K-State is an example of collaboration. It was established with 18 scientists and $250,000 in seed money. The Center now has attracted scientists from many departments and colleges. Even though K-State had a long relationship with the International Rice Research Institute, once the Plant Biotechnology Center was established, IRRI proposed a formal memorandum of understanding to solidify the relationship and enable placement of one IRRI scientist at K-State as an adjunct faculty and one of K-State's faculty at IRRI as an adjunct scientist.

- The team-based approach to multi-disciplinary research is viable and worth the effort. At the University of Missouri it was used to take advantage of the explosion of new molecular biology knowledge and new biotechnology tools with the result that "Food for the 21st Century" is making the University more competitive.

- Robbins and Finley describe in their book why teams don't work. Teams may be created for the wrong reasons. It works well if there is a short-term, solvable problem requiring effort from several diverse components of the organization. The organization may not committed to the team idea. It takes vision and courage by the administration to set and support goals and vision. The reward structure for team members must make them feel safe to do their team jobs; performance expectations and reward must be aligned with the goals. A big concern is the expansion of non-productive paperwork, meetings and reports intruding on the time that team members have for team-based responsibilities. Reduction of activities that do not contribute to productivity of an institution is a way to empower multi-disciplinary teams. The #1 reason teams fail is when they are not given the tools to do the task.

- It does not benefit academia to be isolated from the world especially when the value of information is driven not by the individuals who create its content, but rather by those who market the content. Academics must respond to a changed market. The new academic culture will succeed by its exceptional ability to recognize market needs and provide innovative solutions to market-driven problems through a customized approach. It will also be effective in taking on a brokering role, creating an interface between the private side, government, and various academic sectors, accessing a broad variety of complex capabilities and thinking processes that characteristically are not integrated.

PANEL OF RESEARCHERS / ADMINISTRATORS

Kim A. Wilcox	**Charlotte R. Bronson**	**Bruce Harmon**
Executive Director	Plant Pathology	Ames Laboratory
Kansas Board of Regents	Iowa State University	Iowa State University

- The Regents, Kansas legislators, and the public at large, need a context in which to appreciate the value of research. Undergraduate education is focused on giving students baseballs—facts—without demonstrating the thrill of the catch. Faculty spend far too much time arguing about and putting in place the information that all students in a discipline must have, rather than making sure students understand the heart of research.

- Faculty are asked to perform services for the greater good of the university, including projects that link universities in research. This often involves a great deal of work with little credit. For example, a faculty member may write the grant, disburse the funds to everyone in the multi-university project, arrange meetings and organize the effort to write the paper—and then be listed as the 18th author. To encourage cross-university linkages, administrators must think of ways to reward faculty, or at the very least, not penalize them. For example, the administration might provide clerical assistance; award half a research assistantship for each year of leadership; allot a temporary increase in salary, or even increase the base pay for more significant assignments.

- Iowa State and the University of Illinois are working together on genomics research on soybeans. This is encouraged by the soybean promotion boards in the two states because teams representing more than one state can better compete for federal funding, and cooperation between the states decreases unnecessary duplication.

- The opportunities are great. For example, we now have all the knowledge and computing power to couple fundamental atomic level knowledge with larger length scale simulations and to evaluate materials properties to aid in engineering designs—but this requires teamwork to achieve major breakthroughs in science. Getting scientists together in teams is like herding cats. Big, relevant ideas are critical for a large cooperative project to succeed and actually, money, while helpful, is not the only solution.

PANEL OF CHANCELLORS

Richard L. Wallace
University of Missouri - Columbia

Robert Hemenway
University of Kansas

- There are many avenues for raising funds for research, some more successful than others. Increasing state appropriations and raising tuition have not been options in Kansas. Increasing private giving has been a strong point at the University of Kansas, which has the 4th largest endowment among public universities. KU has also been successful in gaining federal earmarks and in building university-industry partnerships. Recently KU reorganized the administration to provide an infrastructure across the campus that will enable young faculty to capture more federal grants and contracts.

- The defining characteristic of the next decade will be partnerships. We must collaborate across disciplinary, institutional, state and national boundaries to maximize our opportunities. Effective teamwork requires breaking down communication barriers that are part of traditional administrative structures.

- Two possibilities for cross-university alliances could be: a Kansas State–KU partnership to deliver healthcare to the elderly; and a partnership between KU and the University of Missouri as a biology and genetics institute is established in Kansas City.

- Mission enhancement at the University of Missouri has strengthened interdisciplinary research. The wisdom of an integrated approach to life sciences research has become clear over the years and MU has responded by building two programs: Food for the 21st Century and Molecular Biology. These were started with state support and have since garnered significant federal and other outside support.

- MU is engaged in a unique partnership that combines public and private universities, as well as a for-profit and a non-profit corporation. The Donald Danforth Plant Science Center is intended to be a world class contributor to the field of plant science.

- Human intellectual capital is our single most valuable currency.

- This is one of the most productive environments for research in many years because people are open to new ideas and new ways of doing things.

KEYNOTE ADDRESS

CLUSTERS AND COLLABORATIONS

IN THE NEW RESEARCH ECONOMY—

CREATING STRATEGIC INTENT AMONG UNIVERSITIES

Luis M. Proenza
President
University of Akron

That we live in interesting times is the understatement of our modern age. “Seismic rumbles of change,” to use Chuck Vest’s phrase, are plunging research universities into crosscurrents and rapids that already are transforming traditional paradigms for research and graduate education—to say nothing about the relationships between academia, industry, and government.

The sources of cataclysmic pressure are many and include:

- competition among our own universities;
- shifting demographics and their accompanying shifts in national priorities;
- resource constraints; and
- public scrutiny of productivity and accountability in our universities.

Of major concern is the absence of a powerful national driver for Research & Development (R&D) now that the Cold War is over.

Amidst these forces of change, as Eric Bloch suggested, we scientists seem to have embroiled ourselves in a climate of pessimism, a sort of scientific “mid-life crisis,” because 50 years of doing research one way has fostered the belief that it cannot be done another way.

Somehow, the prospect of change always seems to raise a sense of excitement and, simultaneously, a sense of risk.

For some, risk becomes a sense of anxiety. And quite often, particularly in academic and political circles, anxiety leads to “analysis paralysis.” But remember that risk and anxiety are two quite different conditions. A simple story will illustrate the point:

The Surgeon General tells us that cigarettes kill more than 150,000 Americans each year, and that automobiles on our highways kill more than 50,000 people per year. But, nobody seems to be afraid of cigarettes, nor of automobiles. However, according to the Deputy Director of the National Institutes of Health, everyone is afraid of sharks. The Navy says that there are about 50 shark attacks worldwide each year.

The National Bureau of Health Statistics doesn't even keep a record of shark attacks because there are so few. (They know how many people are killed by bee stings, but not shark bites.) The best guess is that sharks kill two or three people each year in the United States. But, the fact is that if you went to a crowded beach and shouted "shark" —everyone would race out of the water, jump into a car, light up a cigarette, and drive home! That's the difference between anxiety and risk. Each of us feels this way about various things and about some activities in our society.

How nice it would be if we could put risk and anxiety into perspective, and move to better distinguish the “sharks” in our midst. Indeed, where reason and calm prevail, there is always optimism, and much that can be accomplished for the common good.

And so, in this reasonable and calm gathering, it is appropriate that we revisit the closing theme of Michael Crow's keynote address to this conference last summer: "How do you <u>think</u> about organizing collectively?"

You may recall that Dr. Crow had elaborated six questions that we might ask to help us think about organizing collectively, and I will echo many of his themes, but for our discussion this morning, I would like to rephrase his general question slightly and ask more practically: How do we <u>go</u> about organizing collectively? How do we organize to enhance and optimize research competitiveness in this Age of Global Change?

To provide an answer to this question requires that we understand the R&D environment, that we know our competition, and ourselves and that we have a sense of what we want to do. Thus, this morning I will develop these three themes:

First, I want to characterize the research economy by outlining the principal features of the U.S. R&D environment, particularly its economic and sociopolitical aspects—to do, if you will, an “environmental scan” on today’s economic and sociopolitical drivers.

Second, I want to discuss academic research competitiveness in terms of some simple analyses of relative growth among institutions and of

their differentiating research portfolios. In other words, I will suggest some simple metrics needed to determine where our strengths and opportunities might lie.

Finally, I want to focus attention on some strategic questions and possible approaches and to talk about competitiveness and collaboration as necessary and complementary elements of an approach I shall call "strategic intent."

Let me thus begin with some comments on the R&D environment. The first thing to be said is that the environment for R&D is a complex and interactive one. It is shaped not only by the quantity and sources of funds available to support research activities, but also by the talent pool and capabilities of the scientists and engineers who conduct research, and by the settings in which that research is conducted, that is, by its "infrastructure"—in the sense of its facilities, its institutional culture, and those other related attributes governed by geographical location and interrelating organizations and facilities, many of which are increasingly global and without boundaries!

The R&D environment also is shaped by prevailing public attitudes about the importance and usefulness of research in the broader context of societal pressures and economic opportunity.

Let's talk first about the size and shape of the research economy itself—the research marketplace, if you will. Worldwide, R&D is a $410 billion industry, of which 90% is dominated by just seven countries, and 44% by the U.S. alone, which accounts for approximately $180 billion. Of this $180 billion in U.S. R&D expenditures—60% is derived from industry, 36% from the federal government and 6% from foundations, states and our own research universities. Within the U.S. research economy, academic performers garnered about $23.8 billion, or 13% of the U.S. total, in 1997.

This 13% academic “market share” is, of course, distributed among an increasingly larger number of our nation’s 3,611 colleges and universities. Just after World War II, fewer than 50 universities performed sponsored research. By 1980, the number had risen to 600 institutions, and, by 1995, to 875 colleges and universities.

If the truth be told, the bulk of America’s research universities are post-World War II phenomena; many have emerged in just the last three decades. And as Michael Crow said last year, there is no single model or form of what a research university is—perhaps much to the chagrin of the Association of American Universities (AAU). If the truth be known, had any of us been approached by most of today’s research universities during the first half of

this century, most of us would have considered their job offers demeaning and well beneath our aspirations.

As you know, marked imbalances exist both geographically and among universities in the distribution of R&D wealth. Moreover, there continues to be a press for expansion and dispersion, as seen in the aspiration of so many institutions wishing to be designated as Research I or Research II universities in the Carnegie Classification.

I would argue, however, that the Carnegie Classification is not particularly meaningful, since total federal obligations need not reflect much about research strengths. I know of one university, for example, classified as Research II, whose total federal obligations are $35 million, but only $4 million of those $35 million are for R&D—the rest coming from the United States Department of Education.

In contrast, take the case of my good university, the University of Akron—which perhaps most of you do not even know—and which currently is not listed as a Carnegie Research II institution. Perhaps that is because the University of Akron is characteristically atypical among research universities. It has several nationally ranked programs (one of which is rated second in the nation, ahead of California Technical and MIT), but in contrast to most other so-called research universities, it derives 75% of its research support from industry. Remember, there is no single model for a research university

Parenthetically, for those of you interested in the evolution of research universities, I recommend you study Roger Geiger's historical analysis in his 1993 book, *Research and Relevant Knowledge: American Research Universities Since World War II*. I particularly recommend his splendid vignettes on the development of selected research universities.

A newer book—*The Rise of American Research Universities: Elites and Challengers in the Postwar Era*, by Hugh Davis Graham and Nancy Diamond—also provides an historical analysis together with quantitative comparisons to identify 50 leading research universities as of 1990. Their list includes 32 "rising" institutions that previously were not highly ranked in national surveys. And, it excludes a dozen institutions holding membership in the elite Association of American Universities.

These are "seismic rumbles of change" indeed!

But to return to the matter of R&D market share, obviously, academic institutions do not have a particularly notable share of this market—only 13%. The bottom line question is this: Can we afford to ignore 87% of the market? I

think not! And, considering the growing international dimensions of R&D, the opportunities to gain market share by “going global” are even larger! If we follow the money, we find that universities are missing out on nearly $160 billion in the U.S. R&D economy alone, and on $250 billion in the world R&D economy.

Now that we have had a glimpse of the R&D marketplace, let us continue with the environmental scan by turning to public attitudes, and particularly to those displayed in federal and state political arenas. Some highlights will suffice:

At the federal level, the growing tension between the budget deficit and discretionary spending priorities has, until recently, dominated the political landscape. Even with the new "politics of prosperity" that has been fueled by growing surpluses, the research "slice" of the budgetary "pie" is still small and threatened by pressures from other segments of the federal budget. What with the discretionary portion of the federal budget now at 32%, and nearly half of that going to defense—and with entitlements and mandatory programs now at 68% and climbing—you can bet that something has to give!

Federal agencies also are signaling changes. I am sure I need not tell this audience of the emphasis now being placed on multi-disciplinary and large center programs, or of the pressure for cooperative agreements with industry, or for that matter, of the growing trend to increase academic productivity by better integrating research and education.

In our states, legislatures have been increasingly less willing to support higher education, at least as evidenced by the decreasing share of state budgets going to academe. Competing pressures from other state priorities have also made themselves felt, where today, for example, prisons and corrections constitute the fastest growing part of state budgets. When it comes to research, most states lack a framework for considering R&D activities, or for integrating R&D at the state level with programs at the federal level.

What is more, with a booming economy, workforce development is today the #1 issue in corporate America. Public expectations in regard to the training of our research professionals are also changing. With the majority of Ph.D.’s now taking jobs in industry, we are having to rethink graduate education. Employers, both academic and industrial, are demanding new skills. I am sure you have heard the litany: They want problem solving skills, communications and interpersonal skills, team building and leadership skills, among others . . . and, in this competitive and fast-paced environment, one industrial recruiter recently asked for "emotional resiliency," as well.

Undeniably, we do live in interesting times, amidst a complex and dynamically changing environment for R&D. "And inherent in change, as it always has been, is opportunity. And, of course, risk" (Merrill Lynch & Co., Inc., 1990). Risk and opportunity are inseparable. And both are best managed by an informed perspective, which is precisely the point of the second part of my remarks, so let us turn to the topic of what we need to know.

In the simplest of terms, if we are to respond to the "seismic rumbles of change" in the R&D marketplace, it helps if we know ourselves; if we know our competition; if we know how to leverage; and if we know how to try new things on for size!

In this regard, let me state categorically that there is no "adequate" measure of research competitiveness or of university strengths—none! All are flawed and caveats abound. Each of our institutions is either first or last on some measure; it all depends on how you frame the questions!

While various approaches have been tried, and there is a whole literature on this subject, none is more commonly used than the "rankings" provided annually by the National Science Foundation based on research expenditures. However, one must be careful not to use total expenditures or total obligations, but rather to focus on federal obligations for R&D, because it is federal obligations for R&D that comes closest to demonstrating competitiveness.

For the period 1976 to 1994, an 18-year time window, federal obligations for academic research grew by 384%, or 90% above inflation. In effect, the pool of dollars available to universities grew by 384%. During that period, among public research universities, one university grew by only 100%, while many others enjoyed increases well above the average of 382% for public institutions. The prize goes to one university that grew by 2000%! How did each of your institutions fare?

This simple "percent growth" approach helps us understand how we all fared comparatively and in relation to the "absolute" benchmark of overall increases in federal obligations. Yet, to examine differential competitive strengths, we must also look in more detail and examine what our research portfolio looks like. So, for example, in regard to the federal support of research, the portfolio question is to know the relative shares of support from each federal agency.

Within the spectrum of federal agencies, six agencies (of the 13 that support academic R&D) account for 96% of all federal funding. These are:

- Department of Agriculture, with 3% of the total;
- Department of Energy, at 5%;
- NASA, 6%;
- Department of Defense, 14%;
- National Science Foundation, 15%;
- National Institutes of Health, 57%.

Few campuses approach the "average" distribution of available federal funds. Looking at your portfolio will tell you something about your relative strengths in those areas currently supported by the federal government.

An even more penetrating analysis is to determine how your portfolio shares have changed over time, and how they are changing dynamically today. That is because growth in agency budgets has not occurred uniformly across agencies or over time, and because one must examine strengths at the micro level as well. For example, funding from NASA peaked right after Sputnik; Department of Energy funding after the energy crisis of the late 1970's; and Department of Defense funding was maximized in the Cold War period. Over this same time period, new programs were put into place as new needs were identified and new research findings suggested new opportunities.

How did your campus fare in specific areas of research? This is a further extension of the portfolio approach. In business, it has become important to think of industrial clusters as meaningful ways to look at state economic strengths, and the Council on Competitiveness has suggested that today, "clusters of innovation" are the harbingers of tomorrow's new industries. So where are your institution's strengths, its "clusters of opportunity" if you will?

One approach may be to examine clusters of strength by the approach used by the Institute for Scientific Information some years ago. ISI, by finding an emerging pattern of citations (clusters of citations), was able to "discover" the new field of immunology before it was so labeled. Thus, if you know how your own clusters are constituted, and you explore what research groups your colleagues are linked to, you can begin to discern a pattern of possible collaborations.

In trying to increase your market share in R&D, these types of data <u>are</u> strategic. You must have such analyses if you are to craft an appropriate strategy for your university. Indeed, such strategic information provides the

context in which you can assess your core activities and emerging opportunities.

Again, do remember that there is no single model or form for a research university. In research, as in business, you cannot be all things to all people, and comparative and competitive advantage requires focus and direction.

What are we to make of all of this in a practical sense? How might you want to approach this dynamic environment at your own institutions now, today! Where are the opportunities? And how might you shape your vision and your strategy? These questions bring us to the third and final segment of my remarks, namely some practical considerations and ideas.

As we begin to explore how one does it, it may be helpful for me to remind you that all of you are really venture capitalists—venture capitalists of the academy. Your decisions are the basis for whether or not your universities earn a return on investment. Think about it!

Although we do have a complex and shifting R&D environment, all of the indicators that I see on the horizon make me optimistic about the future of academic R&D, but not necessarily as we now know it.

First, as I have already suggested, we have a significant opportunity to gain market share. We cannot ignore 87% of the U.S. R&D market, nor the even larger global marketplace for research. For example, organizing for global grants and contracts competition has long been the hallmark of MUCIA, the Midwestern Universities Consortium for International Activities.

Second, opportunity also exists in the very business that we are in, mainly education, if looked at from a research perspective. Educational R&D is an infinitesimally small fraction of educational expenditures, and we have not advanced the science of education nearly enough. Clearly, with Kindergarten through 12th grade education still under attack (reference Nation at Risk, 1983) and in need of reform, you can well imagine the power of any knowledge that can demonstrate what actually works in education! You can bet that this will be a huge opportunity.

Third, other opportunities abound because just as there is no single model or form that defines a research university, so also is there no single approach to gaining research strength. I believe there are opportunities for universities to create greater differentiation among themselves, either as individual institutions or through creative alliances that shape new dimensions of competitive and comparative advantages. Focus and differentiation are

respected elements of competitive strategy, and no university can afford to be truly comprehensive in today's environment.

Fourth, with so many performers of R&D, we should not be afraid to ask what will be the academic equivalent of mergers and acquisitions, of managed health care plans, and of the emerging private practice corporations? What new and innovative forms of outsourcing will be considered? What alliances and coalitions will emerge to consolidate and expand market share? And what comparative and competitive advantages will be expressed as the new generation of research universities emerges in the years ahead, as indeed it surely will?

I suggest that key among the issues that will drive such radical change is the concept of "strategic intent."

In their provocative book, *Competing for the Future*, Gary Hamel and C.K. Prahalad define "strategic intent" as "an ambitious and compelling . . . dream that energizes a company . . . that provides the emotional and intellectual energy for the journey . . . to the future." Thus, "strategic intent" conveys "a sense of direction . . . a sense of discovery . . . (and) a sense of destiny. . . . It implies a significant *stretch* for the organization."

In short, strategic intent asks you to state what it is that you want to be, and it insists that you do so in powerful and ambitious terms! It is a form of the old question: "What do you want to be when you grow up?" And so I would ask, what do you want your university to be when it grows up?

The alternatives are many. You can emulate Harvard or MIT among private universities, or maybe you want to be more like Michigan or Purdue. Or maybe you want to consider how you can best be yourself, rather than like any of the better-known universities, since there is no single model to define a research university.

Please do imagine how much more varied and numerous our alternatives can be, particularly when we expand our thinking to include the possibility of creative collaborations—both among universities and with the private sector and government.

The Council on Competitiveness, in its 1996 report, "Endless Frontier, Limited Resources: U.S. R&D Policy for Competitiveness" had this to say: "Over the next several years, participants in the U.S. R&D enterprise will have to continue experimenting with different types of partnerships to respond to the economic constraints, competitive pressures and technological demands that are forcing adjustment across the board. . . .The innovative responses to

these constraints, pressures and demands include—closer working relationships between research universities and industry, increased interaction between industry and the federal R&D establishment, and company-to-company R&D alliances among domestic competitors, suppliers and even foreign rivals."

Of course, in recent years, perhaps the most interesting partnerships involve the so-called "virtual universities." I will not dwell on them here, but suffice it to say that they merit close observation.

Another form of collaborative innovation involves mergers, which would at first seem like anathema in most large and well-established universities. But the idea of mergers in higher education is not new.

In the first half of the century, many small normal schools became parts of larger universities—and, sometime later, a similar movement occurred in regard to small law schools. In my neck of the woods, both the Akron Normal School and the Akron Law School became colleges within The University of Akron.

In the second half of this century, hundreds of institutions of higher education created consortia or opted to merge. Carnegie Tech and the Mellon Institute joined to become Carnegie Mellon University, Western Reserve University and the Case Institute combined to form Case Western Reserve University, and many such mergers have continued both here and abroad. For example, in 1986, Tift College merged with Mercer University. Here in Kansas, Kansas State University and the Salina Technical Institute merged in 1991. And just this year, venerable Radcliffe College merged with Harvard University.

That mergers are not so uncommon in higher education is evidenced by a whole literature on the subject and, testifying to the maturity of the subject, there is now even a handbook on academic mergers published just five years ago. The authors of this handbook, James Martin and James Samels, state that " . . . mergers at the collegiate level have become one of the most creative, effective vehicles academic planners now have to achieve academic excellence, to articulate a broader institutional vision, and to solidify the strategic position of the combined institution locally and regionally" (*Merging Colleges for Mutual Growth: A New Strategy for Academic Managers*, Johns Hopkins University Press, 1994, p. 3).

The book even provides a typology of higher education mergers, enumerating the following among the principal types:

- pure merger
- consolidation
- transfer of assets
- consortium
- federation
- association
- joint venture
- affiliation

If true mergers perhaps figure in the many hundreds, other forms of collaborations are in the thousands. In looking at consortia, for example, one would do well to start with the unusual model pioneered by Indiana and Purdue, which dates back to the late 1960's.

By that time, both the Indianapolis-based programs of both Indiana University in medicine and Purdue University in engineering were well established. Yet, the leaders of both universities and the state government collaborated to blend those and other programs into a single, new university campus. Since 1969, Indiana University-Purdue University Indianapolis (IUPUI) has doubled in size and built an increasingly stronger reputation. A comparable approach was also developed for the Fort Wayne campuses of Indiana and Purdue.

In 1972, a consortium of universities in Northeast Ohio—University of Akron, Kent State and Youngstown State—worked with 16 area hospitals to develop a plan to strengthen medical education in the region. B.S./M.D. programs were established on each university campus, and the Northeastern Ohio Universities College of Medicine was opened in a central location in 1975. The College now graduates more than 100 physicians each year.

In Massachusetts, five institutions created consortia through which students from any one of the colleges may enroll in courses at the other schools at no extra charge. Members of the Five Colleges Consortium are the University of Massachusetts, Amherst College, Hampshire College, Mount Holyoke College and Smith College.

The same, simple idea of resource sharing applies on an even larger scale. For example, the chief academic officers from the eleven "Big 10" universities plus the University of Chicago form the Committee for Institutional Cooperation, or C.I.C., which has provided a steady spirit of cooperation among otherwise competitive universities since its start more than 40 years ago.

From its inception, the C.I.C. has been governed by three principles:

- "that no single institution can or should attempt to be all things to all people;
- that inter-institutional cooperation permits educational experimentation and progress on a scale beyond the capability of any single institution acting alone;
- that voluntary cooperation fosters effective, concerted action while preserving institutional autonomy and diversity."

The joint efforts of the C.I.C. universities have complemented and augmented institutional programs in most aspects of university activity outside of intercollegiate athletics (which is undertaken by the Big 10 Conference). Through four decades of change, the collaborative approach of the C.I.C. has succeeded in situations in which competition alone may have been counterproductive.

Their Virtual Electronic Library offers a single interface to search all member library catalogs and to allow users to request items from any of the libraries. Recently, the C.I.C. libraries have joined in an aggressive effort to acquire electronic information resources through group licensing, saving more than $7 million in the first four years of the program.

The list of C.I.C. accomplishments goes on and on to include a pioneering regional computer network, the Summer Research Opportunities Program for talented undergraduate minority students, the Academic Leadership Program for administrators, the Minority Fellows Program, and the Women in Science and Engineering Program.

Let us remember, however, that joint efforts need not be restricted to collaboration within and among universities. For example, while I was at the University of Georgia in the mid-1980's, we developed a program which coupled the exceptional plant molecular biology strengths of the University of Georgia with the world renown summer studies program of the Marine Biological Laboratory at Woods Hole. The then MBL president, Paul Gross, and I agreed to advertise the program jointly under the banners of the two institutions—a "win-win" approach because each gained something from the other.

The new research economy also requires increased university-industry cooperation. A prime example is the type of strategic partnership, which we developed at Purdue with Caterpillar.

The essence of the partnership is simple:

- Purdue and Caterpillar have an overarching, master agreement that allows them to avoid negotiating individual projects each time one is begun;
- They sign confidentiality agreements on both sides and protect the academic right to publish;
- High-level personnel from both institutions participate, and personnel are exchanged;
- And, most important, trust is built through mutual benefit from synergistic efforts.

Of course, students are involved in every aspect of the partnership—gaining practical experience in a dynamic industry and having the opportunity for substantive job placements upon graduation. Such collaborations are critical not only to the prosperity of higher education in America but also to the ongoing economic competitiveness of the United States.

Indeed, according to one of the most recent reports from the Council on Competitiveness, "Future U.S. competitiveness will hinge not just on policies and investments at the national level, but on the capacity to foster clusters of innovation in regions across the country."

This theme is echoed in the May 31st, 1999 issue of *Forbes* magazine, where Tim Ferguson writes, "In the new economy, a cluster is made out of brainpower . . . a critical mass of skilled workers, established employers, and entrepreneurs in vital sections of the economy." In the old economy, he states, " . . . proximity to water or rail mattered a lot. Today, proximity to a university campus matters a lot."

Clearly, research universities can be expected to lead these clustering efforts. This was precisely the conclusion of the Indianapolis and Central Indiana High Technology Task Force, on which I had the privilege of serving, when it examined the development of successful technology clusters nationwide. The task force's 1998 report cited university involvement as key to the success of new technology development.

Other examples come to mind from Austin, Research Triangle Park, and Utah—about which Robert Barnhill will have more to say later. Still, even as fast moving and dynamic as technology itself may be, it is well to remember that the establishment of these technology clusters takes time.

Georgia's positioning as the economic heart of the "New South," for example, began in the late 1960's, when Governor Busbee made the unprecedented decision to add 400 faculty positions at just one university. After that early period of basic investment, Governor Harris in 1984 provided strong leadership and initial investments in R&D through what was later, under Governor Miller, to become the Georgia Research Alliance. The Alliance is credited with increasing research sponsorship at Georgia's universities significantly. Between 1990 and 1997, sponsored research at Georgia's universities went from $400 million to more than $700 million.

The Alliance also helped to:

- attract 22 eminent scholars from throughout the world to Georgia;
- accelerate growth in intellectual properties licensed from the university sector to private enterprise;
- encourage business-friendly technology transfer systems such as that of Emory University. Emory grants faculty members leaves of absence of up to one year to participate in a start-up business.

Across the nation, many other states have lagged in innovation and lost market share in R&D. Yet, one of the most encouraging signs that I see on the horizon is that some states, perhaps, are showing signs of competitive awakening, as they increasingly recognize the role of university research in economic vitality.

This year, Indiana created a 21st Century Research and Technology Fund and is prepared to spend $50 million per year in areas of strategic opportunity. Two years ago, Illinois established funding mechanisms to enhance university-based R&D. Just last week, Governor Engler in Michigan announced a $1 billion plan to create a life science research and industrial corridor over the next 20 years.

In Ohio, Governor Bob Taft has called for the state to invest in its future and to become a leader in science and technology. An early success is this year's appropriation of $30 million ($15 million in each year of the biennium) for science and technology programs recommended by the Governor's science advisor.

I could go on and tell you about many other examples or about how we are crafting the future of the University of Akron, but perhaps those that I have cited will have already provided enough fertile ground for our discussion. Suffice it to say, then, that we could all learn from many of these approaches. And, indeed, we must if we are to prosper in this fast-changing research economy.

If and when we do, then even amidst seismic rumbles of change we might come to glimpse the new landscape and new structures of emerging opportunities. We might even craft strategic intent!

I leave you with just one thought: Be cheerful, and plunge ahead!

RESPONSE

to the Keynote Address

Robert E. Barnhill
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University of Kansas

I will begin with "strategic intent" and then work my way through Luis Proenza's main points.

Strategic Intent

"Strategic intent" (Hamel and Prahalad, *Competing for the Future*) has the attributes of direction, discovery, and destiny.

1. 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." Delegation and empowerment, although desirable, are insufficient. "Better is creativity in the service of a clearly prescribed strategic intent."

2. Discovery: "Strategic intent should offer employees the enticing spectacle of a new destination or at least new routes to well-known destinations."

3. Destiny: "Only extraordinary goals provoke extraordinary efforts." Thus numerical goals are less energizing to employees than goals such as being the best in defined competitive areas.

Tools to Achieve Strategic Intent

Employees must be given the tools to achieve the strategic intent of their organization. In terms of university research, these tools include infrastructure, such as a smoothly running research administration office, and reasonable construction times of new laboratory space and acquisition of equipment. Hamel and Prahalad give the industrial example of Motorola and its formation of a corporate university for their employees to learn the tools of statistical methods, benchmarking, systems modeling, and teamwork. I can add to this example that Motorola University recently relocated to the Arizona State University Research Park so that ASU faculty could teach Motorola

employees some of these techniques. Thus this example comprises a private company's collaborating with a public university in providing the tools for the company's employees.

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 our landing on the moon.

Let me add to Luis Proenza's examples on strategic intent. In fact, I will build upon his privately mentioned example of the University of Utah in Salt Lake City. He mentioned that "the technology sectors in Salt Lake City account for $10 billion in annual revenues and that five of the six key factors in the city's development as a technology center hinge on the University of Utah." His "spin-off company that has helped create more than 150 additional computer and software companies" is the Evans and Sutherland Corporation. "E&S" was created around 1970 by David Evans and Ivan Sutherland. One of the best known of the companies due to this partnership is Silicon Graphics, started by Sutherland's Ph.D. graduate, Jim Clark.

At about the same time, Wayne Brown, Dean of Engineering, worked with President David Gardner to inaugurate the University of Utah Research Park. Their strategic intent was to develop a place where local entrepreneurship and expertise could flower. E&S became the anchor tenant for this Park. The strategic intent of Dave Evans and Ivan Sutherland was to become the premier computer graphics research group in the country and they achieved that goal at the university. They then became the first tenant, and the anchor tenant, in the university's Research Park. These three elements of direction, discovery and destiny prevailed for all of these people, relative to their respective goals.

Let us take a second example. Luis Proenza mentioned Roger Geiger's signal book, *Research and Relevant Knowledge*. I would like to walk you through the example of the University of Arizona from that book. Some of you know that I spent a decade recently at Arizona State University, just down the road from the University of Arizona. So this time I am talking about a (former) friendly rival.

Arizona became a state, the forty-eighth, in 1912. It still feels like a frontier. On the eve of Sputnik, the University of Arizona was certainly a frontier with only two doctoral programs in arts and sciences and less than $1 million of separately budgeted research. Today, the University of Arizona ranks in the top 10 public universities in research funding. What happened?

Geiger says "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." In the succeeding years 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. The two corresponding departments became the first University of Arizona departments to receive national recognition in reputational rankings in 1966. Geiger discerns a pattern to establishing these research centers: (1) a natural advantage, (2) topics a little off the beaten academic path, (3) areas of excellence that had far-reaching effects on the rest of the university.

The University of Arizona's rise to research prominence flowered under President John Schaefer from 1971-1982. Long range planning with specific qualitative research goals required the selective treatment of departments. Schaefer's vision was to bring the university to a stature comparable to the members of the PAC 10 and Big 10. Within the university he devoted sufficient resources, including the allocation of indirect cost recovery, to stimulate additional research. Outside the university, research was sold as "economic development," a sure winner in frontier Arizona. Momentum and hard work by subsequent leadership have carried the University of Arizona to its present, prominent position.

Lessons Learned

The “lessons learned” by means of these examples are that strategic intent by the top leadership of the institution, coupled with natural advantages and local expertise can lead to research enhancement that lifts the entire institution.

Luis Proenza discussed three main points: (1) a "scan" of the U.S. R&D environment, including its economic and sociopolitical aspects, (2) academic research competitiveness, including metrics, and (3) strategic questions that lead to "strategic intent."

U.S. R&D Environment

I shall add a few items to Dr. Proenza's first point. 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 follows: private rates of return 24%, public rates of return 66%. Public rates of return indicate that benefits accrue to the whole society. "Put simply, 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 the economic progress in the U.S. since World War II has been due to technology developments.
- Alan Greenspan has stated: "the unexpected leap in technology is primarily responsible for the nation's phenomenal economic performance" (June 1999).
- Internet economy: $300 billion, 1.2 million jobs (June 1999).
- Kansas jobs: average salary $25,495; average salary in information technology $45,781 (1997).
- Information technology from the 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
  - 45% of all corporate equipment investment
  - New start-up every hour (90% "fail")
  - 7.4 million Americans in the information technology industry with $46,000 average salary
  - Catalyst for economic growth and prosperity

Research Performance Measures

Dr. Proenza's second point concerned academic research competitiveness.

There are a large number of performance measures for academic research. At the 1999 summer forum of the National Association of State Universities and Land Grant Colleges (NASULGC) involving its Council on Research Policy and Graduate Education (CRPGE), we spent 1 1/2 days on this topic. We heard from Hugh Graham, co-author with Nancy Diamond of the recent book, *The Rise of American Research Universities,* and from Charlotte Kuh, Executive Director of Science & Engineering Personnel at the National Research Council.

Performance measures are used to rank and rate universities nationally, as well as to provide accountability locally. Well-known rankings are performed by *US News and World Report*, by the National Research Council on graduate education, by the Carnegie Foundation on research, and in the book by Graham and Diamond. One dichotomy is between reputational and data-based rankings. Invoking Donald Stokes' book, *Pasteur's Quadrant*, I would call this a false dichotomy, but most people choose one or the other.

A principal reason that academic performance measures are important is that we will become what we decide to measure. Thus we should select and promote measures that reflect the values we believe are important.

Hugh Graham proposes that reputational rankings are an artifact of the storied past when there were only a few significant universities. In the Knowledge Age, with considerably more interdisciplinary work as well as institutional upward movement, there are no adequate peer reviews for the multitude of research universities. In particular, the academic discipline is among the categories that are inappropriate to use for rankings. The book by Graham and Diamond uses two main categories (federal research obligations and journal publications) with three sub-categories (publications in top-rated science and top-rated social science journals and top awards in the humanities). The book uses a per faculty capita approach. By contrast, the NRC graduate study reputational rankings book uses aggregate numbers in which, other things being equal, the larger the size of the department, the higher its ranking. Graham suggested the following criteria for future studies: journal citation density, top-journal approach, research funding, and outcome measures for doctoral graduates such as first jobs taken after graduation.

At the NASULGC forum, Charlotte Kuh spoke on the National Research Council's study of graduate education. It is clear from her presentation that there will be a future NRC report ranking graduate programs. Her most positive point is that the study represents an effort by the academy to establish rating standards. Her most negative point is that it damages some programs, which should not be damaged. Among the lessons learned from the last report are the following: give universities the opportunity to ensure that the NRC has used the correct data, and consider the audience(s). Unanswered questions include how to handle interdisciplinary areas; how to recognize that more than 50% of our Ph.D. graduates do not go into university positions; and how to recognize the diversity of universities' missions.

A view that came from much of the discussion is that rankings are valid for perhaps the top 20 universities. For universities in the middle, relatively small changes in the data or the criteria can produce dramatic differences in the rankings ("computational instability").

An alternative set of criteria was presented by Anthony Boccanfuso, Pricewaterhouse Coopers LLP, who advises universities on how to identify peer institutions. The criteria are the following: federal R&D obligations and expenditures (55%), endowments per faculty, number of faculty, and licensing income. These are publicly available numbers.

Joan Lorden and Lawrence Martin will develop a paper from the results of this forum. After some subsequent discussion, the CRPGE membership will forward an accepted set of resolutions to the appropriate rankers. In addition to this effort, NASULGC has formed a Measurements Working Group.

NASULGC Measurements Working Group

This working group, chaired by President Martin Jischke, Iowa State University, seeks to bring a "NASULGC" perspective to the issue of measurements and rankings. It particularly would like to replace the *US News and World Report* approach with something that would measure the value added by universities and not focus on inputs only. The working group has met by conference phone call and concurred with the following statement of values:

As public, state and land grant institutions, we value:

1. Access to our programs and services;
2. Programs of study that are both liberal and practical in their character;
3. Both basic and applied research;
4. Engagement with our communities through extension, outreach and other partnerships;
5. Effective and efficient use of resources in adding educational value to those we serve;
6. The public character of our governance and support.

(Emphasis added)

The members of the committee have mailed to President Jischke the mission statements and what could be called performance indicators for their own institutions. Data from additional institutions would be useful.

Example of Performance Measure: Kansas Research Numbers

In Kansas, the three research universities were recently asked for their "research numbers." We interpreted this to mean numbers such as the R&D expenditures compiled each year by the National Science Foundation (NSF) from the 500 research universities, so we took the "NSF numbers" as our starting point. Because the NSF discriminates against disciplines by counting only science and engineering, we added the excluded disciplines. Finally, we also added expenditures from training grants, because we feel these have two equally important missions, research and education. These adjusted totals, which we call the "enhanced NSF numbers," will be used in the future in Kansas to measure our research performance.

Concluding Remarks

Last summer Michael Crow reminded us that we are the architects capable of designing (or re-designing) our institutions. He left us with the paramount challenge to determine our goals and the processes by which we will achieve them.

Luis Proenza has presented the national R&D environment, research competitiveness, and models of collaborations. With strategic intent, we can set and achieve goals.

Our challenge is to set in motion change, and the resulting legacy of achievement, analogously to the accomplishments of David Gardner, Wayne Brown, David Evans, and Ivan Sutherland at the University of Utah and Richard Harvill and John Schaefer at the University of Arizona.

Wheat Genetics Resource Center:

Pioneering Center Without Walls

Bikram S. Gill
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Director, Wheat Genetics Resource Center
Kansas State University

The theme of this year's conference is building cross-university alliances that enhance research. In this context, first I will outline dominant trends and challenges of the 21st century. We must treat these trends and challenges as opportunities to build cross-university alliances to enhance research and make an impact at a global level. I will follow this with the example of the Wheat Genetics Resource Center (WGRC) that is pertinent to this discussion. At the conclusion, I will make a concrete proposal for an initiative that we can launch in Kansas to enhance cross-university alliances.

Dominant trends for the first quarter of the 21st Century:

- Expanding human population from the present 6 billion to 10 billion people;
- Eroding biodiversity and environmental degradation;
- Exploding information and life sciences research.

Dominant challenges for the first quarter of the 21st Century:

- Enhance agricultural and industrial productivity to feed, clothe, house, and entertain the extra billions and billions of people;
- Conserve air, water, soil, and germplasm;
- Educate and train manpower.

Kansas lies in the Great Plains region that is the bread basket of the nation and the world. Kansas and the Great Plains region will play an even more crucial role in feeding the world in the 21st century. In Kansas, the average yield of wheat at the beginning of the 20th century was a little more than 10 bushels per acre. At the end of the 20th century, it is now nearly 40 bushels per acre! This enhancement in yield has, in part, come from improved cultural and agronomic practices, but superior genetics has played

a major role and is poised to play an even more critical role in the 21st century.

The development of an improved variety of wheat requires the expenditure of genetic resources, and we must delve ever deeper into the gene pool to improve our crop plants. Thus, eroding biodiversity, which is one of the dominant trends of the 21st century and especially of species related to our crop plants, could be devastating to the food security of the world.

It was this realization in the early 1980's that led to the establishment of the Wheat Genetics Resource Center at Kansas State University, designated as a center of excellence by the Kansas Board of Regents in 1984. The mandate of the WGRC is to conserve genetic resources of wheat, promote their utilization in wheat improvement through basic and applied research and sponsor the training of students, postdoctoral fellows, and especially visiting scientists from public and private organizations and foreign countries. All materials, technical know-how, and knowledge are made freely available.

The funding for core facilities such as the operation of the Gene Bank was secured from wheat producers (through the Kansas Wheat Commission), the Agricultural Experiment Station, the Kansas legislature, and federal funds through USDA special and competitive grants. The mission of the WGRC is endorsed by grower organizations and university scientists in 33 states. At present, the WGRC has numerous collaborative projects locally, nationally, and internationally. The WGRC has become a center without walls in the true sense of the word.

At present, 70% of the wheat acreage in Kansas is planted to KSU-bred wheat varieties and the value of the harvested Kansas wheat crop exceeds one billion dollars. Some private varieties have WGRC germplasm in their pedigrees. However, the impact of the WGRC is even bigger as its germplasm is used worldwide especially by international centers such as CIMMYT in Mexico, who in turn share wheat germplasm freely with almost all wheat producing countries in the world.

What is the secret of the WGRC's success? Several things come to mind. It has been, and continues to be, investigator-driven. It meets a critical need for readily available wheat germplasm for basic and applied researchers. It has nurtured grassroots participation, support, and shared vision with producers, consumers, administrators, and legislators. It has maintained excellence in research. Perhaps most important, it has provided a forum and a focus for collaborative research to anyone and everyone who

has an interest in wheat crop improvement. So the WGRC is poised to play an historic role to meet the dominant challenge of the 21st Century of feeding the extra billions and billions of people.

Coming to the theme of the meeting, the WGRC model can be applied to build cross-university alliances in the area of conservation genetics in the Great Plains region. Both KSU and KU are located in the Flint Hills, the last remnant of contiguous prairie in the nation. I propose that both universities pool their resources and expertise to develop a center of excellence in Prairie Conservation Genetics Initiative (PCGI). The PCGI will draw on the expertise of: the Konza Prairie/Agronomy group at K-State in ecological and range management research; WGRC expertise in experimental genetics and *in situ* conservation; and the expertise of scientists from the University of Kansas in conservation genetics research. PCGI will work with ranchers, commercial and governmental organizations and homeowners, to conserve and enhance prairie genetics, both on site and elsewhere. It also will produce a cadre of highly trained scientists who will travel the world to tackle the problems of biodiversity loss and environmental degradation that threaten the very existence of life on earth.

THE BENEFITS OF COLLABORATION TO GRADUATE EDUCATION

George S. Wilson
Higuchi Professor of Chemistry and Pharmaceutical Chemistry
University of Kansas

Collaboration is, of course, a critical aspect of human behavior and, as such, has been extensively studied by social scientists. In a recent book, *Organizing Genius: The Secrets of Creative Collaboration,* Bennis and Biederman[1] analyze the activities and performance of such diverse groups as: the Skunk Works, the special group at Lockheed that designed in 180 days the first U.S. jet fighter as well as many other innovative aircraft; the Palo Alto Research Center (PARC) of Xerox that designed the first PC in the 1970's, but failed to commercialize it; and the campaign committee that directed President Clinton's 1992 bid for the presidency. The groups that succeeded did so because of the interaction of exceptional talent, an opportunity not open to all of us, but there are still some important take-home lessons to be appreciated. We need to select the right collaborators, make sure that the mission is clearly defined and understood by all, provide the resources necessary to carry out the project, and make sure that the accomplishments of the group are effectively communicated to the scholarly community. Perhaps most important, however, is a firm belief in the project and its urgency, and the need to complete it before anyone else does.

The subject of collaboration within the academic environment has also attracted significant attention. Such questions as "Is collaboration beneficial to graduate students?" and "How can collaboration be enhanced?" have been the subjects of recent activities supported by the National Science Foundation. In a study performed in the early 1990s, Anderson[2] examined collaboration patterns in the physical and natural sciences, engineering, and in the social sciences. The focus was on the most fundamental of collaborative interactions—the doctoral candidate with his/her mentor. In the physical and natural sciences collaboration is very extensive, and the problem a candidate pursues may well be chosen by the mentor. This is, of course, logical since financial support derived from a successful grant proposal will be needed to carry out the work. By contrast, in the social sciences the doctoral candidate may be required to choose the problem of study and to carry it out, with minimal involvement of the mentor. In departments where the level of collaboration is high, several attitudes emerge. Students believe the graduate experience better prepares them for future professional activities, the interactions with their mentors are more productive, and these interactions

better encourage self-reliance on the part of the student. Collaboration also seems to lead to a more active student role in departmental activities and “fosters an atmosphere of respect and caring."

In 1995, the National Science Foundation sponsored a workshop entitled, *Connecting and Collaborating: Issues for the Sciences*.[3] The participants came from many academic disciplines within the sciences in the U.S. and abroad, and the focus of their discussion was to “understand the scientific, social, and economic impacts of using advanced communications technology." It was recognized that along with greater accessibility of information come “questions of intellectual property, confidentiality, authorial credit, institutional allegiance, privacy, and questions of tenure and promotion." Because information appearing on the Web is not always peer-reviewed, its reliability must necessarily be questioned. However, the ability to remotely access information and even to conduct online experiments remotely in real-time, offers significant opportunity to expand available resources. Technical barriers to connectivity still exist, but here in Kansas and through the leadership of Ted Kuwana and the EPSCoR program, a regional high speed network will become a reality. The Workshop also emphasized the importance of “scientific” (I might say cultural) barriers to effective communication and collaboration. My research demands that I interact with physicians, polymer chemists, and bioengineers who have very different ways of looking at the same problem. Therefore it is necessary to establish a common language and carefully define the approaches to the problem so that everyone understands the rationale.

One of the most intriguing aspects of the Internet is the manner in which it has promoted what is referred to as the “democratization” of science. I have received e-mail messages from a graduate student in Indonesia who wanted me to explain a difference of opinion on a scientific point, a high school student in Toronto writing a paper based on my research interests, or a father in Louisville telling me how urgent it is for my research to be brought to a successful conclusion. I continue to be amazed at how much information is available about what I am doing (information not even generated by me), and how, as a result of the Internet, people do not hesitate to “bother” me concerning a point of interest to them. I encourage my students to inquire of faculty elsewhere if they have questions, and many faculty have been most generous with their input.

If many of the tools for collaboration are in place, what then are the advantages of collaboration in the context of graduate education?

- Access to expertise and resources not available “in-house”
- Opportunity for student to “try wings”

- Exposure to different approaches to the same research problem
- Student experience in managing collaboration
- Exposure to different research environments
- Experience in communication and problem solving

There are, however, barriers to success in collaboration that must be overcome:

- Who is in control?
- Who gets the credit?
- Intellectual property
- Conflicts in management style
- Ineffective communication
- Lack of definition of the experimental plan

I would like to talk about three types of collaborative experiences that I have had over the years: (1) with a colleague in the same department, but a different subdiscipline of chemistry, for 25 years; (2) with three investigators in France, supported continuously during this period by the National Institutes of Health (NIH), for 15-years; (3) industrial collaboration under the support of an NIH Training Grant. These experiences must be regarded as anecdotes as I am in no position to compete with people who study such problems systematically and with a much broader base of examples.

In the first instance, there have now been about 17 graduate students and post-doctoral research associates who have worked under our joint direction. It is made clear to all of these persons at the beginning that they have to satisfy both of us, even if the advice we give seems to be in conflict. This collaboration involves synthesizing compounds (other group) and making physical measurements on them (my group). The issue from a scientific point of view is a central question in chemistry: Can the relationship between the structure of a molecule and its reactivity be predicted and understood? The students are required to manage their collaborations with the other research group. They learn that what is easy for a person trained in one subdiscipline is not necessarily readily implemented by someone trained in another area. Regular joint group meetings emphasize good communication and the need for putting the problem under study in the appropriate context. In this example the institutional and cultural differences are minimal, thus greatly simplifying interactions. Great care is, however, taken to assure proper credit in the form of author order on publications.

The second example presents a large variety of challenges because there are conventional cultural differences (French vs. American) as well as the differences in thinking between chemists and physicians or biomedical

engineers. Research is financed in a very different way in France, and such differences have to be taken into account. The structure is much more hierarchical than in the U.S., and giving graduate students too much latitude in decision-making can create problems. When students come for visits of a few weeks or months, I place the responsibility for development of an experimental plan in their laps, subject to my approval. The collaborating students teach each other, not only about the common science, but also about the way they live and their views on being a professional scientist. When French students are in the U.S. they are obliged to speak English, however, if they wish to write progress reports in French, then my students are required to read them. It is unfortunate that, in general, I cannot enforce the reciprocal arrangement, namely that U.S. students should speak French when they are in France. Although my French collaborators all speak English, they do not like to be reminded that the *lingua franca* is English and not French. (Parenthetically, I would like to see a speaking knowledge of a foreign language be a requirement for science students.) Because communication is so important, we have made use of the Internet and its predecessors for virtually the entire duration of this collaboration. Manuscripts and grant proposals are routinely shipped back and forth electronically thus effectively closing the geographical gap. We have, however, come to realize the significant limitations of this technology in promoting and maintaining human relations. For example, if controversial issues arise, we know that they may not be easily resolved by e-mail because it is impossible to attach the proper level of emotion to the communication with the result that carelessly chosen words can cause an otherwise good discussion to run off track. Personal contact is also very important, and the graduate students must be familiar with their counterparts in France. To their credit the Europeans, through the European Community, now have in my field an established system for graduate student exchange that we would do well to emulate. We have also had to deal with intellectual property issues, which are complicated primarily by the differences in patent law and institutional procedures for dealing with them.

The final experience in collaboration involves an industrial internship that is part of an NIH Training Grant in Biotechnology, the brainchild of Professor Ronald Borchardt of the Department of Pharmaceutical Chemistry at the University of Kansas. The traineeship requires an internship, typically of 3-6 months duration, that occurs late in the tenure of a graduate student, i.e., at a point where he/she has a good grasp of the research problem to be solved. The ground rules are quite specific: the problem to be worked on must be of interest to the particular group in which the student will be working, but must also be relevant to the student's Ph.D. dissertation. The work must be publishable, meaning that only a minimal delay (3 months) is permitted to establish the possible need for patent disclosure. Should intellectual property

be developed during the tenure of the student, an orderly approach to establishment of ownership is outlined. The existence of a model agreement raises everyone's optimism that this seemingly insurmountable barrier can be penetrated. A key to success in this endeavor is finding the "right fit" for the student and his/her industrial mentor. This is accomplished by having a large list of potential mentors. Generally industry will pay travel expenses to and from the site and subsistence support. The cost is quite modest: typically less than $10,000. First, a criterion for the collaboration is the possibility that the student can carry out work that could not be carried out at KU, because the equipment or expertise does not exist. Thus the student is delighted to be able to realize certain goals that previously seemed out of reach. Even in such a short time, the student comes to realize that much industrial research is "fire fighting," i.e., solving urgent short-term problems quite unlike the in-depth studies that often characterize academic research. The results have been quite spectacular. Students have returned with a level of maturity and enhanced confidence in their own abilities. They have had no problem getting jobs because they already know what kinds of questions interviewers are going to ask and why.

Perhaps one of the most important lessons to be learned from the collaborations that I have described is the realization that it is not sufficient to be well grounded in the fundamentals of one's field. It is of paramount importance to be a problem solver, and one who can effectively communicate with other collaborators and reinforce the group's understanding of the goals to be achieved.

I would like to express my appreciation to Professor Janet B. Robinson, Department of Chemistry at KU, for her very valuable input to this presentation.

Notes

[1] Bennis, W. and Biederman, P.W., *Organizing Genius: The Secrets of Creative Collaboration*, Addison-Wesley, New York, 1997.

[2] Anderson, M.S., Collaboration, the Doctoral Experience, and the Departmental Environment, *Review of Higher Education*, 19, 305-326 (1996).

[3] NSF Division of Social, Behavioral, and Economic Research, Workshop on *Connecting and Collaborating: Issues for the Sciences*, University of California-San Diego, June 1995.
Web Site: www.nsf.gov/sbe/sber/sociol/works2.htm

MISSION ENHANCEMENT AT THE UNIVERSITY OF MISSOURI

Jack O. Burns
Vice Provost for Research
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At last year's Merrill Advanced Studies Center conference on "Mobilizing for Research Opportunities in the Next Century," I proposed a strategy of *collaboration and focus* to advance the research goals of mid-sized universities like those in Kansas, Nebraska, Iowa, and Missouri. This theme, echoed in Michael Crow's keynote address, plays on our regional strengths and opportunities to excel in selected areas consistent with the missions and heritage of our public universities. In this paper, I will describe how the University of Missouri (MU) is attempting to implement this strategy through a program called *Mission Enhancement* funded over four years by the General Assembly of Missouri.

The Goals of Mission Enhancement at MU

- Increasing research productivity and extramural funding;
- Achieving national prominence and improved program rankings in selected academic areas;
- Improving graduate program quality;
- Enhancing service to the state of Missouri; and
- Improving undergraduate program quality with enhanced undergraduate research experiences and exposure to more senior faculty in the classroom.

We have completed the first year of Mission Enhancement and have approved programs for the second year that began on July 1, 1999. To date, about 125 new faculty positions have been approved for hiring. Our first "crop" of Mission Enhancement faculty will begin their teaching and research duties at the university for the Fall 1999 semester.

Four broad areas of academic enhancement were chosen consistent with MU's Strategic Plan and based upon extensive discussions with faculty leaders and focus groups. These Mission Enhancement areas are termed *Life Sciences, Connections, Quality of Life,* and *Global Information Access*.

Examples of enhanced programs within these categories are given in Table 1. They were selected using faculty committees to review proposals following a general campus solicitation. It is believed that Mission Enhancement will build upon an already strong base and raise these programs to world-class stature. We are focusing funding in selected areas with strong research and collaboration potential (across campus and the nation).

Table 1. Examples of Mission Enhancement Areas & Programs

Life Sciences	***Connections***	***Quality of Life***	***Global Information Access***
Cardiovascular Health	Biological Sciences	Addictive Behaviors	Network Learning Systems
Crop Genomics	Science Education	Gerontology	Spatial Analysis
Radiopharma-ceutical Science	Communications	Dispute Resolution	Knowledge-Based Health Care
Biophysics	Math & Math Education	Public Policy	Computational Mathematics
Neural Basis of Behavior	Theatre & Writing		Electronic Commerce

The first enhancement area is the "Life Sciences" which has a strong history of excellence and interdisciplinary research at MU. A new Center for Crop Genomics was created last year with several new faculty positions from Mission Enhancement, remodeled laboratories from state and federal funding, and over $11 million in multiyear grants in maize and soybean genomics from the National Science Foundation (NSF) plant genome project. Similarly, we formed a new Center for Radiopharmaceutical Science which takes advantage of the nation's largest university research reactor (a 10 megawatt facility) on the MU campus. The reactor generates short-lived (days to a week) radioisotopes used in the treatment and research of cancer. Over the next few years, MU will seek designation as a Comprehensive Cancer Center by the National Institute of Health's National Cancer Institute. The Reactor and Radiopharmaceutical Science Center along with the Ellis Fischel Cancer Center and the Schools of Medicine, Nursing, and Veterinary Medicine will form the core for our proposal to become a National Cancer Institute Cancer Center.

"Connections" is the second enhancement area with a principal goal to improve student education through direct exposure to research across the

academic disciplines and through exposure to more senior faculty in the undergraduate classroom. As can be seen from Table 1, a wide range of academic areas are participating in this enhancement, particularly from the sciences and the humanities. For example, creative linkages between the Department of Mathematics and the College of Education will be used to design new approaches to Math Education in the public schools, supplemented by a major grant from the NSF. Similarly, a new Center for Literary Arts is being created that will combine the talents of faculty in English, Classical Studies, and Theatre to offer a new range of writing options for our students.

"Quality of Life" is a broad-based program intended to address socially-relevant research in areas such as tobacco and alcohol abuse, and dispute resolution in national and international arenas. Once again, these programs are highly collaborative and join together teams, for example, in Medicine and Psychology, and in Law and Political Science. One such innovative program involves new approaches to research in gerontology, an issue of great importance to the aging rural population of the Midwest. TIGR Place will create a new center for the treatment and research of an aging population using federal funding, new faculty positions from Mission Enhancement, and industry collaborations. It is a joint project between Nursing, Medicine, and Psychology.

The fourth Mission Enhancement area is "Global Information Access." It encompasses computers, computer networks, and the Internet as forces that are rapidly generating new approaches to learning, research, and access to the marketplace in a global information age. Research in computer science, computational mathematics, and geographic information systems are prominent in this area. In addition, an exciting new multi-disciplinary program in Electronic Commerce is being created. It brings together faculty in business, law, journalism, political science, and apparel management to address the explosion of E-commerce on the world-wide web, both as a platform for student learning and as potential intellectual property development for faculty researchers.

The Heartland Research Consortium

As a final example of the collaboration and focus strategy, I will describe an exciting new consortium formed last year here in the "heartland." It is composed of the chief research officers of 10 Midwestern research universities including Illinois, Washington University, MU, Iowa, Iowa State, Kansas, Kansas State, Nebraska, Oklahoma, and Oklahoma State.

The goals of the Heartland Research Consortium include:

- Stimulate new research collaborations between the Heartland universities;
- On-going discussions of issues of common regional interest;
- Learn from one another in addressing challenges of research administration.

The consortium meets twice per year. The fall meeting is at the annual conference of the National Association of State Universities and Land Grant Colleges. The spring meeting alternates between hotels near the St. Louis and Kansas City airports. Our discussions have resulted, in part, in helping to stimulate new collaborations and funding on swine genomics (Iowa State and MU) and in medicine.

The first major initiative of the Consortium is sponsorship of an international conference on *Genetically-Modified Organisms* in Fall 2000. We have garnered co-sponsorship of this conference by the American Association for the Advancement of Science and we are currently seeking external funding. All ten universities are participating in the planning with university teams consisting of scientists, humanists/ethicists, and administrators. This conference is an excellent example of multi-institutional collaboration that will bring international attention and leadership to our region in an area of emerging research excellence for the Heartland universities.

MANAGING INTELLECTUAL PROPERTY

ARISING FROM RESEARCH

P.B. Swan
Vice Provost for Research and Advanced Studies
Iowa State University

Public universities must make their knowledge and expertise available to the publics that they serve. When university researchers develop new knowledge through research, they make it available to the public in a variety of ways, the most common of which is publication in scholarly journals. Additionally they may use other means to call public attention to new information, such as by publishing in trade journals and, through press releases, by providing that information to newspapers, radio, and television. When there is the opportunity for the new knowledge to lead to a potentially useful product or a better manufacturing process, it is developed and protected as intellectual property so that it can be commercialized and the public can benefit. As a result, research universities establish special policies and programs for managing the intellectual property that arises from their research.

Active development and management of intellectual property by universities began in the first decades of this century, but it was not until 1980 that universities received a mandate from the federal government, through the Bayh-Dole Act, to develop and manage intellectual property that results from federally supported research. Recently this legislation, along with current interest in intellectual property related to biotechnology and the information sciences, has caused universities to pay special attention to their intellectual property responsibilities (Table 1). Moreover, increasing collaborations with industry and other universities have put special emphasis on thoughtful and appropriate intellectual property arrangements.

Current interests in the use of the Internet for publishing and in web-based instruction have carried the university's intellectual property concerns into the areas of information resources and instruction. Developments in these areas are causing universities to face many new and perplexing intellectual property questions. This paper, however, focuses on the intellectual property that arises from research and is not intended to address issues of internet- or web-based activities. Instead it considers some fundamental questions that university administrators might ask about managing intellectual property matters related to research grants (such as federal grants) and contracts, such as those for doing research sponsored by

a company. It does not, however, provide a guide to implementing a program for management of intellectual property.

Why Manage Intellectual Property Arising from Research?

The most direct answer to this question is that federal agencies require that intellectual property arising from federally funded research be managed. The university can carry out all of the process, or it can do only the initial stages of disclosure and then notify the federal agency personnel of the existence of intellectual property and give them an opportunity to manage it. Other compelling reasons to manage intellectual property include the need to protect the public investment in an invention and to protect the interests of the inventor(s) (Tables 2 & 3). Moreover, collaborations with other institutions and with industry require thoughtful intellectual property considerations beginning at the outset of the collaboration.

The most uninformed answer to this question is that it will provide a large revenue source for the university. With only a handful of exceptions[1] universities do not realize great revenue streams from intellectual property. Its development and management are expensive processes, and most universities hope only to get enough income from the process to pay for expenses and return modest incentives to the inventors and their departments for their efforts (Table 4).

At What Point in the Process should this Management Begin?

When research is being carried out under contract, the best time to agree on the basis for management is when the contract is being written. Most private entities require this, and federal contracts often have special intellectual property clauses. Sometimes both parties to a contract assume that no intellectual property will arise, due to the nature of the research, but this assumption may be erroneous and can lead to disagreements and hard feelings if unexpected intellectual property results. Usually it is better to agree in principle on the basis of intellectual property management even if none is expected.

When a federal grant for research is involved, general federal policy applies and usually there is no need for special intellectual property consideration at the outset. (A small number of federal programs are an exception to this rule and may appear to be going counter to the spirit of the

[1] In fiscal year 1997 the AUTM survey indicated licensing income of $52 million for Stanford, $50 million for Columbia, $30 million for Florida State, $21 million for MIT, $18 million for Michigan State, $18 million for University of Florida, and $17 million for W.A.R.F.

Bayh-Dole legislation. Those grants and contracts will require special consideration on the part of the university before acceptance.) Most often the first need to manage intellectual property arising from federal grants comes with the disclosure of such from the inventor(s).

The need for early involvement of intellectual property issues in contracting for research suggests that the university should connect its contracting operation with its intellectual property management. The need to receive, as a minimum, disclosures of intellectual property arising from federally supported grants suggests that the intellectual property programs should have good relationships with the principal investigators on those grants.[2]

Who Should Manage the Intellectual Property Arising from Research?

Public research universities operate under both federal and state laws. State laws differ with regard to intellectual property ownership and with regard to the legal affairs of a university. For this reason, the best way for the university to organize management of its intellectual property will vary from state to state. Factors that must be considered include how the inventor(s) rights are assigned to the university and the flexibility that the university has for managing the legal matters related to intellectual property.

Where the university's ability to manage its own legal affairs is limited, it may choose to establish an independent organization that has more freedom to engage directly in legal affairs and to which the university will assign its intellectual property. Such an organization may specialize in intellectual property management only, or it may include additional management of research programs.

In all cases, the university should consider how its intellectual property operation relates to its inventors and should assure a close relationship with them. Moreover, the university should assure that those who manage its intellectual property have the expertise required to manage it efficiently and effectively.

What are the Risks and Benefits Associated with such Management?

A university that has a well-managed intellectual property program is a better research partner for business and industry. Often opportunity for

[2] For one effort to communicate with university inventors see *Intellectual Property Handbook: Benefiting Society with Iowa State Innovations*, Iowa State University Research Foundation, Inc. and Office of Intellectual Property and Technology Transfer, Iowa State University, 1999.

commercialization is required to realize the value of an invention and intelligent protection is a great asset to this process. Appropriate protection of intellectual property can greatly increase its value in the marketplace. Poorly managed programs will produce more disagreements. Moreover, they will result in lost value from the research program and, perhaps, in the loss of the rights of the inventor(s) and public investors in the university.

Other risks and benefits are associated with defending the intellectual property against infringement. If intellectual property is not defended, it is of no value. Its owner and those who have licensed rights to it must defend the property against infringement. This will usually involve legal action, often in the form of limited warnings, but may involve actual lawsuits. The university, or its specialized intellectual property organization, must be willing to take the risks associated with litigation if it is to recognize the benefits.

The university incurs some risks, but also benefits, in the decisions it makes about the license fees and royalties that it will charge or the equity that it will take in the licensee. Charges that are excessive may cripple a new company and can even result in its failure. Charges that insufficiently recognize the value of what is being licensed may lead to the appearance that the public non-profit entity is giving away value to a for-profit entity. This could have implications relating to tax law. These aspects of intellectual property management require wise judgments on the part of expert personnel.

Conclusion

In the next decade well-administered public research universities will have well-managed intellectual property programs. Such programs will facilitate collaborative agreements. Currently, many have established strong programs, but others have not. Most would benefit by thoughtful review and assessment. The questions considered in this paper are among those that must be addressed when thinking about what is involved in establishing such a program. They indirectly suggest some of the criteria that might be used in assessing program effectiveness.

Table 1. Licensing and Other FTEs in Tech Transfer[3]
(AUTM survey for FY97)

University	Yr. Start	Licensing FTEs	Others
Iowa State	1935	5.5	4.5
Kansas State	1942	1.0	1.5
Purdue	1988	3.0	6.0
U. Kansas	1994	5.0	2.0
U. Missouri System	1987	0.5	4.0
U. Nebraska	1996	2.25	0.5

Table 2. Sponsored Research Expenditures ($ in millions)
(AUTM survey for FY97)

University	Total	Federal	Industry
Iowa State	185.5	83.0	8.5
Kansas State	33.6	18.6	5.0
Purdue	206.6	92.0	26.1
U. Kansas	102.9	65.5	20.0
U. Missouri System	140.0	45.6	9.6
U. Nebraska	102.5	32.4	3.5

Table 3. Licenses and Options Executed
(AUTM survey for FY97)

University	97 Total (Cum.)	Exclusive	Non-exclusive
Iowa State	133 (418)	28	105
Kansas State	5 (46)	4	1
Purdue	52 (202)	28	24
U. Kansas	7 (38)	5	2
U. Missouri System	20 (60)	14	6
U. Nebraska	4 (N/A)	4	0

[3] AUTM Licensing Survey: fiscal year 1997, Ed. D.E. Massing, Association of University Technology Managers, Inc., 1998.

Table 4. Income from Licensing
(AUTM survey for FY97)

University	# Licenses Yielding Income	$Millions
Iowa State	186	7.0
Kansas State	31	0.27
Purdue	182	1.8
U. Kansas	30	0.72
U. Missouri System	14	1.4
U. Nebraska	15	0.64

GRADUATE EDUCATION AND RESEARCH IN THE YEAR 2000:

FASHIONING HORIZONTAL FLEXIBILITY IN A VERTICAL WORLD

R. W. Trewyn

Vice Provost for Research and Dean of the Graduate School
President, KSU Research Foundation
Kansas State University

Public research universities face many of the same challenges today that American businesses faced in the 1970's and 1980's—adapt and change or sink beneath the weight of outmoded, inflexible bureaucracies and practices. The private sector was remarkably successful in accomplishing its transformation; one need only view the unprecedented U.S. economic prosperity of the 1990's for confirmation. Time will tell whether those employed in the tradition-clad Ivory Tower can be so insightful.

It is crucial that universities focus their limited resources on enhancing areas of strength and emerging importance, not shoring up areas of weakness or, even worse, distributing insufficient resources equally across the academic spectrum. Equal suffering helps no one—not even the equivocating bureaucrat/administrator in the long run—yet this tends to be the norm in many university settings.

How did American businesses accomplish their remarkable metamorphosis? For one thing, companies were forced to do a comprehensive operational assessment, then change their way of doing business … not an easy task. Some of the most common changes are shown in the adjacent insert compiled by Kansas State University Professor Brian Niehoff. It's interesting to speculate on how these might be applied to research universities. Would they work institution-wide? Can they be used in innovative ways in graduate education and research?

CHANGES IN TODAY'S ORGANIZATIONS:

- **Less Hierarchy/More Flexible Structures**
- **Focus on the Customer (Quality)**
- **Teams, Teams, Teams**
- **Seeking Competitive Advantage**
- **"Value-added" Philosophy**

Brian P. Niehoff, Business Management, KSU:
From the Provost's Lecture Series for 1998-99.

Less Hierarchy/More Flexible Structures

Clearly, the most difficult parameter to implement is the first: less internal university hierarchy/more flexible structures. Universities, with their disciplinary boundaries, are inflexible by design, and their hierarchical structure is unwieldy more often than not.

At last year's Merrill Conference, Professor Richard Schowen argued that "measures that depress the roles of territorial feeling and territorial reasoning (while preserving the benefits we derive from our much-loved disciplines) should advance the cause of institutional flexibility in meeting research challenges."[1] Identifying those measures would, of course, be beneficial, but universities have a long way to go before achieving horizontal flexibility in their historically vertical world.

One common approach to overcoming campus territoriality involves the formation of centers and institutes and interdisciplinary research and graduate education programs. Unfortunately, cumbersome upper university bureaucracies create impediments for such endeavors far too often. And these interdepartmental structures may still be too rigid for timely responses to emerging opportunities in today's explosive information age. New horizontal models or, at the very least, substantially greater flexibility are needed.

Focus on the Customer (Quality)

Most universities would contend that they already focus on the customer—their students—and that they deliver a quality product—a first-class education—to those customers. Many do; that's clear. But, that really isn't the private-sector lesson with regard to focusing on the customer. The lesson is to *listen* to the customer and understand the customer's needs. In that regard, many universities don't measure up. There are still too many remnants of the elitist, "intellectuals know best," attitude lurking about.

For universities, their customers are not only the students they serve, but also the employers who ultimately hire those students. Employers in the private sector, especially, complain that today's college graduates lack many of the skills necessary for success in the workplace: communication skills, real-world problem-solving skills, the ability to work in teams, etc. To answer these criticisms, universities need to open meaningful dialogs with their customers (students *and* employers), then provide quality services that respond to their customers' needs.

There's a reason for the growing competition in the advanced education market: traditional universities aren't listening to their customers . . . others are.[2]

Teams, Teams, Teams

Many research universities do an outstanding job of teaching independent problem solving to their students. Then the students graduate, go out into the real world, and discover that problem solving occurs in teams. Most graduates aren't prepared to work that way.

Academic teamwork, when it exists, too often involves solving a problem in some narrow discipline. Some classes do employ group exercises, but how broad are the issues they address? Most often, not very. Even in academic programs defined as "interdisciplinary," few students actually work as part of a team, solving their part of a larger, complex problem. Some "real-world" models are crucial here.

A broader, systems engineering-style approach is needed. Ideally, this might include natural scientists working with social scientists, working with engineers, working with business analysts, and so forth. Disciplinary constraints of problem solving would be removed, and everyone would benefit from the breadth of the experience, especially if some private sector expertise were thrown into the mix.

One highly innovative graduate program with this sort of blend was launched in 1993 in Maryland. The "From Lab to Market" project at the University of Baltimore, in partnership with the state's economic development agency, brings together teams of master's degree students from business, law, publication design, and engineering to formulate fully developed commercialization strategies for technologies from federal laboratories. Teamwork is an absolute requirement, but too few such examples exist.

Seeking Competitive Advantage

The comprehensiveness of academic programs is an important component of the competitive landscape in higher education, but the meaning of that descriptor is changing. The vast majority of American research universities, public and private, have now recognized that being "comprehensive" doesn't have to mean being all things to all people. Few institutions can afford such exorbitance in this day and age. Consequently, most universities have developed strategic plans to focus their efforts on areas in which they excel or hope to excel.

Typically, these strategic plans include an assessment of institutional strengths and weaknesses in an effort to identify areas of competitive advantage. However, all too often universities become married to the plan itself, forgetting Dwight D. Eisenhower's advice: "Plans are worthless, but planning is everything."[3] The institutions that will win-out in the information age are those that combine institutional strengths and vision with *ongoing* strategic planning. Fixed plans won't work in a rapidly changing environment.

Building strategic alliances offers another valuable approach. Universities in America's heartland have faculty on par with the top-rated research institutions in the country, but often, the number of faculty in any particular sub-discipline are few in number. As a result, partnering with other public sector and private sector entities provides an invaluable means for leveraging resources and creating a competitive advantage.

"Value-Added" Philosophy

If the first item on Professor Niehoff's list is the most difficult for public research universities to implement, the last is unquestionably the easiest. "Value-added" is what higher education is all about. That philosophy is integral to the tripartite mission. Teaching adds value. Research adds value. Service adds value.

Higher education institutions don't necessarily market their wares as value adding, but that's certainly the outcome. If you check the Census Bureau data for average annual earnings based on level of education, you will see that income goes up at every step; value is added. Similar conclusions can be drawn from the economic impact of university research and service.

Of course, "value-added" can mean different things to those delivering a product or service and those receiving a product or service. However, for those institutions focused on their customers (i.e., those listening and responding), value-added should resonate as a "win-win" outcome for both parties.

Graduate Education and Research at Kansas State University

A number of new graduate education and research initiatives have been launched at Kansas State University, many of which should allow us to take advantage of the lessons learned from the private sector. Most of these endeavors are still in their formative stages, so data are lacking as to their long-term impact. Still, we are hopeful that at least some will yield the anticipated positive outcomes.

Graduate Certificate Programs: Policies and procedures have been developed which are intended to allow the proliferation of graduate certificate programs, a core cluster of courses in some specialty area. These programs have the potential to expand our capabilities in graduate education in a variety of ways. For example, more than 50 percent of the science and engineering doctoral degree recipients nationally take jobs in the private sector.[4] A graduate certificate in business could prove to be invaluable for these individuals. Many students should be able to pursue such certificates concurrently with their regular graduate program; others may find them useful for professional development after entering the job market.

For students pursuing graduate study on a part-time basis (a common occurrence in a hot economy for some disciplines), it will be easier to earn a post baccalaureate credential—a graduate certificate. If the certificate is part of the core curriculum for a master's or doctoral program, this may then serve as an incentive for certificate recipients to undertake full-time graduate study at some later time (e.g., when the economy cools).

Examples of some existing, developing and potential graduate certificate programs at K-State are shown at the right. These and other graduate certificates are expected to serve a variety of innovative purposes. Many of them are easily adaptable to multimedia and distance delivery, thereby expanding the customer pool. Others will build more horizontal flexibility into the graduate curriculum.

GRADUATE CERTIFICATE PROGRAMS

Existing/Developing:	**Additional Examples:**
Air Quality	**Agribusiness**
Business Administration	**Bioengineering**
Complex Fluid Flows	**Bioinformatics**
International Service	**Crisis Communication**
Material Science	**Food Safety**
Occupational Health	**Genomics**
Science Communication	**Graphic Design**

A recent article about graduate certificate programs can be found in *CHANGE* magazine,[5] and it is clear that many of the private-sector lessons discussed above are applicable to such programs, i.e., they can enhance flexibility, address customer needs, provide competitive advantages, and add significant value. Moreover, it may also be possible to use them in creative ways to provide experience working in teams.

Graduate Student Recruitment: Competition for graduate students is fierce in many disciplines, especially in the face of declining graduate school enrollments nationally.[6] While the individual graduate programs usually

accomplish graduate student recruitment most effectively, there may be institutional attributes that can provide competitive advantages as well.

At K-State, the graduate school has launched a broad-based *Military Graduate Student Recruitment Program* to capitalize upon the military-friendly, veteran-friendly atmosphere that prevails on campus. Many college campuses are unfriendly toward the military and military veterans, an attitude that has prevailed from the campus-based antiwar movement of the 1960's and 1970's.[7] Few, if any, remnants of those prejudices are apparent at K-State.

The *Military Graduate Student Recruitment Program* has four main focus areas: (1) ROTC students, (2) active duty military personnel, (3) members of the National Guard and reserves, and (4) transitioning personnel (those soon to attain veteran status).

A deferred entry option is being developed which will allow qualified ROTC students applying to graduate school to be admitted, but with delayed entry into their specified graduate program. This should be of value to individuals making a career of the military, as well as the majority who get out after one tour of duty.

Career military officers are required to pursue post baccalaureate education to be promoted, so efforts are underway to recruit significant numbers of these individuals to graduate school at K-State. Additionally, national security experts are concerned that terrorists could introduce biological or chemical agents into the food chain or water supplies in this country,[8] and National Guard and reserve components will be among the first responders to such an emergency. K-State is well positioned to provide advanced education in food safety, environmental remediation, and a host of related areas.

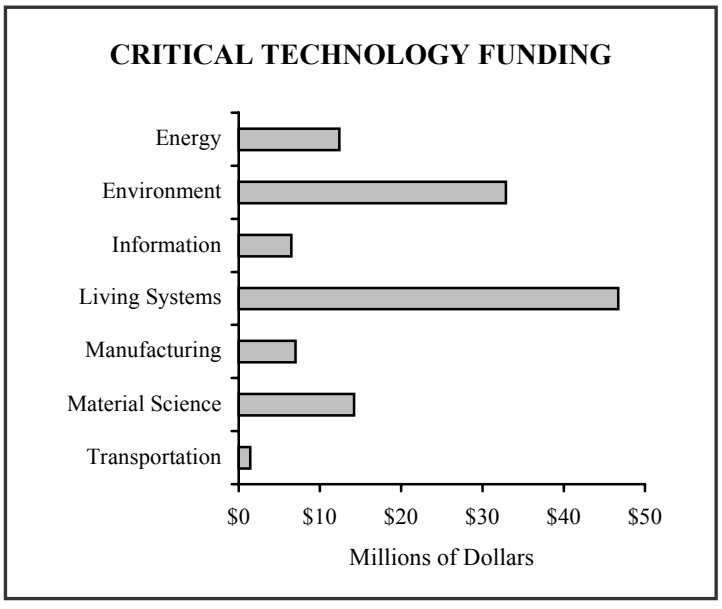
Also, for those leaving the military, graduate school is not normally among the transition assistance options from which they select. This provides an opportunity for K-State to establish a national pilot program working with the appropriate federal and state agencies providing the assistance. These efforts are underway.

Strategic Technologies: The Kansas Technology Enterprise Corporation (KTEC) recently asked the research universities in the state to identify their strategic research thrusts for the future. As part of that effort at Kansas State University, an assessment was undertaken of our core research competencies, an assessment we chose to link to the nationally designated critical technologies.

The federal government defined seven broad national critical technology areas several years ago: energy, environmental quality, information and communication, living systems, manufacturing, material science, and transportation.[9] A summary of extramural funding in those areas at K-State in recent years yielded the results shown in the figure below.

As can be seen, living systems and environmental quality far out-distanced the other areas. Furthermore, the federal critical technology subcategories of biotechnology and agriculture/food under living systems and environmental remediation under environmental quality made up the vast majority of the funding. These three subcategories can all be considered components of agricultural biotechnology, and this is an area where K-State should be able to leverage a competitive advantage.

The concerns of national security experts over agricultural and environmental terrorism (mentioned above under *Graduate Student Recruitment*) present an opportunity for biotechnology research to address the emerging threat. Various programs—most inter-disciplinary in nature—are being formulated to meet future needs in this area.



Of course, even with a focus on agricultural biotechnology, we do not plan to forgo research opportunities that might arise in other areas. K-State leads a 10-state, 14-university hazardous substance research consortium for the Environmental Protection Agency. Research in this area will continue as a priority. An engineering research center proposal is also being developed which links K-State expertise in energy research with that in another U.S. critical technology, material science.

And the KTEC Center of Excellence at K-State, the Advanced Manufacturing Institute (AMI) with its innovative Manufacturing Learning Center, provides an integrated model linking teaching, research, and service.

AMI is gaining ever-increasing support and recognition from federal and non-federal sponsors, and manufacturing remains one of K-State's primary strategic technologies, serving a major sector of the Kansas economy.

Technology Transfer/Entrepreneurship: Commercialization of university intellectual property is a significant activity at many public and private research universities. In some instances, it has been linked directly to the institution's mission.

At Kansas State University, we have allied research and graduate education directly to the institution's technology transfer activities carried out by the KSU Research Foundation (KSURF). Moreover, KSURF has established formal linkages with the Mid-America Commercialization Corporation (MACC), which is charged with facilitating technology-based economic development. MACC, based in Manhattan, is one of three commercialization corporations in the KTEC network.

The horizontal organizational structure has removed hierarchical impediments in the transfer of technology from university research laboratories to the private sector; it employs a team-oriented approach. Naturally, each element has a primary role to play: the research office at K-State handles, quite obviously, faculty research matters; KSURF manages the disclosure and protection of university intellectual property; MACC facilitates commercialization activities, whether licensing to external entities or launching local start-up initiatives. However, decisions and meetings with faculty and other stakeholders may well involve personnel from all three units, plus others.

Entrepreneurial initiatives based on university intellectual property provide a compelling economic development opportunity, and possibilities for external licensing tend to be more limited in remote, non-urban areas like Manhattan, Kansas. Therefore, at K-State, we consider local start-ups to be a preferred mode for technology transfer in many instances. Of course, finding sufficient resources to start them is another matter.

The federal Small Business Innovation Research (SBIR) awards and other business-oriented grant programs provide a means for launching new start-ups, and we have established procedures to allow university faculty to participate in these programs. That being said, no two ventures are ever the same, so few generalities can be made—another indicator of the importance of less hierarchy/more flexible structures.

One key element though is MACC's ability to provide the initial financial, management and business expertise for a new start-up. More

technology-based companies fail because of shortcomings on the business side of the operation than on the technology side. MACC can provide assistance until the company has matured to the point of hiring its own management team. Moreover, KSURF may be able to bear the initial costs of patent protection for the technology, saving another potential drain on a new company's limited assets.

While our efforts in entrepreneurship are relatively recent, we are hopeful that significant successes will be forthcoming. Indications to date are very favorable. Nantek, our first true start-up, has received multiple phase I and phase II SBIR grants, as well as other awards. Nantek already employs a number of KSU graduates. Kansas Advanced Technologies, our newest start-up, has recently received award notices for two phase I SBIR grants. Progress is being made.

We also see additional opportunities to involve K-State graduate and undergraduate students in these initiatives, although student interns are employed to some extent already. Nevertheless, it would be helpful to have technology transfer and entrepreneurship as larger components of the curriculum for students, especially in the sciences and engineering. Various means are being examined to make this happen.

Cashing-in or Crashing in Y2K?

Higher education is at a crossroads in America, but internal pressures to maintain the status quo can be monumental. Those universities that recognize the similarities to the state of U.S. businesses in the 1970's and 1980's and apply the lessons those businesses learned are more likely to prosper or "cash-in" in the next millennium. Those that don't may be facing a significant Y2K problem.

Universities must streamline their operations and create more flexible, horizontal elements in their tradition-bound vertical mold. This will lay the foundation for truly interdisciplinary teamwork and partnering to solve the complex issues and problems of the coming century. Universities that do these things while listening to their customers—all their customers—will automatically have a competitive advantage. What's more, they will likely be adding additional value at all levels in teaching, research, and service.

At Kansas State University, we are attempting to adapt some of the private sector organizational changes to graduate education, research, and technology transfer. Time will tell how successful these efforts will be.

Notes

[1] Richard L. Schowen. "The End of Interdisciplinary Research." In Proceedings of the Merrill Advanced Studies Center conference *Mobilizing for Research Opportunities in the Next Century*, vol. 102, pp. 51-60, Lawrence, Kansas: University of Kansas, July 1998.

[2] Jeffrey Selingo. "Businesses Say They Turn to For-Profit Schools Because of Public Colleges' Inertia." *The Chronicle of Higher Education: Today's News*, 14 July 1999.

[3] Dwight D. Eisenhower. Statement made in a speech at the National Defense Executive Reserve Conference, 14 November 1957.

[4] Committee on Science, Engineering, and Public Policy, National Academy of Science, National Academy of Engineering, and Institute of Medicine. *Reshaping the Graduate Education of Scientists and Engineers*, National Academy Press, Washington, D.C., 1995.

[5] Alice J. Irby. "Postbaccalaureate Certificates." *Change*, pp. 36-41, March/April 1999. Also, note the editorial in the same issue by Ted Marchese entitled, "The Certificates Phenomenon," p. 4. In it, Mr. Marchese states: "Unlike so many developments we feature in *Change*, the certificates phenomenon seems almost entirely good news."

[6] Peter D. Syverson. "Data Sources: Early Returns of 1997 CGS/GRE Survey Reveal Second Year of Graduate Enrollment Decreases." *Council of Graduate Schools Communicator*, 31 (10): 7, November/December 1998.

[7] Jay Mathews. "No Glory, No Parades, No Jobs?" *The Washington Post*, 29 April 1995. Or, for a review, see: R.W. Trewyn and James A. Stever. "Academe: Not so Hallowed Halls for Veterans." *Journal of the Vietnam Veterans Institute* 4 (1): 63-75, 1995.

[8] "U.S. Could Face New Terror Tactic: Agricultural Warfare." *The Philadelphia Inquirer*, 22 June 1999.

[9] National Critical Technologies Panel. *Report of the National Critical Technologies Panel*, U.S. Government Printing Office, Washington, D.C., 1991. Subsequent reports have also been published, but with essentially identical critical technologies.

INTERDISCIPLINARY RESEARCH IN THE HUMANITIES:

RECIPES FOR ELEPHANT AND RABBIT STEW

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I borrow the culinary metaphor in my title from the well-known anthropologist Clifford Geertz. His elephant and rabbit stew analogy reminds us that cross-disciplinary marriages rarely occur between equals and thus may generate anxiety. Geertz notes, for example, that history has increasingly borrowed subjects and methodologies traditionally associated with anthropology, while anthropology has adopted diachronic analysis that has always been history's domain:

> History is threatened (one hears it said) by the anthropological stress on the mundane, the ordinary, the everyday, which turns it away from the powers that really move the world—Kings, Thinkers, Ideologies, Prices, Classes, and Revolutions—toward bottom-up obsessions with charivaris, dowries, cat massacres, cock fights, and millers' tales, that move only readers, and them to relativism. . . . Anthropologists complain that the historian's reliance on written documents leaves us prey to elitist accounts and literary conventionalisms. Historians complain that the anthropologists' reliance on oral testimony leaves us prey to invented tradition and the frailties of memory.[1]

Geertz concludes that, despite the "shouting in the street" (his term) about the blurring of disciplinary boundaries, the encounters between history and anthropology have on the whole been salutary and that the influence of one discipline on the other has stabilized: "Any conjunction, whether as a mixture of discourses or as a convergence of attention, is bound to be an elephant and rabbit stew ('take one elephant, one rabbit ...'), about which the elephant need not unduly worry as to its savor coming through. As for the rabbit it is used to such arrangements" (334).

I suspect Geertz would be wary (I certainly am) of the kind of disciplinary blending recommended by E. O. Wilson in which all boundaries between disciplines disappear through universal "consilience," as he calls it. In an unpalatable recipe for elephant and rabbit stew, Wilson argues for the unity of all knowledge—specifically that of the Humanities and the Social Sciences, which he lumps together, and the hard sciences. In his recipe the flavor of the hard sciences, especially biology, overwhelms that of the

humanities and social sciences. He attempts to explain all phenomena—including aesthetic enjoyment—in biological, that is, genetic, terms.[2] Both the Geertz model and the Wilson model for contact between the disciplines suggest fairly permanent changes in disciplinary fields; in Geertz's formulation the influence is mutual, in Wilson's one-sided.

I want to concentrate here on humanities research and what I consider salutary encounters between research fields for humanities scholars. Geertz is rather self-effacing (perhaps ironically so) in proposing that history is the elephant and anthropology the rabbit in his interdisciplinary stew. Rarely is a humanities discipline the dominant flavor in any cross-disciplinary recipe. The culture wars that are so much in the news these days have in part been motivated by the humanities' adoption of social science topics and methodologies. Geertz's own landmark work on Balinese cock fights has had significant influence not only on history but on literary studies as well. Humanities scholars have to some degree abandoned their traditional territory—the appreciation of the true and the beautiful—to focus instead on social phenomena such as gender, race, and class.[3] A certain number of humanities faculty at the University of Kansas (KU) have moved a portion of their appointments to area studies programs where they can more comfortably include social science material in their teaching and research.

Without passing judgment on these "arrangements" as Geertz calls them, I want to focus the remainder of my remarks on the interdisciplinary recipes that I believe are most productive for much humanities research. They are not the blendings that create permanent changes in an individual scholar's field but flavorings that make a difference in that scholar's current project or in the way he or she conducts his or her career-long research program. Rather than addressing the abstract level of fields or disciplines, I want to talk about interactions between real people who are carrying out specific creative or research programs. It is difficult to find a precise term for the kinds of experiences with another discipline that I have in mind, so I will just simply baptize them "inspirational encounters." In an inspirational encounter a scholar receives an enabling idea from another; one disciplinary approach borrows a spice or two from the other.

I offer my own career in Spanish literature and the history of ideas as an example of an enhancing interdisciplinary encounter with philosophy. When I was an M.A. student at the University of California at Davis, the graduate teaching assistants' offices were located across the hall from the Philosophy Department on the floor below those of the regular foreign literature professors. I got to know people in philosophy, among them Marjorie Greene, who introduced existentialism and phenomenology into this country just a few years before I met her. Her explications, especially her lucid

account of Maurice Merleau-Ponty's ideas on perception, left an indelible impression on me. Several years later when I was beginning a dissertation at UCLA on an early twentieth-century Spanish novelist, Marjorie's brilliantly vivid synopses of the phenomenological movement came back to me as I was casting about for central ideas to guide my Ph.D. thesis. I was struck by how the quirky verbal style of my modernist author seemed to be carrying out the phenomenological project of description prior to reflective thought. In researching this lead, I did indeed discover that there was a copy of a work by Edmund Husserl, the German founder of phenomenology, in the author's personal library, and my dissertation took flight.

My own story leads in to the second part of this cooking show in which I offer some ways to prepare the kitchen for elephant and rabbit stews, opportunities for humanities scholars to create new recipes with ingredients from other disciplines and perhaps flavor someone else's dish in the process. If you are a desultory cook, you can hope that the elephants and rabbits find their way into the pot on their own—that they will have chance encounters of the kind that I did with an emerging philosophical school. Or, if you believe, as I do, that these meetings and minglings move cutting-edge research forward, you can devise situations in which they are more likely to occur. One can read around in other disciplines, but for truly creative and original work, there is no substitute for face-to-face encounters, for the give and take discussion that makes someone else's work more meaningful and more likely to produce that rare spark that ignites.

At last year's Merrill Advanced Studies Center retreat, Richard Schowen argued for the center model for research, because the center system, he said, allows faculty to come together from different departments and disciplines for interdisciplinary work. (Dr. Schowen, by the way, also indulged in a culinary metaphor to define three types of interaction between disciplines. Under the rubric of "Four-Alarm Sushi" he offered dishes about as inedible as elephant and rabbit stew for "multi-disciplinary," "interdisciplinary," and "cross-disciplinary." (I refer you to last year's Merrill conference proceedings for ingredients and preparation instructions.) I am using the term interdisciplinary in a slightly looser and less scientific manner than Dr. Schowen; I mean any encounter between disciplines that creates a new dish, a new recipe in the kitchen of human knowledge.[4]

Humanities research is less overtly amenable to center-type collaboration than the sciences. Seldom do humanists apply for research grants *ensemble* or work together on large projects of a truly original nature. The collaborative projects most common in the humanities are anthologies and bibliographies that are not considered to be the most prestigious kind of humanities scholarship, which is typically the single-authored article or book.

Rather than a lab full of people, the humanist usually requires a "room of one's own," to borrow Virginia Woolf's famous words. Humanities research is often a lonely enterprise undertaken by the individual scholar holed up in the library, archive, or study to read, think, and write.

A Humanities Center is, however, an ideal location for the casual or semi-formal inspirational encounter of the kind I outlined above, the encounter that can prove so important for an individual scholar's progress. The Hall Center for the Humanities, for example, provides a venue and a forum for faculty from across the campus and even for people from off-campus to come together to share current research and for dialogue. There are currently eight ongoing seminars on a variety of topics that draw faculty primarily from the humanities and social sciences but occasionally from the sciences as well. These are well-attended, often an average of 20-30 faculty per monthly meeting of each seminar. Topics for each seminar session are widely publicized well in advance so that interested faculty can plan to attend. In addition, every fall there is a formal seminar with eight faculty committed to attend weekly meetings on a particular topic led by a senior faculty member. These have been directed and populated with faculty from most of the professional schools as well as nearly all the departments in the College.

Allan Hanson of the Department of Anthropology at KU experienced a major change in his theoretical orientation to anthropological work through an early Hall Center seminar on semiotics. Subsequently, he wrote an article "The Making of the Maori" that made national and international news when his theory of Maori culture as invented tradition was misinterpreted in the popular press as relegating Maori customs to ersatz culture. Hanson was at the time participating in another Hall Center seminar on narrative led by literature professor Bill Andrews. The theories of narrative under discussion in the seminar gave Hanson the means to reformulate his argument about invented tradition in a second article that clarified his position and defused the criticism leveled at the first article.

We need many more of these kinds of opportunities for fruitful interdisciplinary encounters. We should encourage them with logistical support, especially to bring people together from areas that don't normally share space with each other—humanities, social sciences, sciences, and the professional schools. The sciences (undisputed elephants) have much to offer the humanities (perennial rabbits). Medical science is currently making an important impact on literary studies, some of which focuses on the way the body and disease are deployed in literature across the ages. Current work in genetics, psychology, and sociology could surely assist humanities scholars who are interested in the way in which gender is constructed socially and biologically.

The humanities can also contribute to the health sciences. For example, a humanistic endeavor—film studies—has been assisting some clinical psychologists, who have discovered that humanities materials like films (the novels or narratives of the present and future) are useful in treating certain destructive psychological behavior patterns. When the patient does not heed professional advice to change a behavior, the therapist recommends a film in which a character acts in a parallel way. Mental health professionals have found that patients can much more readily objectify the behavior in which they are engaging when they see it mirrored in film. Once the behavior is identified and objectified, patients are able to modify their own reactions in specific situations that had confounded them in the past.[5]

When I recommend more logistical support for encounters between members of disparate fields, I mean facilitating the necessary time and space for the encounters to take place. It is relatively easy for faculty from the several humanities disciplines to come together at the Hall Center for the Humanities despite the limitations of time we all confront, but it is a challenge for humanities faculty to meet scientists and medical professionals, especially the latter who carry out their work in Kansas City. The scientifically oriented research centers might consider some colloquia or other activities with the humanities center. Roger Sunde, University of Missouri expert on nutrition and participant in this year's Merrill Center retreat, suggested founding a Four-State Institute for Ethics that could address ethical issues in medicine and other areas of human endeavor. That would certainly be an ambitious undertaking, but it could lead to major break-throughs in some of the issues that trouble humanity at large (cloning, assisted suicide, abortion) as we move into the new millennium. The Merrill Center retreat offered the elephants and the rabbits a unique opportunity, if not to join in a stew, at least to consider the merits and logistics of doing so.

Notes

[1] Clifford Geertz, "History and Anthropology," *New Literary History* 21 (1990): 322.

[2] E. O. Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, 1998).

[3] Geography is currently undergoing a similar dissolution of its disciplinary boundaries with a somewhat less paranoid reaction. A recent issue of the *Chronicle for Higher Education* ("Geographers, in an Expanding Discipline, Struggle to Define Their Space," April 16, 1999, A20-22), Peter Monaghan

writes that "These days, at one extreme the discipline [geography] is akin to geology and related earth sciences, focusing on such subjects as climate, land forms, vegetation, and water. At the other extreme, its embrace of the latest critical theory draws it close to literary and cultural studies, as well as to anthropology, psychology, and sociology." In my own area of literary studies, geography has inspired interest in research on space in literature as well as in cartography, especially as part of what are known as colonial and post-colonial studies.

[4] Dr. Schowen's description of the benefits of center-oriented research is as follows: "The telling quality of these centers has been that they lie beyond the normal territorial organization of the university. Their responsibility is not to the dean of any school or college, nor to the chair of any department, but rather to the university research enterprise and—in effect—to the faculty at large. This feature allows projects to be attacked readily by crews of investigators from any combination of entities in the university. At the same time, the question is largely skirted of how to make a territorial assignment of grant income, credit for publications, and the other vital signs by which universities measure the health of their internal organs" (Richard L. Schowen, "The End of Interdisciplinary Research." In Proceedings of the Merrill Advanced Studies Center conference *Mobilizing for Research Opportunities in the Next Century*, vol. 102, p. 57, Lawrence, Kansas: University of Kansas, July 1998). His examples, however, were understandably, given his own disciplinary background, taken entirely from what he called the "hard sciences."

[5] "Psychologists are Giving Film Therapy Thumbs Up," *Los Angeles Times*, July 4,1999.

INCREASING RESEARCH FLEXIBILITY WITH

ENDOWMENT FUNDS

(In Defense of Research by Serendipity)

Don Steeples
McGee Distinguished Professor of Geophysics
University of Kansas

The purpose of this paper is to consider how the freedom associated with spending endowment money as opposed to grant money for research may allow a professor to explore high-risk research without the possible embarrassment of a public failure. At the University of Kansas (KU), the expenditure of Distinguished Professor endowment funds requires only fiscal, not scientific, accountability, which is a great advantage to those fortunate enough to have access to such funds. Like an old-time country doctor, one can bury one's mistakes.

The ideas presented here are in part gleaned from the book "Shocks and Rocks" by National Academy of Sciences member Jack Oliver, one of the leaders in the development of the theory of plate tectonics in modern geology. From grammar school onward, we are taught about THE scientific method, as though it were the only method with any merit. This cherished method is commonly known as "hypothesis testing."

At least two problems with this classical form of the scientific method come to mind. First, investigators tend to get married to a hypothesis. That is, their egos become involved, and they are afraid to be wrong. As a result, they may not be willing to admit to a failed experiment, or they are reluctant to recognize that they were on the wrong side of the hypothesis at the outset, or they may carry the research well beyond the point of diminishing returns.

The second problem is that the hypothesis-testing method is so deeply ingrained in the competitive scientific-funding system in the U. S. that obtaining funding from such sources as the National Science Foundation (NSF) is very difficult unless a proposal contains a testable hypothesis. For example, Dr. Wes Jackson, a MacArthur Fellow from The Land Institute (TLI) in Salina, Kansas, recently proposed to the NSF a study to use TLI's unique facilities to study the long-term effects of different types of vegetative cover on soils. The proposed research was to be limited to a single soil type located in adjacent locations, and it included virgin prairie, Conservation Reserve Program grass, and active

cropland. Besides examining the micro- and macrobiota, the chemistry, structure, and texture of the soil were to be investigated as well.

Dr. Jackson's proposal received reviews that were all "very good" or "excellent," but the NSF panel rejected his plan because it lacked a distinct hypothesis. The reviewers otherwise were impressed with the proposal, but because it lacked an explicit, testable hypothesis, the proposal was not considered fundable. This kind of experience with competitive funding sources is all too common.

Dr. Oliver points out in his book that, in addition to hypothesis testing, he has used two other scientific methods that have little to do with testing a hypothesis. He calls these two methods "Science by Synthesis" and "Science by Serendipity." As an example of the *synthesis* method, he cites the famous "Seismology and the New Global Tectonics" paper from 1967, of which he was a co-author. This paper is seen by many as the rational beginning of modern plate-tectonic theory. As an example of *serendipity* he cites the 1967 paper by Oliver and Sykes that reported the chance discovery, by means of earthquake seismic methods, of the sinking into the earth's mantle of crustal slabs or *plates*, which was one of the keys to unlocking the ways in which the dynamic earth works. To quote Jack Oliver:

> The message here for young scientists is, of course, that no one style of doing science is obviously superior or should be exclusive, and furthermore that science would be less effective if forced into any one such mode. I hope this point is made sufficiently clear so that all peer reviewers will note it! I shudder to think of how backward science might be if all research of the past had been confined, as some peer reviewers have erroneously recommended, to only projects for which the hypothesis is "clearly and explicitly" stated or the problem "sharply defined."

Although both the hypothesis-testing and the synthesis methods are considered appropriate bases for the expenditure of endowed funds, this paper provides an example of the use of endowed funds from the Dean A. McGee distinguished professorship at KU in support of research by serendipity.

Dictionaries define serendipity as "the faculty of making providential discoveries by accident" and as "a gift for finding valuable or agreeable things not sought for." Such a gift favors those who are observant and well prepared—as well as lucky. To describe my own experience with serendipitous discoveries made possible by McGee Professorship funds, I would like first to discuss the background of my research.

The subject of my research is imaging the shallow underground using seismic reflections (sound echoes). This type of imaging has much in common with ultrasound imaging as used by the medical profession and with deeper types of imaging as used by oil companies as they search for geologic structures capable of holding petroleum reserves. In both cases, the principal differences are those of spatial scale. Physicians often work on a scale of millimeters, dealing with structures found in the human body. Oil companies use a scale of hundreds of meters as they deal with structures in the earth. My colleagues and I, however, analyze features on the scale of one meter.

Constructing images of the shallow underground is desirable for many engineering, environmental, and geological reasons, such as searching for underground voids that might cause the collapse of structures and roads. Seismic imaging requires a source of underground sound waves, and that is where my first example of serendipity arises. Physicians use a small electronic transducer that produces sound in the range approaching one megahertz. Oil companies have long used dynamite as an underground sound source with frequencies in the sub-audible to low-audible range, i. e., about 10 Hz to 50 Hz. My work requires frequencies from about 100 Hz to about 1000 Hz. Musical middle C, for example, has a fundamental frequency of 264 Hz. For many years my group has been using rifles as sound sources, including a 50-caliber machine gun fired into shallow holes in the ground. Despite decades of effort by our group and many others, no one had ever extracted sound waves successfully from the ground at frequencies above 600 Hz.

With $24 worth of McGee Professorship endowment money, I went to a local auto-parts store and purchased a 100-foot-long sparkplug wire. I could tell that my graduate students did not have their hearts in the experiment, and that they were just going through the motions to placate the old man who pays their salaries. We disconnected one sparkplug wire from the engine of my truck and connected the 100-foot wire in its place. Then we connected the other end to a sparkplug about 90 feet away that had been pressed into a dampened hole in the ground one centimeter in diameter by about two centimeters deep. We arranged our sound sensors (which are low-frequency microphones called *geophones*), started the truck, and began listening with our seismograph. In an experiment that required less than two hours to perform, we were able to extract sound waves from the ground at frequencies up to about 1400 Hz. It took us about half a day to analyze the data and another day to prepare graphics and a manuscript for publication. The paper was published in the March-April 1999 issue of *Geophysics*, the world's leading journal in exploration geophysics. Incidentally, the $300 page-charge fee exceeded all of our other research costs for this experiment.

Although a new shallow seismic wave source resulted from the sparkplug experiment, getting the sound waves into the ground is only half the problem in near-surface imaging. The other half is sensing the sound with geophones attached to the ground. Oil companies typically position geophones on the ground at intervals of the order of tens of meters. For our work, we commonly use geophone intervals as small as five centimeters, which makes such surveys very expensive because of the amount of human labor required. Prior to 1997, we had never experimented with geophone intervals smaller than 25 centimeters, but our KU research group set the world record in 1986 for the shallowest seismic reflection at 2.6 meters using that geophone interval. This record stood until 1996, when a graduate student at Stanford recorded reflections at a depth of 2.0 meters.

We accepted the loss of the record to Stanford as a challenge, so late in 1997 we began experiments with geophone intervals at 10 centimeters. We regained the record by acquiring reflections at a depth of 1.5 meters. In early 1998 we decreased our geophone interval to five centimeters and improved the record to a depth of 0.6 meters, where it now stands. As a slightly inebriated Australian professor told me upon viewing the data at a conference reception a little over a year ago, “Thish could schtart a whole new indushtry!” In his slightly impaired state, he did not realize the tremendous cost of doing such a survey.

The desire to radically decrease the cost of such surveys is where serendipity enters the picture again. Having established that this type of shallow imaging was possible and heartily wanting to trigger a whole new industry, we needed to find a fast, cheap, and effective way to plant lots of closely spaced geophones. I wanted to know the severity of the problem that we faced, and it seemed to me that the best way to initiate that was to bolt a bunch of geophones to a rigid medium to find out how the seismic signal was affected.

All of the mathematical analysis of geophones dating back to the early 1940s suggested that it would be impossible to extract usable signal from multiple geophones attached to the same rigid medium. But sometimes one experiment is worth a lot of equations and computer models. With about $7 worth of McGee endowment money, I bought some nuts and bolts and went to work with the arc welder in my basement. I bolted the geophones to a scrap of board, and the next time my graduate seismology class was out in the field for an experiment, we planted the board-mounted geophones in the middle of a line of geophones that had been planted in the usual way. Much to our surprise, we found that it *is* possible to bolt many geophones to a single rigid medium and still collect good seismic data. These results were published in a paper entitled “Geophones on a Board” in the May–June 1999 issue of *Geophysics.*

Extending these results with about $200 worth of McGee endowment money, we purchased some long pieces of channel iron from a steel supplier in Lawrence and bolted 72 geophones to the channel iron. We hauled everything to my farm in Palco, Kansas, and welded the channel iron, with geophones attached, to the underside of the frame of an 11-meter-wide tillage implement. Using the hydraulic power from a large farm tractor, we were able to plant 72 geophones in about two seconds in our test line, whereas planting the comparison line, where we used normal human-planted geophones, required 15 minutes of labor from each of three people. Upon recording signals on both lines, it became obvious that the key seismic information had not been affected by the presence of the rigid steel medium to which the geophones were bolted. We have shown that it is possible to plant large numbers of geophones quickly and cheaply, while preserving the salient features of the resulting seismic data. These results were published in the April 1999 issue of *Geophysical Research Letters*, a leading refereed journal of current research topics.

In summary, none of the results described here could have been foreseen or described in the form of a testable hypothesis, which seems to be necessary for submission to a funding agency such as NSF. The total outlay for the research summarized in these three refereed papers, including student salaries, was less than $10,000. The upshot is that having the freedom to spend a relatively small amount of money without having to write a proposal or, in the case of failure, a final report, has allowed me to think freely, move quickly, and perform serendipitous experiments that I would have been embarrassed to propose to colleagues outside of my research group.

My point is that the Federal funding system, at least in its competitive venues, is strongly biased toward proposals in which hypothesis testing is the method of choice. Knowing that, how can university administrators assist their faculties and staffs in obtaining Federal funding? My suggestion is that providing readily accessible seed money with no scientific reporting strings attached such as endowment funds to individual researchers would be a good policy. The freedom to explore high-risk research will pay off handsomely in some cases, but it will also lead down many blind alleys in which the money may seem to have been wasted. Consequently, even top-notch, experienced scientists cannot be expected to produce large amounts of funding from each parcel of seed money. Nevertheless, across the broad spectrum represented by a university, many successes may be expected over time.

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Is Anyone Out There Listening?

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"Once more into the breach, dear friends, or close the gap with the bodies of"... a comatose public. Is Anyone Out There Listening?

As scholars we know how to share information rapidly with the people who need to know. As I was typing some notes for this talk, Prof. Harry Titus from Wake Forrest stopped by on his way to Colorado. Just back from a symposium in Burgundy, he passed along the latest news on the 8th and 9th century crypt under the Cathedral of Auxerre—and the address of his web page where I can see the new photos of the work—a nice mix of traditional information sharing—that is to say, personally and verbally and electronically. (In return, I directed him to Lucas, Kansas and the Garden of Eden, something every medievalist should see).

The important question is not how we enhance scholarly communication among ourselves but how we communicate with a wider audience. First and foremost we teach. Teaching remains the finest (noblest?) form of scholarly communication. Of course when we teach, we do more than transmit information. We also teach how to use information, how to evaluate ideas, and (we hope) how to create more "knowledge."

Good teaching does not have to consist of one to one communication. The image of two people—student and teacher—sitting on a log, may have been unduly praised. Today one to one communication may come through a machine—without human contact. With present low funding for education, we must get our material across to massed students. That's OK. Large lectures—or massed computer screens—can be electrifying. An electronic classroom may be effective for high school students who come to us lacking (shall we say) the contemplative mode, or for highly motivated people who need factual information—and know they need it. But to inspire people we need to establish personal relationships (today, I still need my e-mail or my Art History 150-151 web site).

For sheer rapid accurate dissemination of information, nothing beats the combination of images and words. You will recall the memorable image of the Frankfurter queen of 1952, for example. The arts (in this case photography) have always been in the forefront of transmitting vital

information. The earliest art, painting in caves, still communicates its message: man down, bison disemboweled, and hairy rhino running off, warning, instruction, shaman's trance?) In ancient Rome there is a splendid piece of imperial propaganda for Augustus (an image saying through the ages I will convince you or bury you). Here is a man in his 60's, his body armor turning him into a super warrior, his bare feet indicating his status as a demi-god. Demi Gods still stare out at us from magazine covers—did this Hercules read Charles Atlas ads? Was he a 98 pound weakling with sand in his face? Sex sells—and so do pictures. Did you rush out and buy Taboo perfume after seeing this ad in Vogue? And today we have learned that pictures still communicate faster and more effectively than words. Or at least that's what Calvin Kline people decided.

Lots of people are looking.
Is anyone out there also reading?

When Henry V led the English against the French at Agincourt, the world as he knew it—the world of information through pictures and oral history and poetry—was crumbling before the force of a new technology more powerful than his English longbowmen. In the 15th century, "The Age of Mechanical Reproduction" dawned. Soon the printing presses would be making the labors of countless scribes as obsolete as the French knights in heavy armor. Henry's stirring words—"once more into the breach," or whatever he actually said—would today be a press release, leaving later day Willie Shakespeares with less scope for their imaginations.

Scholars throughout the western world would use the new technology to create multiple, nearly identical images and to disseminate their theories and discoveries (e.g. The sex life of the mandrake plant). When images as well as words could be reproduced, everyone could argue from the same page. For herbalists and alchemists a rose could no longer be a symbol of a flower but must resemble a rose seen in nature. Herbalists would become botanists and alchemists became chemists. They were people who changed things—into other things, grapes into alcohol for example (e. g. the distillery, and samplers).

How patrons in the 15th and 16th centuries must have despaired at the cost of setting up an alchemist's lab when every Tommaso, Ricardus, and Henricus could see—and demand—the latest equipment! See what Rudolph II is giving his team in Prague! Have you heard about the breakthroughs the Prince Henry group is making in Portugal? Their breathtaking study of Atlantic tradewinds. And what about that mad Genoese sailing for Isabella? He claims he just discovered a new world—where people

wear feathers and eat people. One amazing thing after another and all spread with the speed of the new printing presses.

But wait. As we know, new technology can be double edged. Remember who first profited from the new technology—advertisers, gamblers, and propagandists. The earliest prints advertised saints' shrines and relics and became souvenirs of pilgrimage travel (prints made by and highly profitable for the churches and monasteries holding miracle working relics). Printers also made playing cards (known as paper dice and originally hand painted—imagine the possibilities of fraud). And, of course, printing spread vicious political propaganda!

The real trouble makers did not originate in Silicon Valley but in the Rhein-Main. Gutenberg in Mainz dramatized the full force of the information explosion with another break-through—moveable type. More and more people could afford books, and they read them. Words and images—the power of the media was born in the Protestant Reformation—Luther vs. the Pope.

Now 500 years later, the computer age has dawned as brightly as the age of printed books—I mean "hard copy"—or do I mean "hand held reading devices"? And human beings, the stubborn survivors, faced the same challenges all over again. On the plus side —speed and accuracy—if handled well. On the minus side—plagiarism, theft, lies and slander. Information or disinformation. How to share? With whom to share? Can we protect information and ideas? Should we? How do we apportion credit? Rewards? In the visual arts, for example, "appropriation" is a major tool—creative reuse of other's work makes intellectual property issues very controversial.

Visual images are long lasting (many of you seem to remember the Charles Atlas ads). The most effective way to get out a message remains visual. The magazine or newsletter arrives in ones home or office. Then action is required to get rid of it, not to keep it. And even in the act of discarding, the eye may stop the hand. Herein lies the communicators' challenge—to capture the readers' attention in that glance. Once caught, the modern reader demands a succinct, pointed text. Sometimes even "bullets" not paragraphs. The point is that we learn rapidly from images, even the Frankfurter Queen.

The mission for all of us in universities is clear—we must communicate with everyone because we—and our friends—cannot function without wide public support. But, as our speech and writing becomes ever more technical, and we depend on private in-group-speak for scholarly communication, the

public can no longer respond to us. For the researcher it is important to maintain a high level of scholarship, even while simplifying and popularizing.

Roger Martin (KU's excellent science writer) distributes the blame for poor communications equally among four groups:

- the public (who present us with a challenging combination of curiosity and ignorance);
- the media (who reject an educational role and define news in their often sensational own way);
- the scholars (who are, as Martin says, "less than silver tongued," and—as I know too well—fear the stigma of being known as popularizers);
- and his own colleagues, the official public relations people (who under pressure may turn out little other than snooze-o press releases).

I defer to Roger's experience and judgment, but I think scholars and public actually want the same thing. Researchers are relentlessly curious enthusiasts who may hit upon their best ideas in moments of relaxation or sheer zaniness (like Bruce Naumann turning himself into a fountain). Most folks outside academe are also eager and curious but they, too, want entertainment with their information. In other words, at heart, both producers and consumers of our research "product" agree; they hope for exciting new stuff arrived at and presented with a bit of pizzazz. Coming between the two are serious, stuffy officials and media types who spoil the fun—with certain exceptions of course.

What we want and need are translators—like the University of Missouri's "Mizzou Magic."

The job of scholarly communication falls to all of you—senior members of the academic community, especially those of you who have left your ivy-ed halls for the cubicles of administration—luxury cubicles perhaps but cubicles all the same. You must defend the professors who are tongue-tied by their own jargon, belittled by legislators for their esoteric interests, and swamped by demands of the university bureaucracy. You must create and sustain a public interest in their expensive and time consuming work. To do this you need bright creative people to help you, not Dilberts with PowerPoint.

Remember—artists and humanists have long been the experts—using sounds and images as the primary means of information transmission, carried by individuals but transmitted to the tribe. Epic poetry conveyed belief systems and so did theater, dance, ritual, pageant, liturgy. Public art, painting and sculpture formed a permanent record of ideals and beliefs—knowledge that meant survival.

Artists like Nam June Paik remind us with his "Computer Parents," that when communication is no longer limited by human voice or eye or ear, we have become isolated as never before. The meeting of minds, researcher to researcher, becomes ever easier even as human contact shuts down. Both as originators and recipients of information, we often sit alone in our boxes communicating by machine. But boxed communication will not do for everyone. Vital communication with the public goes far beyond today's theme of university alliances.

ELIMINATING THE SCHOLARLY COMMUNICATION CRISIS:

FROM HERE TO *NEAR*

David E. Shulenburger
Provost, University of Kansas

The U.S. research university has led the world in both basic and applied research. Our continued leadership is critically dependent upon researchers being able to share their findings widely. Much of this sharing has been institutionalized through a system of scholarly journals, but ten years of annual compounded increases in excess of 10% in the prices of many scholarly journals, especially in science, technology and medicine, have reduced the availability of information to scholars and threaten to reduce the universities' contribution to both basic and applied research.

As provost of a research institution, I have to stretch our budget to address many needs. The library has not fared well over the last decade, even though it has maintained its share of the university budget. That constant share has permitted the library to purchase a declining proportion of the scholarship that has been produced. In fact, in order to purchase the same proportion of published serials and monographs as a decade ago, our acquisitions budget would have had to increase by 250%. Instead, our budget has increased only about 50%. I do not know of any university with sufficient resources over the past decade to hold constant the proportion of journal scholarship purchased by its libraries. More narrowly, I do not know of any university that in the past decade had increases in its acquisitions budget sufficient to buy even the same number of serials and monographs it bought a decade ago, much less keep up with the tide of new scholarship.

At the University of Kansas we have responded with some increased funding, increased interlibrary loan activity, cooperative buying ventures, use of electronic document delivery, etc., but these responses are palliatives, not solutions. It is time for solutions, for this crisis is growing to the point that scholarship and education will be damaged significantly if we do nothing. Although scholarly journals are not the entire problem, they are the most acute part of it, and my remarks focus on them. The Association of Research Libraries' statistics show their unit costs have climbed 169% from 1986 to 1997 while monographs went up 62% and the consumer price index went up 46%. Surely a cost increase nearly quadruple that of the general level of prices warrants our attention.

If we are to keep scholarship available in our libraries we must assert that, at some point, all of it must become part of the public domain. We must then find a way to make that information permanently accessible to scholars and the public in a useful fashion. I no longer believe that solutions that fail to deal with ultimate ownership of scholarly communication, i.e., copyright, are viable. I have reached this conclusion because I believe in the market. What the market reveals is that scholarship published in many academic journals has real economic value. While it is fashionable to characterize all scholarly journal articles as "seldom read" and "of primary value only in negotiating the academic credentialing game," the truth is far different.

Some commercial publishers of academic journals in science, technology, medicine, and lately the social sciences, have demonstrated the economic value of scholarly journals by raising their prices far in excess of production costs. The effort by libraries to combat these cost increases by canceling journals that were inordinately expensive on a per use basis has not affected the profitability of these journals. Even if the rates of increase in prices do finally decline, such decline does not demonstrate that publishers have ceased to exploit the value of journal contents. Even monopolists do not forever raise prices at a higher rate than do competitive producers. The difference between competitively organized markets and those that tend toward monopoly is the level of prices and volume of product produced, not the continuing rate of increase in prices. What we need to make scholarly communication affordable is a reduction in price back to competitive levels, not a reduction in the rate of price increase.

I would be more sanguine about solutions other than those that deal with copyright ownership if I believed that many non-profit scholarly associations would continue to ignore the market worth of the material contained in their journals. Recent evidence is that they are beginning to exploit it. I take little comfort in the fact that they have not yet gone so far as their profit-making brethren, for I fear that if society members were now faced with the choice of raising dues or paring back their organization's human and physical infrastructure in order to make scholarly work more accessible to libraries, they would choose to leave journal prices high.

Indeed, it is because of the demonstrated economic worth of information contained in many scholarly journals that I do not subscribe to the popular notion that a cure for the scholarly communication problem is for universities to cease evaluating scholarship by counting a faculty member's publications. In addition to overlooking the reality that quality universities do not evaluate quality "by the pound," such a notion ignores the fact that universities are not the only entities who profit from the research results contained in scholarly journals. Great universities must encourage the

generation of knowledge through research and the spread of that knowledge through publication. Any institution that evaluates a faculty member on volume of publication without considering the quality is not a place of higher learning. Thus I vigorously reject the notion that in an expanding age of knowledge, reduction of the quantity of scholarship published is a viable solution.

Even if we were to somehow reduce the rate of increase in prices of existing journals, the birth rate of new journals is so high that we still could not afford to buy even a large number of them. While many new journals do not merit acquisition, others are of high quality and constitute the sole access to scholarship in some very narrowly defined academic fields. Failure to add the latter journals to the collection will cause specialized scholars and their students to lose timely contact with their most important scholarship. A viable solution must deal with both the problem of price increases for existing journals and the rapidly expanding number of new journals.

My proposal is simple: when a manuscript by a U.S. faculty member is accepted for publication by a scholarly journal, a portion of the copyright of that manuscript will be retained for inclusion in a single, publicly accessible repository, after a lag following publication in the journal. We know that "the devil is in the details," but in fact, the details are not important to the principle of my proposal. Moderate alteration of the details would still leave my proposal a viable solution to the problem we face.

At present, essentially all scholarly journals require that all copyrights pass from the author to the journal when a manuscript is accepted for publication. In this proposal, only the exclusive right to journal publication of the manuscript would pass to the journal. The author would retain the right to have the manuscript included in the National Electronic Article Repository (NEAR) ninety days after it appears in the journal. The faculty's published article would be transmitted to NEAR upon its publication, by federal law as part of a funding agency stipulation or by contractual agreement with the University employer. NEAR would index manuscripts by author, title, subject and the name of the journal in which they appeared. (The electronic form would be searchable on many more dimensions.) NEAR would see to it that articles are permanently archived, thereby assigning responsibility for the solution to another problem brought to us by the electronic age. NEAR could be funded by universities through "page charges" per article included, by federal appropriation, by a small charge levied on each user upon accessing articles or by a combination of these methods.

I do not expect that this plan will generate substantial opposition from faculty members since it guarantees them access to all scholarship published

by U.S. faculty members wherever they happen to be located or employed. The proposal, by its universality, addresses the fear that any attempt by faculty to withhold any part of the copyright will lead journals to reject manuscripts. If the requirement were ubiquitous in U.S. universities, no journal, domestic or foreign in origin, would relinquish the possibility of publishing all work arising from U.S. faculty. Thus no U.S. faculty members would need fear that their manuscripts would be rejected because of partial copyright retention.

Of course much scholarship is generated outside of the academy and by scholars abroad. If journal publishers find that the work of U.S. university authors must appear in NEAR, surely they would find little reason to oppose inclusion of all their articles in NEAR. The current U.S. Government requirement that only a portion of copyright of articles authored by its employees be surrendered could quickly be modified to require inclusion of such articles in NEAR. Employees of private firms commonly must receive clearance from their employer before they publish an article based on their work. It would seem reasonable that once one decides that something a firm paid to produce can be published, granting wider exposure by including the article in NEAR would be acceptable. Thus, it is reasonable to expect that work published in U.S. journals by international scholars or by government or private scientists would be included in NEAR.

Journals now generally have exclusive ownership of the copyright to manuscripts nearly into infinity. Under my proposal, this exclusive ownership right would be truncated to a period of 90 days. While 90 days is arbitrary, in my view, it is enough time to leave sufficient value with the journals. Journal subscribers will continue to pay for more timely access to information. But free or low cost access after 90 days would surely depress the extraordinarily high prices now charged by some journals and curb the publishers' ability to increase those prices seemingly without limits. Since all scholarly journal articles would pass into the public domain in 90 days, individuals, libraries, agencies and businesses would choose to subscribe only to those journals where timely access justified the cost. The amount by which prices would fall will vary inversely with the rate at which the value of the information contained in the journal deteriorates over time. I would assume that a journal of portfolio analysis would drop little in price, while a journal of cosmology would drop substantially. Similarly, new journals would be free to spring up, but their impact on library costs would be tempered by the reality that the material they contain would be in NEAR 90 days after publication.

In response to proposals that bear some of the elements of this one (for example see Bachrach et al. in *Science*, Sept. 4, 1998, p. 1458), scholarly journals often proclaim that they add value through their refereeing,

editing, printing, etc., and therefore deserve to reap the fruits of their efforts by retaining exclusive rights to articles. I do not deny that journals add value. Furthermore, I believe that any solution that attempts to eliminate journals would do scholarly communication a great disservice. In my field, the title *American Economic Review* tells the reader a great deal about the quality of the articles within. In an age with more information available than time to read it, every screening aid of this nature is valuable. What I do deny is that journals are entitled to all the value of an article. What they are entitled to is the value that their refereeing, editorial and publishing processes add.

I intend for this proposal to apply only to "scholarly" journals. Articles such as "Who Will Own Your Next Good Idea?" in the September 1998 issue of *Atlantic Monthly* address the concerns of professional journalists that erosion of copyright protection threatens their livelihood. A proper definition of the term "scholarly journal," while not a trivial task, ought to allay such fears. A critical characteristic of scholarly journals is peer-refereed materials, something not found in the popular press, where those who are paid by the piece for their work make a living. Universities have a claim only to the journal-disseminated scholarship produced by their faculty, not the work of journeymen authors.

How do we get from here to NEAR? An easy solution would be the passage of a federal law requiring that the work published in scholarly journals by U.S. university faculty members be deposited in NEAR within 90 days of the date of its publication. A variant would be to require that all work arising out of federally funded research subsequently published in a scholarly journal be deposited in NEAR. I would welcome the former and cannot envision any serious political opposition to the latter. NEAR, of course, would have to be created by the same legislation. Federal agencies as a condition of research grants and contracts also could require deposit of resulting articles in NEAR.

Alternatively, an organization like the Association of Research Libraries, the American Association of Universities, the National Association of State Universities and Land Grant Colleges, the Library of Congress, OCLC (Online Computer Library Center, Inc.), or a private foundation might establish NEAR. Then, university by university, we would have to pass copyright ownership policies that require deposit of journal articles in NEAR. We in Kansas have moved in this direction in the hopes that such a vehicle will soon be created. The intellectual property policy that was adopted by the Kansas Board of Regents in November 1998, includes the following:

> Upon the establishment of national governmental or nonprofit entities whose purpose is to maintain in an electronically accessible manner a

publicly available copy of academic manuscripts, the Kansas Board of Regents will review each entity and upon determination that providing the manuscripts will not jeopardize the publication of articles or infringe on academic freedom, require the creator(s) to provide the appropriate entity a limited license for the use of each manuscript.

I add this proposal to those already on the table. There is room for multiple approaches, and certainly there are alternatives to NEAR.

- ARL has spawned SPARC to create innovative approaches to reduce journal costs. To date, it has joined with professional societies to create three new scholarly journals with prices substantially lower than those of existing journals in the same field. While I support SPARC, I note that three is a tiny portion of the tens of thousands of journals extant. In addition, it is possible that SPARC will lead to a proliferation of journals that will require increased library budgets rather than the hoped for reduction.

- AAU continues to work on the decoupling project. This project is designed to form refereeing panels to review manuscripts that subsequently will be available electronically to all and for journals to consider for publication. To date, professional societies have been unwilling to work with the AAU in forming the refereeing panels.

- Some universities are considering changes in intellectual property policies such that the university retains part ownership of manuscript copyrights. This approach has two problems. First, journals may refuse to publish articles unless they have exclusive copyright ownership. I hope journals would not take this stance, but I have little confidence they will not unless a great many universities simultaneously adopt this approach. Second is the problem of cataloging. How does a researcher find a manuscript if it is on the web site of any one of 300 universities? Clearly, simply retaining faculty–produced manuscripts on the university web site is of limited utility to researchers elsewhere.

- University groups including the Big Ten universities' Committee on Institutional Cooperation, the Big Twelve, plus groups of universities within states (such as Ohio) have formed buying cooperatives. These arrangements permit members to pit their collective purchasing power against the market power of very large journal publishers. Unless such cooperatives can make good on threats not to buy journals from a publisher, I am not sanguine about the ability of such groups to do more than slightly mitigate price increases.

- Finally, individual faculty who are members of scholarly associations can insist that their associations remain true to their founding purpose to referee and disseminate disciplinary research at reasonable cost to the academy. To do so they must insure that no more scholarly journals are sold to commercial publishers and that their own societies charge no more for their journals than warranted by the production costs. This approach will have no impact on the cost of journals remaining in the commercial sector.

For the reasons cited above, I do not believe any of these actions will provide substantial help in the foreseeable future.

Any proposal that does not guarantee the ultimate right of the academy to inexpensive and open access to the scholarly communication it generates will not solve our problem. We must deal with the thorny issue of copyright ownership. Probably, we will have to obtain protection from anti-trust action if we choose to act in concert to make NEAR a reality. I believe I have outlined a proposal that will resolve the scholarly communications crisis while protecting the legitimate rights of all who make scholarship possible.

I welcome your evaluation of this proposal and your assistance.

I wish to acknowledge the great influence William J. Crowe, Dean of Libraries and Vice Chancellor for Information Services at the University of Kansas, has had on my thinking in the area of scholarly communication. Bill and I work closely together in strategizing and philosophizing about how best to deal with the immense problems facing university libraries today. His knowledge and vision are important assets for our university, and the academy.

AGRICULTURAL BIOTECHNOLOGY:

COMPETITIVENESS THROUGH MULTI-STATE COLLABORATION

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Each of our universities wants to grow and develop its research program. Universities are places where people are the most important resource and the most important product. With these circumstances in mind, several principles undergird research program growth and development.

1. Universities cannot rely solely on direct allocations of state and federal resources for growth; a research institution cannot leave its destiny in others' hands.

2. The principle role of universities is education. This results in a broad, thin layer of expertise across subdisciplines in each degree granting unit (departments) and critical mass for deep research requires a distinct organization.

3. University departments are cultural centers where faculty receive protection, social exchange, professional development, and professional recharge over their careers. Changing departmental structure requires a culture change. Universities desiring a nimble response to change don't have the time for departmental structural change.

4. Faculty and students produce everything. Administrators create opportunities for faculty members to be fulfilled in their work, while guiding university products in cohesive, focused directions to fulfill the institutions' missions. Faculty fulfillment lies in one's ability to see growth and progress, income growth for the family, recognition by peers and the community, and contributions to science and to humankind.

5. Research centers work as a second tier organization to build a critical mass of faculty across teaching units without disturbing departmental cultures. If properly constructed, centers can create opportunities for faculty fulfillment.

   a. Centers without walls or jurisdictional boundaries and without rigid membership lists let anyone participate while avoiding bureaucracy.

   b. The shingle effect of creating a center is an effective marketing device.

c. A substantial seed money fund creates centripetal force for quick organization and quick product and allows for preliminary work to build excellent proposals.

d. Faculty steering committees assure feasible agenda setting.

e. Centers can reach across departments, colleges, universities, states, and nations in search of talent.

6. Collaboration requires being open to genuine partnership rather than remaining in the "proposal for sale" mode. I take instruction from Farmland Industries, a rapidly growing cooperative company with nearly $10 billion in annual sales, which never met a competitor it didn't explore. Farmland evaluates whether competitors and customers are doing some things better or cheaper, and whether there are different customer service assets, in order to form joint ventures or merge whenever it serves the company's interests. Partnership requires finding genuine win-win solutions and recognizing that other institutions are better at some things while ones own is better at others, and joining forces so both can prosper.

7. I learned the principle of relationship marketing from an executive of Bank IV before it was merged into Bank of America. The bank offered a single officer to each major customer. This officer met with various departments of the customer's company to determine the customer's banking needs, then went back to the bank to handle all of the customer's services for them ... a personal banker for a large company. Universities are large, complex organizations. Agencies and companies find them difficult to use. Center directors can serve the external role of relationship marketers—one person in the university to contact who will have all of the expertise available in a broad area—that's customer service.

K-State has applied these principles in several core areas, including plant biotechnology, environmental and natural resource management, wheat production and processing, food safety, community health and agricultural value added science. I will illustrate how K-State has built a competitive critical mass in the area of plant biotechnology using these principles of collaboration.

After studying how to coalesce K-State's biotechnology assets we learned that interests were widely dispersed. There was a strong affinity group in the plant molecular biology area, so the Plant Biotechnology Center was established. Originally 18 scientists were identified, a small enough group that the chair of Plant Pathology agreed to serve as director, with no additional pay. A faculty steering committee was established as the governing and operational board, composed of one biologist, one biochemist, two plant pathologists, and one agronomist with the USDA-ARS (faculty leadership). A

plant transformation specialist, another molecular biologist, two research assistants, and a $250,000 competitive grant pool were added to the Center (seed money). Anyone at K-State could participate in proposal development (no boundaries). The Center now has attracted scientists from biology, biochemistry, plant pathology, agronomy, entomology, and grain science (across departments and colleges).

The shingle effect appeared immediately. Once the Center was approved by the Regents, the International Rice Research Institute (IRRI) proposed a formal Memorandum of Understanding, though K-State had been working with them for many years. K-State made one IRRI scientist an adjunct professor and IRRI made one K-State scientist an adjunct scientist.

Shortly thereafter, the Plant Biotechnology Center at K-State, the Center for Biotechnology at the University of Nebraska, the Plant Transformation Center at Oklahoma State, and the Nobel Foundation, in Oklahoma, formed the Great Plains Cereals Biotechnology Consortium to add depth, fill gaps, and seek grants together as one entity in a strong, competitive position. Together, 80 faculty among the three institutions have interest in some facet of plant biotechnology.

Already, the Consortium has submitted proposals through the National Science Foundation's EPSCOR program and the Department of Agriculture's National Needs Fellowship mechanisms. It has also developed a relationship with the International Rice Research Institute in the Philippines and entered serious discussions with the International Maize and Wheat Improvement Center (CIMMYT) in Mexico. All of these efforts are directed toward strengthening research programs to understand and manipulate the processes which cause adaptation of wheat, corn, and sorghum to biotic and abiotic stresses, and apply the results in practice. The target is to reduce the $700 million annual loss of potential grain yield in the three states due to plant stress, and to build genetic resilience to stress in cereal crops, which are fundamental to the world’s food supply.

Collaboration requires lots of effort in the development of personal relationships among scientists. However, in states with smaller university scientific infrastructural investments, collaboration may be essential to collect the critical mass of resources to be competitive in national resource acquisition.

NURTURING MULTI-DISCIPLINARY NUTRITIONAL SCIENCES

ON THE EVE OF THE 21ST CENTURY

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The University of Missouri (MU) implemented an outstanding idea in the mid-1980's that fostered life sciences research and set the stage to make MU more competitive in the 21st century. Then Dean Max Lennon of the College of Agriculture led three colleges—Agriculture, Home Economics, and Veterinary Medicine—to propose to the state legislature a program entitled "Food for the 21st Century" (Lipner, 1991). This program was to stimulate innovative research for improved food, fiber, nutrition and health in the 21st century, and it was envisioned to increase incrementally to $8 million of new funds that would foster research in several vital areas. This support has now brought our teams of researchers to national recognition in Plant Molecular Biology, Animal Reproduction, Nutritional Sciences, and Food, Feeds & Natural Products. The addition of new funds to the program by the state ceased in 1991, at about $4.5 million per year of recurring funds.

I was recruited to become the Nutritional Sciences cluster leader in 1990, about four years after its initial funding. In my recruitment, I was sold on the idea by the success of two clusters in the initial years, by the excitement of implementing multi-disciplinary, team-based research at universities as a means to reinvigorate the institution as well as its research, and by the opportunity to build an aggressive, future-focused program in nutrition. My nearly ten years at Missouri has reinforced my enthusiasm for this team motif for multi-disciplinary research, but it has also given me gray hair as I've struggled to implement team-based research within the traditional structure of a university. My task today is (1) to review the Food for the 21st Century team-based approach to multi-disciplinary research by describing several key aspects of the Nutritional Sciences Program, (2) to review several approaches that we have used to successfully implement our programs, and (3) to discuss several key impediments to implementing team-based research in the traditional structure of a university. My hope is that this presentation will highlight important roadblocks, often inherent in university administration, that can otherwise burden teams to the point that they cannot succeed. My wish is thus to help eliminate these administrative roadblocks so that multi-disciplinary and multi-university research teams will be successful.

Food for the 21st Century Nutritional Sciences at the University of Missouri

The Food for the 21st Century clusters at the University of Missouri are comprised of regular faculty from various departments plus new hires of faculty for the Food for the 21st Century program. The program generally provides full salary support for new faculty with recruitment packages that include recurring technical support and supply funds. These faculty become regular members in one or more specific departments. Initially, Food for the 21st Century faculty were generally 100-percent research but today they are key academic faculty that participate fully in all aspects of university life. Cluster leaders manage the program funds and faculty to achieve the objectives of their program, in consultation with advisory committees, deans and department chairs. A key aspect is that the cluster leaders are the decision-makers for use of cluster funds so that these valuable program funds can be used effectively to promote research and not simply to shore-up weaknesses in traditional programs. A second key aspect from the beginning was regular review of these programs by external review teams of prominent scientists in the discipline of the cluster. This enhances visibility of our program and provides immediate feedback and gives confidence in the direction of these programs. The success of the Food for the 21st Century program at MU can be measured by: the top-five ranking of the Plant Sciences Cluster by the National Science Foundation; the top-five ranking of the Animal Reproduction Cluster by the U.S. Department of Agriculture; and the top-20 ranking of Nutritional Sciences by the recent Gorman report. To sum it up, the Food for the 21st Century program provided an infusion of new funds at a key time that allowed MU to take advantage of the explosion of new molecular biology knowledge and new biotechnology tools.

Food for the 21st Century Nutritional Sciences today has 25 faculty (including three 100-percent-funded faculty and three partially-funded faculty) in 10 departments and in five colleges including the research reactor. The objectives are (1) to employ the newest technology and knowledge to the study of nutrition in order to better understand the underlying molecular roles for nutrients in health and disease, and (2) to train students—undergraduate, graduate and postdoctoral—for Nutritional Sciences education and research in the 21st century. To accomplish these objectives we have used the 10 programs. These include the grant strengthening program, investing in fellowships for graduate students and for undergraduate students in summer research, providing core facilities for the faculty to learn and use cell culture and molecular biology techniques, funding outside speakers for our seminar series and a week-long spring lecture series on nutrition, and sponsoring our fall poster session. Rounding out these programs are outside program review in four-year intervals, and mini-sabbatical opportunities for researchers to learn new techniques quickly by visiting other investigators. The result has

been that outside funding by Food for the 21st Century Nutritional Sciences principal investigators has increased to $2.3 million in 1998; the graduate program has been revitalized; and Nutritional Sciences on campus is now regarded as being on the same playing field as the other strong life sciences programs and departments.

Tools for Teams to Achieve their Goals

How did the Food for the 21st Century program nurture Nutritional Sciences at MU? I was charged with leading campus Nutritional Sciences to become a nationally-recognized research program. It didn't take long to realize that the short time and relatively modest funds precluded the long-term broad-front approach that gave rise to traditional strong research programs and departments such as those at Cornell, Wisconsin and Davis. Thus, to gain national recognition, we needed to concentrate our efforts in selected areas of emphasis. We chose "molecular mineral nutrition" because we had a core strength in that area, because MU already had a tradition and national reputation in this area, and because new developments in molecular biology suggested strong future returns in this area. A second area of emphasis in "lipids, membranes and signal transduction" was chosen because the newly hired faculty were concentrated in the areas of membrane and cell nutrition, because they complemented a number of existing faculty in that area, and because nutrient modulation of signal transduction offers high potential as an important mechanism by which diet and nutrients modulate disease as opposed to health. These choices of emphasis areas also reflected consideration of disciplinary strengths present in adjacent states so that the impact of competition was minimized. This concentration of effort was not supported by some department chairs, who remained entrenched and demanded faculty in all traditional areas. Key administrative mentors—deans who actively supported our goals—were necessary to achieve the refocusing of our resources into these emphasis areas.

A second tool that teams can use, because of their flexibility, is to take advantage of negative situations to achieve needed change. In 1991, the university was again in a phase of examining its degree programs for degree-granting productivity. More than 80 programs were listed as targets for elimination, including Nutrition. The initial membership of the Food for the 21st Century Cluster was chosen by interest and self-selection, leading to a large membership. Within the group, there was a much smaller group that actively participated, contributed, and needed the program because Nutrition was central to their discipline and research. The evolution of Nutrition on campus, however, was held back from real change by the larger group. To remove Nutrition from the elimination list, we prepared a justification that required that members participate actively in the program; membership in the graduate program dropped from 40 faculty to 11 faculty whose interest in Nutrition was

sufficiently central to their goals. With this decrease in the denominator, multi-disciplinary Nutrition began to prosper on campus.

Nutrition was not prospering because of the overlapping interests of traditional programs versus multi-disciplinary programs. Chairs rightly wanted credit for students, courses taught, and degrees. So they smiled support but blocked more substantial activity like teaching of needed modern core courses in Nutritional Sciences. A multi-disciplinary "area" program in Nutrition had existed, unfunded, on campus since 1966 but was clearly secondary to departmentally-based degree programs. This area program did have the ability to grant M.S. and Ph.D. degrees in Nutrition, and had a series of courses on the books. The flexibility of the team approach again came to the rescue. The Food for the 21st Century faculty decided to begin teaching a multi-disciplinary graduate core under existing listed courses. The result was a solidified graduate program that was one of five programs at MU that doubled between 1992 and 1997 when overall MU graduate enrollment dropped by 21.6%. Today, the course contents now match with their titles, and we have a graduate handbook, a unified graduate exam program, and an active graduate student association. A recent outside review panel indicated that we were one of the top-12 programs in the country offering graduate education in Nutritional Sciences.

A third tool that we have used to make multi-disciplinary teams effective is to match programs with goals. Too often, the team programs in a university setting must be parallel to existing institutional programs. A major goal of the program is to increase extramural research funding. Our initial attempts with funding mini seed-money grants, locally reviewed, found lots of takers, but had little linked outcome in terms of publications and extramural grants. The principal investigators simply used these funds to augment their approach to satisfying departmental demands. Thus a "Strengthening Grant" program was initiated in 1993 to provide supplemental funds to principal investigators who had submitted an unsuccessful application to National Institutes of Health or USDA with the goal of funding additional research to strengthen the proposal for resubmission. This program thus rewards only faculty who submit national extramural grants—the goal of interest here—and it uses national peer review to provide input for improvement. The Strengthening Grant application is a 1-page form requiring 3 inches of text outlining how the proposed plan will strengthen the application, plus the department chair's signature so that he or she knows that Food for the 21st Century is investing in this faculty member. My office generally approves the grant in one day! There is no need for campus review panels, and no need for new approvals for animal care, radioisotopes, human subjects, recombinant DNA, etc., and the time that principal investigators must invest in redundant grant writing is minimal.

We've also used a similar approach, matching our program to the external goal, in our fall poster session program. This early September event uses abstract forms that are replicates of forms used for abstract submission to our national meeting (due in November), and so faculty can use the event as a reporting mechanism for summer research by their students and postdoctoral fellows and get draft abstracts and posters prepared several months ahead of the deadlines. In summary, university administration of multi-disciplinary teams at MU has allowed Nutritional Sciences to take advantage of the flexibility of the team approach to match its programs with goals of increased national presence at meetings, and goals of increased submission and funding of national extramural research grants.

Impediments to Team-Based Research

I hope by now that my enthusiasm for the team approach in general and for Food for the 21st Century at Missouri, in particular, is coming through. Time alone constrains me to stop at this point and to turn to discussion of why the team approach is not always successful at a university.

A recent book by Robbins and Finley (1995), provocatively entitled *Why Teams Don't Work*, provides a safe outline for a still-active Cluster Leader to discuss this topic. These authors grouped reasons that teams often fail into the fourteen categories. All fourteen are relevant to large universities in the Midwest as well as on the coasts. Especially relevant to this conference's interest in multi-disciplinary and multi-university research, they argue that teams are often implemented for the wrong reasons, that the organization often is not committed to the team idea, that team members are often not rewarded for their team work, that organizational procedures often are incompatible with team functions, and that teams and team members are often not given the right tools for the assigned task.

Under confused goals and bleary vision, Robbins and Finley suggest that organizational "leadership has foisted a bill of goods on the team." Teams are often implemented for the wrong reasons, perhaps because it's the current thing to do rather than because there is a short-term, solvable problem requiring effort from several diverse components of their organization. Another reason for failure may be because the team has a vision but the administration does not share in that vision. Today especially, clear goals and vision are required for implementation of a team with true potential for success. I would like to carry this argument further by suggesting that for teams to succeed, it takes vision and courage by the administration, rather than reliance on democratic processes, to set and support goals and vision for the teams that they send off into the rough seas of university policies, procedures and politics.

A “toxic team culture” can sentence a team to failure in an organization or set of organizations. Traditional units and unit administrators in these organizations likely will feel threatened when teams are first introduced, and they will often erect barriers to the multi-disciplinary effort. Our failure to implement a multi-disciplinary core graduate curriculum in Nutrition for more than 25 years is but one example. In today’s world of politically-correct behavior, administrative mentors of team activities should be especially vigilant in watching out for *glass* barriers to team-based activities. If an organization does not really commit to teams, say Robbins and Finley, then teams are doomed to failure.

A key category in this discussion is rewards. The reward structure for team members must make them feel safe to do their team jobs. This means that their performance expectations and rewards must be aligned with the objectives and goals. Robbins and Finley suggest that teams fail because “people are rewarded for the wrong things,” and thus team as well as individual efforts must be rewarded. Interesting, these authors further indicate that some experts even view individual merit reward systems as counterproductive to a team environment. Whatever the case, this viewpoint stresses the need to carefully consider and then rework the reward structure when a university decides to use a team approach.

When I quoted, “The team is at the mercy of an employee handbook from hell,” at this conference, it drew considerable chuckles. The discussion turned serious, however, as we discussed the demands on faculty researchers' time today. My number one concern here is with the expansion of non-productive paperwork, meetings, reports, etc. that intrude on the time that team members have for their team-based responsibilities as well as other responsibilities. As a cluster leader, I see my faculty struggling to find solid chunks of time for the important thinking, grant writing and research that are major goals for them, their team, and the university. This load is often doubled or tripled when separate reports are required from different primary units. Something has to give when new team responsibilities are assigned; reduction of process activities that do not contribute to the endpoint productivity of an institution is one way to empower multi-disciplinary teams.

In my mind, the #1 reason teams fail at universities is that they are not given the tools to do the assigned task. Robbins and Finley nicely summarize this: “The team has been sent to do battle with a slingshot.” To take advantage of the strengths of a team approach, my suggestion is to put the funds and team in the hands of the team leader and then get out of the way. Micro-management of a team inhibits the synergistic mixing of ideas and talents that is key ingredient making teams such a powerful approach to solving discrete, short-term problems.

Summary

In the above three sections, I have tried to outline why the Food for the 21st Century program at the University of Missouri has been successful in nurturing multi-disciplinary Nutritional Sciences. I think it is clear that the Food for the 21st Century program is a novel and unique Missouri idea that fosters multi-disciplinary research. This team approach has empowered Nutritional Sciences to become one of the top-12 programs in the country, and we have higher expectations. This strengthening has occurred largely because of the flexibility engendered by a team approach. Important tools for our success include: selecting a discrete set of emphasis areas in which to invest; using situations and systems that are advantageous to flexible teams; and using programs that match with the goals of our program. This clearly shows that teams can work in a university setting. Conventional structure at a university, however, may block the effectiveness of teams, and thus is something that administrators must recognize and adjust if their teams are to be successful. In particular, the university must commit to teams, pick goals with vision and courage, and reward team efforts for teams to be successful.

So, am I suggesting that this is beyond the grasp of universities today? My view is enthusiastically just the opposite. I believe that multi-disciplinary approaches offer an experimental way for peaceful transitions which in turn allow disciplines and universities to evolve. The individual colleges within Oxford and Cambridge have not been successful by remaining behind their sandstone and limestone walls for more than 400 years, but rather, they have succeeded by expanding beyond those walls in interesting, collaborative efforts that permit these institutions to evolve. Multi-disciplinary and multi-university approaches will provide new solutions and new discoveries that will keep our institutions vibrant, if we will only empower these teams and get out of the way.

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A BUSINESS-OREINTED VIEW OF THE ACADEMY

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We have always perceived that the academic organization is different from its competitive counterparts. Part of that perception is driven by the fact that we have to be different in order to compete. That view is really a crutch that does not provide a leverage for our continued survival. There is a difference in the academy, but the difference is generated by a realization that we must be different not to beat our competitors, but to respond to a market that has changed. Once we realize that the market is different and describe those differences, we can structure our operational strategy to be competitive in that market. Then we will not only survive, but we will prosper.

"The new barrier to entry is not volume or price; it is in finding the right fit between particular technologies and particular markets" (Robert Reich, *Point of View*, Spring 1991).

What is the academic market? Who do we work for and what is our product? Once we define these entities, then we know how to develop some innovative approaches to meet those needs. Our market is the private sector of the global community. It is not government, and it is not academia! They may be our partners, they may be our intermediate customers, but they are not our market. In my view a market is described by an entity that creates wealth, not one that pays for the service. An example of this approach is illustrated by a government contract, some of which we have in our organization. The government pays for some delivered effort; however, wealth is created only when the industrial sector leverages that product to some delivered value to the public sector (the public sector includes the global community). Our approach then must incorporate the best components of the public and private sector, with a focus on developing and growing our extramural interfaces. How we accomplish that implementation will determine our competitiveness in the open market.

We could also define the creation of wealth in terms of the teaching and service missions of the academy. Wealth is created in the teaching environment because we transfer knowledge to individuals where that knowledge did not exist or where it is but poorly organized. When students leave the academy they are capable of creating wealth where they may not have been able to accomplish that task before they entered. Wealth is not completely synonymous with money. In the broadest sense it encompasses all of the end products generated by the scientists, the technologists, the humanists, etc. We can place value on the contribution of the art historian

who enables people to appreciate art and its impact on the human condition, just as we can also place value on the contribution of the technologist who can make a better and faster computer. The real wealth to be gained comes when the technologist and the art historian team up to use their particular contributions to leverage increased wealth.

"In the High Value enterprise, profits derive not from scale and volume but from continuous discovery of new linkages between solutions and needs" (Robert Reich*, Point of View*, Spring 1991).

We should note the tendency for the government labs to be privatized rather than nationalized. One interpretation is that the management structure in the private sector is more efficient and therefore the productivity of those entities is increased. In the nature of the changing market the more justifiable reason for privatizing the government lab structure is tied to the ability of the private sector to create wealth by translating the output of the lab to something of value. Currently the private sector has had only limited success in that effort. They have not recognized the change in the market. The Academy must, if we wish to succeed, develop an interface with the private sector, take an aggressive position of how public and private sector interfaces can be developed, and lead to the development of these relationships for the benefit of the state and the nation.

In the past, the view of the academy (internally and externally) has been that we are isolated from the goings on of the real world. We have had a tendency to place ourselves above the fray. However, "the fray" is where everything happens! This is especially true when the value of information is driven not by the individuals who create content, but by those who market the content.

Teaching advanced subjects has always been the purview of the academy. Until recently this was indeed the case. Several major companies currently market high level educational products and services to the academy's customer base (in Engineering, NTU has a 15-year history of providing engineering education at a distance; Microsoft Corporation is beginning to market higher education materials; and Phoenix University recently began service with internet-based education). Several companies have internal "universities" that service the needs of their employees. Most of these providers use the traditional academic resources (our professors) to develop and provide content material. They market what the academy produces.

"The key assets of a high value enterprise are not tangible things, but the skills involved in linking solutions to particular needs" (Robert Reich, *Point of View*, Spring 1991).

There are three attributes resident in the spirit of the academic institutional process that, once recognized, can guide the organization's success. Those attributes include "High Tech," "High Touch," and most importantly "High Value." "High Tech" because we provide innovative solutions to market-driven problems. "High Touch" because innovative solutions require an exceptional ability to recognize market needs. "High Value" because once those needs are recognized it takes courage to provide efficient, responsive, and marketable solutions. We can be different as an institution if we tailor our current capabilities and mission to adapt these values to the way we conduct our business.

"Speed and agility are so important to a high value enterprise—Power depends not on formal authority or rank, but on capacity to add value" (Robert Reich, *Point of View*, Spring 1991).

What skills should we nurture within the development of the new academic institution? Reich has identified three critical ones. First is an ability to uniquely develop solutions to problems—**problem solving skills**. This is one where we have experience. Sometime it is developed in our industrial, academic, or government training and experience. It is a diverse skill requiring expertise from a broad number of disciplines. To be effective it requires cooperation from a variety of people in an organization. To be successful it demands a new operational culture.

The next skill identified by Reich is less tangible—**problem identification skills**. These skills are developed rather than acquired. This process, instead of selling concepts, requires listening, understanding and finally developing a cohesive description of what the market wants. This is the custom part of the high value process. Rather than delivering standardized goods, the outcome of this activity is the development of a customized solution specific to customer needs.

Finally, problem solving and problem identification processes require integration—**brokering skills**. This is where the new culture of academia is effective. When the market needs are identified, someone assembles the correct set of problem identifiers and solvers, builds the correct interface between the private, government and academic sectors and guides the completion of the effort. This ultimately becomes a management of ideas.

"Instead of a pyramid, the high-value enterprise looks more like a spider's web with strategic brokers at the nodes. Each point on the 'enterprise web' represents a unique combination of skills" (Robert Reich, *Point of View,* Spring 1991).

This structure describes the mechanism for efficiently accomplishing the goals of problem solving and problem identification, and linking the results

of these two activities to the market (brokering). Most of the problems that lend themselves to such a solution process are complex and require interdisciplinary technology components. Our ability to respond to the challenge of the changing high value market, requires the evolution of an academic culture that has the following characteristics:

Agility: The ability to identify and respond to quick response market requirements.

Speed: An efficient system that allows decisions to be made with care, quality and expediency.

Interdisciplinary: Access to a broad variety of complex capabilities and thinking processes that characteristically are not integrated.

Integration: The ability to recover, use, and manage resources that exist both internally and externally.

Communication: The ability to transfer ideas, direction and information without fear of lost control, competition, survivability, etc.

Change: A common denominator in all institutions. Our response to and acceptance of change will allow our other skill sets to be developed.

Accountability: A real opportunity if we accept the task of proactively presenting our successes and accomplishments and the value of these to our investment community (the state, our students, our customers, etc.).

Collaboration: The process of turning a competitor into an ally. The process of setting aside all of our past and current biases to find innovative solutions to complex problems using partners that can deliver success collectively.

Marketing: We have to have presence in the national and international communities. Our constituent base must know who we are and what we represent. We must market ourselves as effectively and with all the skill sets of any major private corporation. If we do, we will be effective in accomplishing our goals.

The Big Picture: A recognition of the direction, focus and ultimate goals of the academic organization, by both our internal and external contributors.

The new academic culture does not exist in its entirety as yet. That is neither good nor bad, but reflects the nature of the process of change. We will ultimately be different than we are today. That process is continuous and occurs in many different ways—attitudes change, new people bring their changes to the operation, the market changes, and/or established faculty respond to different opportunities. All that remains is for us to be prepared to respond to opportunities when they present themselves.

Our strategy incorporates technical diversity, distributed responsibility, and focused implementation of specific objectives. With this approach we can quickly develop a broad customer base that requires individual customized services—High Tech, High Touch, High Value.

THE DEAN'S ROLE IN FOSTERING COLLABORATIVE,

MULTI-DISCIPLINARY RESEARCH

Sally Frost Mason
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Professor of Molecular Biosciences
University of Kansas

Two years ago at these gatherings, I stressed the point that a dean's role is to act as a facilitator—a facilitator of the faculty, staff, and students that comprise the school or college that he/she is administering. Indeed, facilitation becomes even more important to a dean when the topic turns to research. Few deans can maintain a full research program, teach, and still serve as the administrative "leader" of one or more units. At the University of Kansas (KU), like many other public research institutions, the College of Arts and Sciences is a large and diverse collection of more than 50 departments and programs spanning the humanities, social and behavioral sciences, and natural sciences and mathematics. As a dean, formerly engaged in independent research as a life scientist for many years, the transition to administration has meant a change in focus of the types of scholarly activities that I can conduct myself. More and more, I find I take great and vicarious pleasure in the research and teaching accomplishments of the many colleagues who are part of an operation that includes nearly half of all tenure-track faculty on our campus. The opportunities for a dean to exercise skill at facilitation are thus numerous and limited only by resources and imagination.

Within the College of Arts and Sciences at KU, there are several examples of collaborative, multi-disciplinary efforts that the dean and other administrators have helped facilitate and grow. Of the two examples listed below, the first is an example of a research/outreach/grant-driven set of activities that are models for developing programs across disciplinary boundaries, particularly within the humanities and social sciences. The second example, also research grant-driven, is a much newer set of activities within the sciences that has great potential for fostering true collaborations across the disciplines of the biological, physical, and mathematical sciences.

Area/International Studies Programs

KU has been the beneficiary of a number of Department of Education Title VI National Resource Center (NRC) grants for a number of years. Currently, Russian and East European Studies (REES), Latin American Studies (LAS), and East Asian Studies (EAS) are all funded as NRC's, and African Studies has been funded in the past. The first step in preparing to become an NRC involves formation of a center and appointment of a center director, who is also the principal investigator on the grant. Once formed, the

center continues to function using both grant monies obtained and internal resources committed to help fund the goals of the center as outlined in the grant. To be successful in the funding arena, the center must establish that it has sufficient expertise in the language, culture, politics, economics, etc. of a particular region of the world (or plans to acquire that expertise to complement existing strengths). This has meant quite often that faculty need to be added across a multiplicity of departments who would then contribute dually to the center (program) and department.

Collaborations evolve at many levels because of these centers. For example, the center director, well before the grant or grant renewal is to be submitted, begins to plan by examining what, if any, areas of expertise might need to be enhanced in order to support the case to be made for the grant. The director early on begins discussion with the relevant departments about the potential for mutually beneficial faculty hires. Then, once these partnerships have formed, the needs are brought to the dean's office and prioritized with other hiring requests that have been made by College administrators. The fact that priorities such as these bear the endorsement of at least two units usually situates them advantageously for high priority. Moreover, the grant will usually pay a portion of the salary for these positions for a period of years with the understanding that at the end of two or three years, the institution assumes full responsibility for this expense. This type of arrangement can be extremely attractive administratively, either as a method for generating some salary savings ("shrinkage") that can be used to support infrastructure on a temporary basis or as a means of affording a new faculty hire sooner, rather than later, as base salary dollars become available. Consequently, REES, for example, has faculty partners in more than a dozen different departments that span the entire range of divisions across the College.

Although NRC's are not models unique to Kansas, I have discovered that few institutions are as successful or as aggressive as we have been in brokering joint appointments. Indeed, many of the faculty affiliated with these centers have joint appointments—a 0.5 FTE tenured or tenure-track appointment in a department and (usually) 0.5 FTE appointment within a center. We have been doing these for many years across many units within the College, and with other schools and, as a result, the fears that often accompany a pre-tenure joint appointment are minimal and often unfounded. Part of this success is due to a clearly written joint appointment agreement document that is shared with all parties at the time of appointment, and a faculty contract written in such a way as to guarantee, as much as possible, that work relevant on both sides of the appointment is taken seriously. Here again, a dean can work to ensure that the college-level promotion and tenure committee gives full credit for the work done by faculty appointed jointly.

Not only do the NRC's create opportunities for faculty collaboration on research, but each center has as part of its funded mission an outreach component. Outreach may be into the local schools or it may extend into the international communities that the NRC's represent. Usually, both types of outreach are ongoing through the centers at any given time. By sending into classrooms across Kansas KU faculty and staff who are knowledgeable about Russia or Latin America or Africa, we employ a potent tool for stimulating young minds to think globally. A stellar example of the influence that an NRC can have within a state was most obvious several years back when an international exhibit, "Treasures of the Czars," was brought to Topeka, Kansas. The number of visitors to this exhibit from all over the Midwest was phenomenal, and the exhibit itself was presented and marketed with help from REES faculty and staff here at KU.

The NRC and other area studies centers at KU have been in existence for well over a decade now and provide outstanding examples of how collaborative, multi-disciplinary research can be developed and maintained. The road has not always been smooth for each of these centers and their strength depends to some degree on the talent and determination of their directors, but their overall success as models of collaborative effort is undeniable.

A Model for the Sciences—EPSCoR

When first introduced into the state of Kansas nearly 10 years ago, many of us recognized the potential of the National Science Foundation's version of the Experimental Program to Stimulate Competitive Research (EPSCoR) and believed it would stimulate collaboration and multi-disciplinary research in the "hard" sciences, particularly physics and chemistry. The initial NSF award totaled approximately $4.5 million over 5 years, and was matched at least dollar for dollar by money from the state and institutions. The state program director and principal investigator on this grant had some discretion in how the money would be spent, but primarily it was to be committed to a series of large, multi-year, multi-investigator projects, with lesser amounts committed to stimulating smaller (often pilot) projects that met the objectives of the EPSCoR program.

Indeed the first systemic initiatives undertaken in Kansas were successfully funded only if they involved cross-institutional collaborations and/or evidence of inter-institutional cross-disciplinary activities. Senior faculty put together "groups" consisting of junior faculty, post-doctoral fellows, graduate students and undergraduates with plans to conduct hierarchical levels of mentoring down through the entire chain of participants. Some of these efforts were indeed successful in garnering new opportunities for faculty hires, for enhancing the graduate programs, and for improving overall infrastructure at KU, Kansas State University and Wichita State University,

the three participants in the statewide EPSCoR program. The groups were focused around common faculty interests across the institutions, for example, developmental genetics, chaos theory, materials synthesis, and others. The money provided by the grant was to be used primarily to enhance the research opportunities of the younger faculty, improve infrastructure generally, and stimulate interactions among the group participants.

Early on, it was gratifying to see the collaborations develop. Over time, however, it has become clear that junior faculty, in particular, believe (justifiably so) that their long-term success, i.e., tenure, will be judged not so much by collaboration and collaborative work, but by the independent efforts they themselves have undertaken. In some cases, EPSCoR was the springboard for this success, but more often than not, collaboration would be viewed as competition, and success in this competition meant going out on your own to bring in more money.

Indeed, in recent years, during the tenure of the second five-year contract from the NSF, increasingly more funds have been committed over time to junior faculty in the form of "first" awards. For these, there is no requirement of collaboration or mentorship by a senior faculty member to compete for first awards; there is only the necessity of writing and submitting an NSF grant through the normal channels while at the same time submitting to EPSCoR for a first award.

The good news is that this has worked quite well. Grant productivity overall has increased at the university and young science faculty are having significant success in competing for federal funding. First awards have helped in a number of cases; in just as many, first awards were not needed as a prelude to success in the funding arena.

What role has a dean played in all of this? While still associate dean, I was able to serve as co-principal investigator on the NSF award and thus as associate project director for the statewide initiatives. I worked closely with the project director, Ted Kuwana, who has been instrumental in bringing talent, resources, and a healthy collaborative viewpoint to the state. He has made tremendous contributions to improving science across the state of Kansas and improving the stature of Kansas with federal agencies like the NSF.

My own enthusiasm for the collaborations that were established through EPSCoR was high, and the contract submitted at that time reflected the collective enthusiasm of many of us for these opportunities. Shortly after receiving the notice of award, I became interim dean, and my level of direct participation has fallen significantly over the past few years as a result of new responsibilities and concerns about conflict of interest. Still, the willingness to commit new faculty lines, start-up monies and matching dollars for major

equipment and infrastructure have all come through the dean's office, and I take vicarious pleasure once again in the successes of our faculty and students who have benefited from EPSCoR. I can also reflect on where we've been thanks to EPSCoR and how this model has worked in the context of the highly successful NRC's mentioned in the preceding section.

Where are We Now?

In spite of good efforts made through the EPSCoR initiative and other federal grants that encourage large-scale collaborations locally and nationally, the sciences, and thus scientists, still tend for the most part to think and act as independent contractors. There are of course notable exceptions to this, especially in physics and math, where huge consortia of faculty working in theoretical and particle physics or chaos theory are the norm. But, for the purposes of rewards, groups in science tend to build around individual investigators who may themselves be surrounded by graduate students, post-doctoral fellows, and technicians. To build such a group requires grants, to obtain grants suggests you must be actively publishing, and if all of these things are happening, then tenure and promotion are moot points. So, it is still a rare individual in the sciences who succeeds solely on his or her ability to be an integral part of a collaborative group. Institutionally and nationally we need to think more strategically about whether this is indeed what we are all about.

A better model, I would contend, is the one that has grown out of the NRC funding opportunities. Faculty who are participating collaboratively and in genuine multi-disciplinary work are being rewarded with promotion, tenure, merit salary, travel opportunities and the like, despite fears that "serving two masters" in joint appointments can be "hazardous to one's academic health." I believe the scientists are moving in this direction, but I applaud the humanists and social scientists for leading the way.

OF BASEBALLS AND FOUL BALLS:

THE CONTEXT FOR RESEARCH

IN THE KANSAS BOARD OF REGENTS OFFICE

Kim A. Wilcox
Executive Director
Kansas Board of Regents

Last year at this meeting, Chancellor Hemenway shared that when he spoke with legislators about research, his guiding principle was: "All research is applied." While some scientists might have seen this as a slight to basic research, it was simply the observation of an experienced educator who recognizes that effective instruction typically builds on a meaningful context for the learner. Legislators, and the public at large, need a context to appreciate the value of research. Potential research applications can provide that context. In my time this afternoon, I'd like to share my observations on the context for considering research that presently exists within the office of the Kansas Board of Regents. These observations may apply to varying degrees to other governing board offices, as well, but I will leave it to you to make those extensions.

The short version of this talk is as follows: "There is no context for considering research in the Board office." While accurate and perhaps disheartening, that version may not be fully enlightening, so I will attempt a more elaborate rendition.

Public governing boards face a host of responsibilities, the two largest being budget and policy development. On the budget side, two items consume most of the time and attention of the Board. The first is the determination of the tuition rate (or other student-cost metrics) each year. Tuition rates are important to the Board, both for their financial impact and for their political sensitivity. Much discussion and debate is associated with determining these rates and in defending them before the legislature and the public. The second major budget item is the annual request for state support. This request is operationalized in different ways in various states. In Kansas, it typically consists of a requested percentage increase in salaries and other operating expenses. Budget issues have a well-defined timeline with specific planning activities scheduled throughout the year. The most active period, of course, occurs in the spring while the legislature is in session.

Policy development and policy implementation activities cover the full gamut of topics and include both continuous administrative processes, such as program review, and one-time issues. Aside from intellectual property and some ethical issues (e.g. human subjects policies) there are few research

policies that require Board review and approval. This means that the topic of research is not on the Board's agenda (or Agenda). The differentiation of agenda from Agenda is important. Here, I use the small "a" version to denote the list of broad issues addressed by the Board, with the large "A" version denoting the published meeting agenda. In fact, much of the attention of the Board is reflected by, and shaped by, it's monthly meeting Agenda. Without specific items on that Agenda any activity, including one as important as research, is largely invisible.

Arguably the most important parameter in shaping Board thinking is the central office staff. Kansas' central office is minimal and is organized to support the Board's primary activities. Research issues, where appropriate, are addressed by academic affairs staff who spend most of their time focused on program review, program approval, and related activities, most of which target undergraduate education. As a result, there is no cadre of staff to shepherd research issues through the Board. This focus on instruction, as distinct from research, is consistent with public and legislative interest. It is also consistent with the message that colleges and universities are currently sending to the public through the media, including television ads recruiting students which focus on many aspects of the university, but seldom on research. I could argue for, and against, the creation of a "Research Division" in our Board Office. But there are more fundamental issues that I'd like to consider here.

It is important to note that this lack of attention to research on the part of our Board is not malicious, but simply the result of a lack of appreciation and understanding of the research enterprise. In fact, most members have a sincere interest in research and take pride in excellent research programs. In keeping with the theme of this meeting, they also value collaborative programming, and especially inter-institutional collaborations.

In the short term, it is relatively easy to educate Board members on research. Here in Kansas, the three research universities (University of Kansas, Kansas State University, and Wichita State University) developed an excellent presentation on the role of research and graduate education this past spring for our Board. That session featured active scientists at each university and highlighted the role of research on the campuses. In my year working with the Board, that session was by far the most successful and had the most impact of all the presentations made to the Board members. I imagine similar presentations are being made in other states as well, but these are only short-term strategies; we need to consider more fundamental strategies, as well.

Here is a baseball. Like most objects, it's value is somewhat context-dependent and determined by the individual assessor. I could give this to an artist who might appreciate its intriguing symmetry and starkly contrasting

color scheme, I could offer it to an anthropologist who might value it as an artifact of the modern age and interpret its form within the social context of the day, or I could offer it to an athlete who would see it as a sports implement. In a broader context, we could attach a dollar value to the materials, manufacturing, and marketing associated with its distribution in Topeka, Kansas—$3.50.

Now consider a different situation, it's the middle innings of a relatively typical major league baseball game. It's mid-summer and it's hot. A long foul ball is hit down the third base line. Out of nowhere, some young man appears, without a shirt, but with a hat and glove. He leans way out over the wall and snags the ball in a daring catch. All of a sudden, 20,000 fans go wild. That is the same ball that's worth $3.50, but because of the context, it has brought 20,000 people to their feet. Why? Because everyone there appreciates not the ball, but the process of acquiring the ball. They recognize the special combination of **timing** (being in the right place at the right time), **preparation** (having a glove and having it on your hand at the important moment), **skill** (clearly this guy has some modicum of baseball talent) and **nerve** (risking a fall onto the field and facing security teams, or dropping the ball and risking embarrassment on the Jumbotron replay) that contributed to the successful catch. Successful research demands all the same ingredients. In research, timing is everything, being in the right place to take advantage of existing knowledge or circumstances is a recurring theme in the history of discovery. Scientists must be skillful and prepared, or those opportunities will be lost. They must also be risk-takers, not only in the large sense that we often associate with great discoveries, but more importantly in the day-to-day sense that characterizes our willingness to submit our proposals and findings to peer review and criticism.

Traditionally, we have given our students baseballs but not let them appreciate the process or the thrill of the catch. We teach history, but we don't share the excitement of the work of historians in piecing together written records, period artifacts, oral interpretations, and other data to interpret a period of history, a person, or an event. We teach chemistry and laboratory processes, but too few undergraduate students leave their weekly chemistry lab filled with the "excitement of discovery" that we recognize as the heart of research. As a result, students leave our undergraduate institutions without an appreciation for how scientists combine seminar information, library research, and experimentation (both successes and failures) to triangulate on what we believe to be "the truth."

Yesterday, we discussed the impact of the "adherence to the written text" as a factor in shaping humanities research, I would argue that we have also let our "adherence to the canon" overly influence our instruction in all disciplines. Here, I use the word canon in its broadest context and apply it to the accepted tradition that dictates the *required* information that must be part

of the education of all students in a discipline. We have argued for too long about which “baseballs” must be provided to every one of our students, and we have failed to fully consider the importance of “the catch."

I am thinking about all of our students here, but I am particularly thinking of our non-majors. Most would agree that majors in a discipline should master the canon of a field, but that may not be true for non-majors. Most of the students in introductory chemistry or physics are taking their only course in the field and perhaps the only laboratory science course of their entire educational career. Similarly, most students in undergraduate history courses are not history majors. These non-majors will forget many, if not most, of the facts (baseballs) offered up by their chemistry or history instructors. By focusing on the products and not the process of research, we have lost a great opportunity to educate the public about what we actually do. None of the current Kansas Regents is a scientist or historian. But like most college graduates, each took a college history course and a natural science course. Had those courses helped them understand “the catch," rather than just the “the baseballs” we would all be better off. Regents are selected from the general public. When we have succeeded at educating the public, we will have succeeded at educating the Regents, as well.

I have appreciated all of the successful collaboration stories that we’ve heard during the past two days. As a bureaucrat from the Regents Office, I need to live up to my reputation and offer a disheartening story of failure.

Three years ago, a colleague in Linguistics, Clifford Pye, and I submitted a curriculum enhancement proposal to the National Science Foundation. This proposal had many components, including enhancements to our departments' collaborative program with Haskell Indian Nations University and the expansion of laboratory coursework in Speech-Language-Hearing and in Linguistics. The proposal was funded, and with matching funds from the Provost and Dean, we created three student computer laboratories for state-of-the-art speech analysis and synthesis. The central curricular component of this project was the creation of a natural science course, entitled Speech Acoustics, that included a laboratory experience. Students in the lab would participate in real research experiences in speech, a medium with which they are familiar and one which can serve as an exciting entrée to a range of science areas from experimental phonetics, to information technology, to audio engineering, to linguistics. We proceeded to develop the course, laboratory exercises, and other materials. The initial offerings had small enrollments, but were well received by the students and the instructors, and were more successful than we had hoped in exciting students about the discovery of science. The course, however, was never fully integrated into the university curriculum, because the College faculty believed that it was not sufficiently broad to serve as an introductory course in the physical sciences. We had focused on “the catch," but the university

community was not ready to accept that paradigm, instead, they believed in the importance of “the baseballs."

I began by noting Chancellor Hemenway’s guiding principle that “All research is applied.” In many ways, he has been forced to adopt that principle by the context, not of the legislature, but of the public as a whole. A public that we have taught to focus on “baseballs” rather than “fly balls."

MARSHALLING FORCES

IN A COMPETITIVE RESEARCH ENVIRONMENT—

SOME SLIPPERY ISSUES

Charlotte R. Bronson
Department of Plant Pathology
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Not being a research administrator myself, I often wonder what drives administrators. What do they think about and what do they worry about? What gives them a sense of satisfaction? The world I understand is that of the ordinary faculty member, because that is what I am. I am a plant pathologist and fungal geneticist and I spend most of my time studying how fungi cause diseases on plants. The force that drives me is a love of genetics and my main worry is finding the time to write the papers and grant proposals that I know I will need to advance my career. I get my satisfaction from successes in the laboratory, and occasionally, the classroom.

Despite the fact that my heart is in the laboratory, increasingly, my time is not. For better or worse, I continue to be asked to perform service for the greater good of the university. I am not complaining, but I am still trying to understand how to do it well and I wonder whether it is something from which I will eventually derive satisfaction.

This last year, I was asked to establish a cross-university linkage between Iowa State University and the University of Illinois. This is my first such attempt and it is still in its infancy, so my understanding of the process is probably naïve. However, since I am still a faculty member "in the trenches," I hope my comments will help the administrators in the audience understand the perspectives of researchers called upon to perform administrative tasks. The better administrators understand their faculty, the easier it will be for administrators to achieve their goals.

An Attempt to Create a Cross-University Linkage

The linkage I will be telling you about is for genomics research on soybeans. The effort began last fall when I was asked by the associate deans of the colleges of agriculture at Iowa State University and the University of Illinois to help create a cross-university linkage in soybean germplasm improvement.

A significant driving force behind the linkage has been the concerns of the soybean promotion boards in Iowa and Illinois. These boards are major sources of funds for soybean research in the Midwest. Iowa State University,

for example, gets approximately 2.5 million dollars annually from the Iowa Soybean Promotion Board. The boards are thus very interested in having their universities do the best possible research. Over the years, they have expressed a number of concerns about the way that universities do research. These concerns have driven their interest in encouraging cross-university linkages. For example:

"We need big picture, bottom-line results."

The promotion boards exist to serve the growers. In order for check-off funding to continue, the boards need to be able to show high impact results. This is often easier to get from multi-investigator projects than from individual investigator projects. The team approach can produce bigger impacts.

"We put a lot of money into our universities; we want to see our dollars leveraged as much as possible."

The boards know that well organized teams of researchers, especially teams representing more than one state, can compete better for federal funds than can individual investigators.

"University research seems uncoordinated and duplicative."

The boards know that university researchers are free to do essentially whatever kind of research they want. There is no overall university research plan. It is every researcher for himself or herself. They also know that researchers at different universities often don't talk to each other. This is obvious whenever the boards meet to compare their research activities. Why should the Iowa board pay for the same research to be done in Iowa as is currently being paid for by the Illinois board to be done in Illinois? They want the researchers at various universities to work together in an organized manner.

"We want new traits and new technologies in the public sector, where they are freely available and not controlled by the big seed companies."

The boards are concerned by the way that big industry is starting to dominate agricultural research. They are looking to universities to produce new, desirable soybean traits that will remain in the public sector, where they will benefit growers and the public, not just a company's profit margin. Conducting plant biotechnology research independently of companies is, as many of you know, not as easy as it once was. Companies such as Pioneer, Monsanto and Novartis have very large, well-funded plant biotechnology research programs. Pioneer and a number of other seed companies have

excellent plant breeding programs. The result is that it is difficult for academic researchers to compete with, or sometimes even to keep up with, industry. One way to increase our competitiveness with industry is to form alliances with other universities. Another solution is to find research niches companies do not occupy, presumably because they do not see them as profitable in the near-term.

Because of concerns such as these, the Iowa and Illinois boards are supporting efforts by Iowa State University (ISU) and the University of Illinois (UI) to establish cross-university linkages in research relevant to soybean production and utilization. The first step was the signing of a Memorandum of Understanding between ISU and UI in May 1998 that states that the two institutions agree to work together in research and development initiatives related to soybeans. Last fall, the associate deans of the colleges of agriculture of two institutions brought together research representatives from ISU and UI (five from each institution) who had interests in soybeans. I represented soybean biotechnology. At the meeting, we discussed research areas that might be appropriate for cross-university linkages. We looked for areas in which there was (1) research strength at both institutions, and (2) potential for future funding by various agencies.

One of the areas chosen for further discussion was soybean genomics and germplasm improvement. I and my counterpart in Illinois were asked to take responsibility for exploring this area further. Our first step was to write small grant proposals to our respective boards to get funds to bring together all researchers at both universities involved in soybean genetics, biotechnology or germplasm improvement. The result is the Iowa-Illinois Joint Research Planning Session: "*Genomes to Germplasm: Optimizing the Application of Biotechnology to Soybean Germplasm Improvement.*"

The purpose of the meeting is to produce a list of common research goals and a plan for achieving them in an efficient, coordinated manner. Most importantly, it is to develop a series of proposals to be submitted to the Iowa and Illinois boards, multi-state soybean boards, and/or federal agencies. When these proposals are funded, the joint research will begin. Because, at the time of this writing, we haven't met yet, I do not know how well the meeting will work in establishing linkages. However, I will tell you how we hope it will work and some of the lessons I am already learning about establishing and maintaining cross-university linkages.

The Iowa-Illinois Joint Research Planning Session

Invited Participants

Since our goal is to establish linkages in the area of soybean germplasm improvement, we have invited all researchers at ISU and UI

involved in the genetics, molecular biology, transformation and breeding of soybeans. There are 16 faculty in this area at ISU and ten at UI. We have also invited a soybean utilization expert from each university to help us decide what traits should be incorporated into soybeans, and an administrative representative from each university, specifically the associate deans of the colleges of agriculture. We have also invited the Iowa Soybean Promotion Board and the Illinois Soybean Checkoff Board to send representatives as they see fit.

Tentative Meeting Schedule

To achieve the goals of the meeting, we have organized it into five sessions spread over one and a half days. They are as follows:

Session 1: *Priorities in Soybean Improvement*

Assuming that technology is not limiting, what traits should be engineered into soybeans? Who would benefit and why? Would any progress we make on these traits be negated by efforts already underway in industry? That is, what aspects of soybean germplasm improvement should be given a high-priority by the public sector? To help us with this session, each participant will be given a booklet beforehand on "Economic Implications of Modified Soybean Traits" published by the Iowa Agriculture and Home Economics Experiment Station. We will also have meetings beforehand on our respective campuses with crop utilization experts.

Session 2: *Joint ISU/UI Research Capacity*

What are the strengths and weaknesses of each institution in soybean genetics, molecular biology, transformation and breeding? In what areas do the research capacities of ISU and UI complement? To assure that this session goes smoothly, the researchers from each institution will discuss and catalog this information for their institution before the joint meeting.

Session 3: *Prioritization of Research Efforts-I*

What kinds of soybean germplasm improvement can we achieve in the priority areas given the current research capacities and funding resources of the institutions? How can we achieve those priorities most efficiently?

Session 4: *Prioritization of Research Efforts - II*

Which additional priorities outlined in Session I can be realistically achieved if additional resources or expertise were available? How long will it take to achieve these priorities and what additional resources or expertise would be needed? Which agencies would likely fund this work?

Session 5: *Implementation*

In this last session, we will make final decisions on our research priorities and assign responsibilities for writing grant proposals.

Thus, what we hope to get out of the meeting is one or more proposals for multiple-investigator, cross-university projects in which the research efforts are coordinated, synergistic, free from duplication, and in niches not already filled by industry. We are also hoping that this meeting will engender a shared sense of purpose among the participants, as well as a plan for continuing communication.

Slippery Issues in Establishing and Maintaining Cross-University Linkages

Since I have just started my efforts to create a cross-university linkage, I am drawing on my experience with other linkages to predict problems that might arise. I am also drawing on conversations with other faculty members who have established cross-university linkages in the past. As far as faculty members are concerned, the overall problem with cross-university linkages seems to be **"more hassle for less credit."**

Establishing and Maintaining Communications

Distance creates barriers to communication and slows the research effort. The group will need ways to break down the barriers. E-mail and phones are helpful for routine information transfer, but to initiate and maintain a relationship requires trust and that requires face-to-face contact. At a minimum, there should be an initial organizational meeting of the researchers. This should last at least a day, preferably longer, so that the researchers start to understand and feel comfortable with each other. Once the linkages are established, there should be yearly Project Meetings. Again, these should be face-to-face and last at least a day. Short meetings are helpful additions—over lunch or at a breakfast in association with a regular scientific conference.

Dealing with Egos

Although it is tempting to avoid "difficult" people by not inviting them to participate in a linkage, everyone conducting relevant research should be invited. There are probably a variety of ethical reasons for this strategy, but a pragmatic reason is that the commodity boards have no patience for internal academic squabbling. It is best to invite every researcher who is even remotely relevant to the proposed project. Those who can't get along with the group, or find they can't contribute, will eventually drop out of their own accord.

Another problem is that not everyone who participates in the effort to create the linkage may get funding, or, if they *do* get funding, they may not get the authority or credit they feel they deserve. In a large, multi-investigator project, there can be only one leader, only one first author, only one first principal investigator, and only one spokesperson. Participants must be reminded of these facts at the outset to reduce the possibility of hard feelings.

Finding Money and Time

Establishing and maintaining a cross-university linkage takes time and money. It will be necessary to include in budget proposals sufficient funds for yearly meetings. In addition, someone has to handle all the arrangements for the yearly meetings and, if the research funds are coming to a single "coordinator," he or she will need to administer any needed subcontracts.

Allocating Credit

If the research is truly multi-investigator, so are the publications. The problem is that multi-author papers are actually harder to write than single author papers, yet less credit is given per individual for the multi-author papers. This is especially true when the number of authors is large. How do you give adequate credit to everyone in publications and at promotion, tenure and raise time?

A case in point is a publication of a friend of mine. He is the 18th author out of nineteen on a publication derived from a multi-university research project. This is despite the fact that the project was his idea and he wrote the grant to do the research, disbursed the funds to the other researchers, arranged the project meetings, and organized the effort to write the paper. He informed me that it took the group two hours just to decide the order of the authors on the paper and some were *still* unhappy. Would a review committee or administrator seeing this paper be able to recognize the extent of his contributions?

This brings up the related problem of how to give credit to the leader for all the time he or she spends organizing the group. How is this type of activity adequately described in a promotion document or yearly activity report so that it is appropriately "counted" by those deciding promotion, tenure and pay raises?

Finding Incentives for Participation

There is little doubt that cross-university linkages are good for science. This fact will be incentive enough for some faculty members to stay involved, despite the hassles. And, if things work well, most of the participating faculty

should end up with extra dollars in their programs. Yet many faculty members may not believe the extra dollars are worth the extra annoyance. After all, why endure the frustrations of a group project when you can get more money and more credit for less hassle by writing a grant by yourself?

Faculty members have learned that the academic system rewards selfishness. Verbal expressions of appreciation from administrators do not carry nearly as much weight with faculty as promotions, pay raises, or other tangible perks. Why should faculty members get involved in a project that gives them more headaches for less reward?

How Administrators Can Promote Cross-University Linkages

The most important thing that administrators can do to promote cross-university linkages is to get their faculty to "buy in." Cross-university linkages cannot be established (at least, not successfully) by a dictum from above. To get faculty members to "buy in," administrators must recognize and acknowledge that large multi-investigator, multi-institutional projects are more work and often do not benefit individual researchers as much as single investigator projects. To encourage cross-university linkages, the reward system for faculty researchers needs to be adjusted to tangibly reward participants and not penalize them.

To reduce the penalty, administrators could provide clerical assistance to arrange meetings and/or handle budgets, as appropriate, so that the researchers and their technical staff are not saddled with these tasks. One possibility might be a pool of part-time secretarial help paid at the college level. Such assistance could be made available to multi-institutional projects on an "as needed" basis. Another suggestion is to make sure that all faculty members know how to properly indicate their contributions to research papers in their promotion and tenure documents. It is probably a good idea to do this also in annual faculty activity reports, since these can have big impacts on annual raises.

The most important thing that needs to be done, however, is for administrators to find a way to give tangible rewards to the individuals who take on leadership responsibilities for cross-university linkages. At present, many faculty members view any expression of thanks for their organizational work as lip service that has no impact on their salary or promotions. They see publications as the only avenue for advancing their careers or improving their personal financial situations. Some of the individuals with whom I talked were quite bitter about this. It is little wonder that so many faculty members view selfishness as the key to success in academia.

Fortunately, there is hope. I have seen several rewards for special service that faculty members seem to appreciate. The first is to give the

individual half a research assistantship for each year of their activity in the special leadership role. This has been done at Iowa State University for faculty members who accept the chairmanships of certain large interdepartmental graduate programs. It has been extraordinarily successful in encouraging faculty to volunteer to serve. An alternative is an "administrative increment," that is, a temporary increase in salary.

Neither of these rewards is particularly appropriate for the situation I have described, where the service, though above the ordinary, is not as extensive. In this instance, a less substantial reward might be in order, for example, a small increase in the person's base salary. The amount could vary depending on the extent of their activities. However, it need not be large. An extra raise of as little as $500 can make a big difference in how the person feels; it is tangible evidence that one does not have to be selfish to advance one's career. The raise should come with a note or a verbal explanation that it is in appreciation of their special service on the behalf of the institution.

In summary, for research administrators to succeed in establishing productive cross-university linkages, they need to go back a few years and remember life as an ordinary faculty member. They need to think about what motivated *them* to take time away from their research programs to help others. While it may never be necessary for researchers like myself to fully understand what motivates research administrators, it is essential that research administrators understand what motivates researchers.

My Favorite "Slippery Issue"

I have told you about my efforts to create a cross-university linkage and some of the "slippery issues" with which I have dealt or anticipate dealing. I have also given you my perspective on how administrators can help. However, cross-university linkages are not the only slippery issues with which I have dealt recently. My research focuses on slippery fungal slimes. This is a topic I love to discuss. However, I will restrain myself and save my "slime" seminar for another, more appropriate conference.

"HERDING CATS" —

A NEW INTER-INSTITUTIONAL SCIENCE NETWORK

Bruce Harmon
Deputy Director, Ames Laboratory
Distinguished Professor of Physics
Iowa State University

I'd like to talk to you today wearing two hats. One I wear as a computational scientist specializing in condensed matter physics, or more generally, materials science, and the other as an administrator and organizer of a new national network to promote interdisciplinary research among groups within the Department of Energy (DOE), universities, industry, and other government agencies. We have heard many of these themes expressed in earlier talks and comments, so some of the motivations and ideas for fostering such a network will be familiar.

Of course a solution to our problems is funding, additional funding. But with budget caps, tax cuts, defense, and social programs, the funding for science may be approaching a zero-sum game. Strategic areas will be identified for increased funding, but other areas will likely be pinched. The current priority areas identified by the National Science and Technology Council (NSTC) include (1) Information Technology, (2) Global Change, (3) Climate Change Technology, (4) Emerging Infectious Diseases, (5) Protecting Against 21st Century Threats, (6) Aviation Safety, Security, Efficiency, (7) Plant Genome, (8) Food Safety, (9) Integrated Science for Ecosystems, (10) Educational Research, (11) Nanotechnology. While I will speak about research relevant to high performance computing under item 1 and dealing with phenomena under item 11, there is no guarantee that there will be major increased funding for computational materials science.

Within the Materials Science Division of the DOE it is recognized that additional funding to provide each national laboratory with all the new resources to compete is not possible. One way to pursue new science is to assemble teams of experts from various groups and to share resources from different laboratories. The question is how we get scientists to work together across institutional and interdisciplinary boundaries. This is the problem of "herding cats," according to a friend who recently retired from Argonne National Laboratory. John Wesley Powell, the one-armed civil war veteran and geologist who first explored the Grand Canyon, wisely knew that coercion was not the answer. In testimony to the Allison Commission in 1885 he said: "Scientists spurn authority. They are as a class, the most radical democrats in society—patient, enthusiastic, and laborious when engaged in [absorbing] work … but restive and rebellious when their judgments are coerced by superior authority."

Even the simple answer—*money*—is not enough (although it sure can help). A large cooperative project needs important, relevant, and big ideas. The Manhattan Project and the Mission to the Moon are at one end of the example spectrum, and even High Energy Physics Accelerators have been based on big ideas. Today the mood of the country and the mood of Congress is to denigrate *big* projects, for example, the F22 fighter plane (too expensive), the Superconducting Super Collider (too expensive, and management problems), and perhaps the Spallation Neutron Source (management problems).

Before describing the compelling argument, the important vision, for investing in computational materials science, let me start the story a little over a year ago when panel meetings were taking place. At that time the DOE had started plans for a Strategic Simulation Initiative (SSI). This was to be a non-defense sister project to the Accelerated Strategic Computing Initiative (ASCI) that has placed the world's fastest supercomputers at the weapons laboratories to simulate the properties (e.g. aging) of nuclear weapons. When actual testing was banned, ASCI was proposed and funded as part of Nuclear Stockpile Stewardship. The computers employed are massively parallel, with thousands of processors. They are not at all easy to use. Not wanting the future of supercomputing to be completely dominated by the Department of Defense (DOD), the non-classified part of DOE was inclined to start SSI. Other agencies have joined and the interagency IT**2 initiative is generally slated for funding this next fiscal year (although there is now some funding trouble). The SSI was aimed at big projects and both the global climate modeling and the combustion components were identified early. A small remaining part of SSI is designated “basic science." Materials Sciences were welcomed to compete for part of the basic science piece of the pie. There were several national panels convened to discuss what computational materials science would propose as its main thrust, and a rather natural vision arose; however along the way it was clear that our community was not accustomed to working in large teams. We were called a “cottage industry” by some, and indeed the discipline is filled with single principal investigator groups, many competing against each other rather than working toward any single goal. We had to induce a cultural change to assemble a large team and agree on a project worthy of these remarkable computing resources. This new collective cooperation is not meant to replace single principal investigator groups which continue producing outstanding research, but rather the goal is to foster cooperation in order to work on truly large scale projects requiring multiple talents and disciplines.

Last December three of us went to the DOE’s materials sciences division and suggested the idea of a network. We had two models in mind. One was already in place among DOE laboratory experimental groups, called the Synthesis and Processing (S&P) Center; and the other was in place in

Europe, called the psi-k network. To foster collaboration among groups in different countries, the European community put up money to support postdoctoral fellows and students in joint projects, provided that they join groups located in a country other than the one in which they were trained. We were given the green light to organize such a network and the Computational Materials Sciences Network (CMSN) was started.

First let me describe the major science theme running through the current proposals for CMSN projects, and then I'll give a few specifics about the network. This information and a more elaborate description can be found on the CMSN web pages at: http://cmpweb109.ameslab.gov/cmp/ccms.

As in the automotive and aerospace industries, materials scientists and engineers are beginning to make greater use of powerful computers to help comprehend, design, process, and produce better materials with desirable properties. In many cases bigger computers are not just better, they are vital for simulations of real materials. Today's scientists are starting to calculate the structures and properties of real materials, calculations that were unimaginable just a few years ago. Until recently, our knowledge of materials arose mainly from trial-and-error techniques. Only with information about the atomic and molecular structures have scientists been able to comprehend materials at the most elemental level. Today, extensive computer modeling capabilities can complement and accelerate laboratory development. Computer simulations tools which should be available in the near future could substantially reduce the amount of time required to take a new material from synthesis to product, a process that currently takes a minimum of 10 years, and may take as long as 25 years. In the United States economy, this time lag to market is generally the principal barrier to new materials development.

The key new vision is that we have nearly all of the knowledge and computing power to couple fundamental atomic level knowledge with larger length scale simulations to evaluate and understand materials properties enough to greatly aid engineering designs. Scientists refer to multi-scale modeling when they want to describe interactions and properties at increasingly larger length and time scales. Scientists have a reasonable handle on both the smallest-length scale, which cannot be seen with a microscope, and the largest-length scale, which can be seen with the naked eye. In between is the intermediate-length scale, which scientists call the mesoscale, where there exist particularly exciting materials science challenges. It is the structure at the mesoscale that ultimately determines vital materials properties such as mechanical strength and magnetic behavior.

By accurately modeling and tailoring the mesoscale, scientists expect to:

- Create materials with new and innovative properties, such as polymer lasers;
- Extend the capabilities of existing materials, such as those that underpin silicon-based semiconductor technologies;
- Process materials cheaply and efficiently, reducing costs and waste.

These achievements will impact developments such as:

- Lightweight materials for transportation;
- High-temperature alloys for higher-efficiency turbines;
- Magnetic materials for motors and data storage;
- Opto-electronic materials for communication and information technology;
- Bio-compatible materials for implants, etc.

With this grand vision in mind, the mission of CMSN is: To advance frontiers in computational materials sciences by assembling diverse sets of researchers committed to working together in order to solve relevant problems that require cooperation across organizational and disciplinary boundaries. This project requires scientists with expertise in solving the quantum mechanical interactions, computer scientists skilled in parallel computing, and engineers who can make use of the atomic scale data (suitable averaged) for calculations of bulk material properties and design. The intent of the modest funding is to foster partnering and collective activities among these disciplines. It is expected that scientists who join CMSN projects are already funded (by DOE or other agencies) for work somewhat related to that portion of the project they would be contributing to within CMSN.

CMSN was launched February 3, 1999 when a number of possible project topics were discussed at a meeting of about 60 scientists. So far, four workshops have taken place. Three proposals have been submitted, with one funded; we expect that three or four more will be funded this next fiscal year. The workshops bring together 20 to 30 scientists to focus on specifics. Some of the scientists decide that the topic has narrowed in such a way that they are not interested in pursuing the project, and they decide not to join the effort. This is fine. There is certainly not much additional money at stake, and people have to be committed to the overall goal before the modest funding for travel and shared students and postdoctoral fellows is appealing. So far there has been great enthusiasm, although the exact mechanisms for the large scale collaborations are less well defined and will undoubtedly undergo modification and optimization during the first year or two of operation.

CMSN is a new experiment, one that could lead to a cultural change that may enhance large-scale cooperation in a discipline that is poised for major breakthroughs. It reminds me of many small villages forming a modern city, with common goals for infrastructure and economic prosperity.

REMARKS: PANEL OF CHANCELLORS

Richard L. Wallace
Chancellor
University of Missouri - Columbia

I was pleased to see "alliances" chosen as the focus of this year's conference. I truly believe that the defining characteristic of the next decade will be "partnerships" and the need to collaborate across disciplinary, institutional, state and national boundaries to contend with complex challenges and maximize our opportunities. I am personally, and the University of Missouri is institutionally, committed to building cross-university alliances.

I also much appreciate the wit and good humor we bring to our exchange of ideas at this conference. I appreciate the comments so many of you have made. As a concluding speaker, let me take a minute to respond to a few questions and issues, and then I'll mention collaborative initiatives I value at the University of Missouri (MU).

I agree that information technology will continue to foster competition and we will have to work harder to hold market share in providing educational programs. At this point, there are a few of our faculty colleagues who share this concern, but, at least at MU, it is my impression that most do not.

I am troubled by our discussion of measurements. Sometimes we only measure because we can measure. At the national level, I am concerned by the current dialogue within the American Association of Universities (AAU) about membership rules. I am concerned that the AAU is too tradition-bound and inward-looking as it considers this important issue. If the group were to re-examine its purposes, this might lead to different conclusions about the size of the organization and the types of criteria that should be applied for membership. Clearly, I see the need for a larger organization.

Related to Luis Proenza's talk, I agree that we are in a period of change and there are areas in which change is very rapid. There will be both risks and opportunities. Regardless of what we do or don't do, there will be internal change. What is the best way? We should approach it calmly and with reason. If we react with strong resistance to what is coming externally, it will become negative in impact.

In regard to administrative hierarchy, I believe we must make it less rigid. The old style is to live within "silos" so that communication goes up and down. Some administrators now take a more permissive view and recognize that effective teamwork requires us to break down the silos or communicate

across the silos. This is terribly important. If we cannot get beyond the old style of communication, partnerships are impossible.

In regard to teaching and learning, the MU faculty have worked hard the past 10-15 years to improve the quality of the learning experience for undergraduates. The faculty at MU have revamped the general education curriculum and have created living/learning environments, and we've put significant resources into both efforts. In regard to teaching assistants, we recognize their necessity and value within institutions of the type that we represent, but it is very important that we deal well with the issues of proper support, proper training, and proper screening. Also, at MU, we are trying hard to build a bridge between our research and undergraduate education missions. We are doing so by involving more and more of our undergraduates in our research programs and this makes unique use of the type of institution that we are. Of course, improvement of the undergraduate learning environment has brought additional pressure on individual faculty members to work harder and do more. Finding the proper balance is a constant tension, and it must involve the reward system. While some faculty would rightly complain that we have not gone far enough, it is clear to me that today we do reward a quality job at the undergraduate level much better than was the case in 1982.

I liked Marc Johnson's comments about "centers." One important point I would like to make is that partnerships begin at home. An important focus at the University of Missouri over the past 15 years has been to encourage and reward interdisciplinary research activity on the campus. This has been particularly important for our faculty in the colleges of agriculture, food and natural resources, medicine, veterinary medicine, arts and sciences, human environmental sciences, and engineering. Through mission enhancement we continue to strengthen linkages and build new ones. Two of our earliest ventures were the Food for the 21st Century and the Molecular Biology programs. Both were started in the 1980's with state support and both have subsequently attracted very able new faculty and significant federal and other outside support. Based on the foundation provided by these two programs, it was an easy step to expand the focus to the life sciences and the development of interrelated research programs devoted to a safer, more abundant food supply, improved health care, and cleaner air and water. As we have become increasingly aware of the complexity and interrelated nature of all organisms, the critical need for an integrated approach to life sciences research has become clear.

We believe the Donald Danforth Plant Science Center will become a world class contributor to the field of plant science. This is a joint venture of plant scientists in the Midwest, involving MU, Washington University, the Missouri Botanical Garden, and the Monsanto Company. We have since been joined by the University of Illinois and Purdue. I would welcome participation

by Kansas State, Nebraska and the University of Kansas. We want the number of participants to grow so that it is truly a Midwestern operation. This unusual partnership combines public universities, a private university, a non-profit corporation and a for-profit corporation. It has been a very interesting new model to launch and manage. I think it's important that I explain Monsanto's role. The corporation is represented on the Center's board of directors, but is insulated from influencing its research program. We have a large board of directors and Monsanto has only one seat on a governing body of 14. Monsanto provided land and funding, but our plan is to develop some endowment through fund-raising and to fund most research through competitive research grants. We break ground next week on a facility that will require about 45 million of the almost 200 million now in place.

The incredible variety of research alliances at MU is worth noting—and celebrating. One of the most successful in my experience is FAPRI, the Food and Agricultural Policy Research Institute affiliated with MU and Iowa State University. In studies ranging from the farm to the international marketplace, FAPRI uses comprehensive data and computer modeling systems to analyze the complex economic interrelationships of the food and agriculture industry and prepared baseline projections each year for the U.S. agricultural sector and international commodity markets. Another success story is RUPRI, the Rural Policy Research Institute. RUPRI brings together MU, Nebraska, Iowa State, and the University of Ulster, along with numerous other collaborating organizations and 80 universities in 40 states. A major RUPRI focus is multi-university, interdisciplinary teams working with legislative and administrative decision makers in two areas: (1) the rural impacts of Medicare reform and the Balanced Budget Act; and (2) welfare reform and workforce policy.

There are many other examples at MU (as would be the case for the other institutions represented here), and I will not go further in providing descriptions. I will simply close where I started—with a strong emphasis on the importance of alliances and partnerships coupled with the observation that, indeed, they are more difficult to organize and manage, yet they are the key to achieving much more than would be possible in isolation. Collaboration also requires very tightly focused goals and targeted energy—both to provide the infrastructure within a given institution and in regard to the institutions which these partnerships successfully create.

REMARKS: PANEL OF CHANCELLORS

Robert Hemenway
Chancellor
University of Kansas

The noble expression of the mission of the university is research. When we say that our goal is to seek the truth and to seek new knowledge—that's research.

To conduct research costs money, and there is never enough money. I've never seen us have enough money to fund all the research. This is good; our aspirations should exceed our resources. It is the responsibility of the Chancellor to increase revenue in order to achieve the aspirations. And you must show the implications of research to legislators. There are many forces which would deny us those aspirations as a research university. For example, when a reporter interviewed a legislator in Colorado and told him that a professor had made an important discovery that could win the Nobel Prize, the legislator responded, "so what?" There are forces in the societies in which we live that don't share our aspirations.

When we talk about "coastalization," those are real forces at work. That is why we become caught up in the rankings game. It validates our ambition. The University of Kansas has two #1 programs in the country: Special Education and Public Administration. When we have a chance to tell alumni and supporters that we are #1, this is a way to validate our ambition to be a university operating in the major leagues.

If you are going to play in the major leagues, you must recognize that you will provide a quality undergraduate education. We are constantly able to do what we do as a research university because of the quality of our undergraduate education. We have committed $75,000 - $100,000 to undergraduates who are doing research. They see themselves as Nobel Prize winners from this experience, and the opportunity for undergraduate research is what sets us apart from other institutions.

If it is the Chancellor's job to raise revenues, what are the ways?

1. Increase state appropriations
   —Midwestern states do not often appropriate large increases.
2. Increase efficiency and save money; reallocate the money saved
   —This is positive but you can't reallocate your way to excellence.
3. Raise tuition
   —We are from a state (Kansas) that believes in high access, high quality, and low cost education.

4. Increase and improve private giving
   —KU has the 14th largest endowment among public universities. KU couldn't be a research university if it weren't for this giving. Our new capital campaign will be 500-600 million dollars.
5. Increase federal grants and contracts
   —We've re-organized at KU in this way, and we're seeing some success. We improved the infrastructure to support research across campus. The idea is to support young professors.
6. Increase federal earmarks
   —KU and MU are in the top 20 for earmarked funds. An example in Kansas is the Dole Institute for Public Service and Public Policy.
7. Form university-industry partnerships
   —This is an important source of revenue for research. In the spring of 1999 alone, KU generated 10 million from these sources. Examples are the public-private partnership between Farmland Industries and KU in which we train middle managers, and the 21 million dollar deal with Coke that provides scholarships to KU employees and their children.
8. Form public-public partnerships or university alliances
   —KU has an alliance with Midwest Research Institute in Kansas City.

It's easy to see the benefits of crossing university lines, but bureaucracies, distance, and competition make it difficult. KU has a medical school and K-State is a land grant institution with a cooperative extension service. I've long thought that the way to deliver preventive healthcare to an aging population is to use the extension system and build a cross-university alliance between KU and K-State. This would take a full university effort. There are also opportunities in the Kansas City area with MU. The civic leaders, the chamber of commerce, and the area development council all support health sciences and life sciences research in Kansas City. The founder of American Century has designated 400 million dollars to support a world class institution for biology and genetics. When the human genome is fully mapped, the Kansas City area wants to participate in this research. It takes bi-state investment and both governors to achieve it.

When two universities join together, there is a tendency to see it as an incremental collection of resources, assigning an increment of faculty to a specific problem. This multiplies by two our leveraged capabilities, but it is possible to get ten times leverage with industry alliances.

Allen Greenspan says that a conceptual economy is based on information, knowledge, and ideas, not on product. As an example, I have an ad from Merrill Lynch offering a grant competition for recent Ph.D. candidates who can explain the market-based benefit of their dissertation. Part of this deal involves introducing the researcher to leading entrepreneurs and venture capitalists. It proves again human intellectual capitol is our single most

valuable currency—in other words, it proves the value of research. Ideas have value and currency. They are powerful.

This is the best environment for research that I've seen in my lifetime. What the Internet has bone for business is the best example of the economic engine generating new ideas. E-bay has a market value of 17 billion dollars. This is a new idea. People are excited about new ways of doing things. Research universities must take advantage of this resurgence.

CONFERENCE PARTICIPANTS
1999

Keynote Speaker

Luis M. Proenza, President
University of Akron

Iowa State University

Charlotte R. Bronson, Professor of Plant Pathology

Bruce Harmon, Deputy Director of the Ames Laboratory
Distinguished Professor of Physics

P. B. Swan, Vice Provost for Research & Advanced Studies

Kansas State University

Bikram S. Gill, Director of the Wheat Genetics Resource Center
University Distinguished Professor of Plant Pathology

Marc A. Johnson, Dean of Agriculture
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R. W. Trewyn, Vice Provost for Research & Dean of the Graduate School
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Andrew J. Blanchard, Director of Research, College of Engineering
Professor of Electrical Engineering

Jack O. Burns, Vice Provost for Research

Roger A. Sunde, Professor & Chair of Nutritional Sciences
Cluster Leader, Food for the 21st Century

Richard L. Wallace, Chancellor

University of Nebraska

Thomas Rosenquist, Director of Research, Medical Center in Omaha
Chair, Cell Biology & Anatomy

Other Participants

Keith Yehle
Legislative Assistant to Senator Pat Roberts
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Bob Woody
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Robert E. Barnhill, Vice Chancellor for Research & Public Service
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Roberta Johnson, Director of the Hall Center for Humanities

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