MOBILIZING FOR RESEARCH OPPORTUNITIES IN THE NEXT CENTURY

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Table of Contents

MASC Report No. 102

INTRODUCTION AND EXECUTIVE SUMMARY 1

KEYNOTE ADDRESS AND RESPONSE 11

PANEL OF VICE CHANCELLORS 23

PANEL ON FEDERAL FUNDING AND INDUSTRY PARTNERSHIPS 31

PANEL ON COLLABORATIVE HUMANITIES AND CROSS-DISCIPLINARY
WORK IN CHEMISTRY 45

WOMEN IN SCIENCE 61

PANEL ON ENHANCING SUCCESSFUL SCIENTISTS 65

PANEL OF PROVOSTS 83

PANEL OF CHANCELLORS 89

LIST OF PARTICIPANTS 93

INTRODUCTION

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

This collection of papers represents discussions arising from the second in a series of regional conferences on the topic of research support sponsored by the Merrill Advanced Studies Center. We hosted "Mobilizing for Research Opportunities in the Next Century" on July 15-17, 1998 in the retreat center at Valley Falls, Kansas. The gathering included thirty-two administrators, senior faculty scientists, and guests from three research institutions: the University of Kansas, the University of Missouri - Columbia and the University of Nebraska - Lincoln. The keynote speaker was Dr. Michael Crow, Vice Provost for Research at Columbia University. Senator Pat Roberts, Kansas, also joined the group for dinner on the concluding day.

In 1997, the Merrill Conference focused on pressures that hinder the research mission of higher education. Although many of these pressures remain, this view yielded in 1998 to a new outlook characterized by a sense of impending renewal due to the predicted budget increases at the national level. With the assumption that new opportunities are on the horizon, participants discussed how best to compete for new resources. Discussion focused on "roadmaps" to guide productivity individually and collectively. The group also worked towards identifying regional initiatives of potential interest to national funding sources.

The purpose of the gathering specifically was to examine upcoming changes, explore existing resources and areas of productivity, and consider ways to formulate research priorities for the region that enhance effectiveness at the national level. Michael Crow, as our keynote speaker and invited commentator, provided comments and suggestions as the group discussed the impact of changes in research policies on public universities.

The gathering provided an opportunity to develop a broadly-based sense of research and scholarship in regional universities. It was also beneficial to examine ways to strengthen the research mission relative to the universities' current standing, and in comparison with peers outside the region.

EXECUTIVE SUMMARY

In a series of seven panel discussions, the 1998 Merrill Conference participants explored mechanisms to enhance research, including partnerships with industry, special funding sources, and collaborative external funding in humanities scholarship. Participants also discussed ways to enhance the productivity of life/behavioral sciences research and cross-disciplinary research, and ways to bring women into senior science roles.

Collaboration by universities in the region was a topic of considerable discussion, since development of a regional initiative or "niche" could lead to national funding. Potential niches that were discussed included: quality of life, high-speed telecommunications and information technology, bio-sciences and the environment, and plant sciences.

Much discussion was generated by the keynote speaker in his comments throughout the day. Here follows excerpts from his key presentation.

KEYNOTE SPEAKER

Michael M. Crow
Vice Provost for Research, Columbia University
Professor of Science and Technology Policy

- The final form of the research university has not yet evolved.

- Before 1850, we saw a number of different strands of research university take hold, each peculiar to its own national history in Europe. In the 1890's in America, there were five prototypes of top research universities in each of three categories: state schools such as Illinois, Michigan, Wisconsin, Minnesota and California; private schools such as Columbia, Harvard, University of Pennsylvania, Princeton and Yale; and experimental/private schools such as MIT, Cornell, Johns Hopkins, Stanford and University of Chicago. Today most institutions are still chasing these fifteen schools, competing to enter this arena.

- When American research universities were taking hold in the 1890's, our technological resources were very different. Science was critical for only a select set of industries. A century later, science underpins innovation in virtually every major industry. In the future, we cannot imagine a separation between university research and emerging technology.

- Look at how innovation actually occurs and the role of universities. For example, in the realm of information technology, a set of disciplines owes much to the rise of one specific technology–computers; however, the ability to encode information in electronic signals, process and compute them, is a skill drawn from science and engineering in many fields, from physical chemistry and applied mathematics to applied physics. Thus, the convergence of applied and fundamental research. And universities are doing both, operating on the cutting edge. The continued vitality of companies depends on university knowledge generation.

- University-industry interactions sustain long-run technological change. Industry benefits from the universities by hiring trained scientific and technical personnel, acquiring instrumentation and methodologies, and from direct access to researchers capable of solving complex problems.

- Christopher Freeman describes the history of science and technology policy in three phases:

  1) beginning with military purposes;

  2) developing into commercially-centered science and technology policy; and

  3) evolving into a broader array of quality of life issues that can be tackled through science and technology.

  Most acknowledge that America exists somewhere in the second phase.

- Roger Noll believes that the decline in the growth of federal commitment to science will result in favored funding for elite universities, leaving second tier institutions to seek industry funding. This does not have to be a negative outcome. Universities distinguish themselves by their relationships to other segments of society.

- If universities are constrained to follow a model of the "American Research University" many options will be overlooked. Universities can legitimately contribute to many applied goals. To seize opportunities in a changing environment, universities must ask key questions, including "what niche is each institution willing to fill?"

PANEL OF VICE CHANCELLORS

Robert Barnhill
Vice Chancellor for Research
University of Kansas

Jack Burns
Vice Provost for Research
University of Missouri

A. L. Chapman
Vice Chancellor
KU Medical Center

- To compete with mega-universities, Midwestern institutions "team" with other institutions and the non-academic sector. An example of creating a productive "niche" in Missouri is the Plant Science Institute which involves the Missouri Botanical Garden, the Monsanto Company, the University of Missouri-Columbia and Washington University.

- At the University of Kansas, the Center for Research, Inc. is an example of organizational change in terms of: teamwork, competitiveness, models for mentoring and accountability.

- The national Research and Policy Committee of the Committee on Economic Development in its 1998 report stated that it is essential to maintain the role of government in supporting basic research as industry continues to focus on product-directed goals.

PANEL DISCUSSION ON FEDERAL FUNDING

AND INDUSTRY PARTNERSHIPS

Victor S. Frost
Acting Director
Information & Telecommunication Technology Center
University of Kansas

Ted Kuwana
Project Director
EPSCoR Program
University of Kansas

- EPSCoR is a federal-state partnership program developed with the intent of more evenly distributing research dollars among states. Kansas and Nebraska were the last to be designated in 1992, for a total of eighteen states and Puerto Rico. The primary funding agency is the Department of Defense, but others include NASA, the National Science Foundation and the National Institutes for Health.

- The NSF EPSCoR program in Kansas, K*STAR, has helped forge an unprecedented linkage among science, engineering, mathematics and computer science researchers at each of the three Ph.D. granting regents universities. Additionally, the Kansas Science and Technology Council was organized as a part of K*STAR and conversations between KTEC and the Council resulted in the Futures Fund which provides state matching dollars for EPSCoR and similar projects the meet the state's strategic technology priorities.

- Research competitiveness is an economic issue. Federal research and development funds for Kansas increased to $80.37 million in FY 1996. This pails in comparison to neighboring Colorado which garnered $279.79 million in FY 1996. The per capita outlay of federal funds for research and development averaged $31 for Kansas as compared to $75 for Colorado. The per capita average for the 50 states was $56.

- Economic growth in the United States during the 1990's has been fueled by information technology.

- The Information and Telecommunication Technology Center at the University of Kansas develops and transfers technological innovation to the private sector through an interdisciplinary research environment involving 100 students from electrical engineering, computer engineering, computer science, and mathematics. Its state-of-the-art laboratories focus on high-speed networking, lightwave technologies, and wireless and digital signal processing. More than 30% of its funding comes from the private sector, including a strong affiliation with Sprint.

- Examples of industry/university interactions include: direct sponsored research, joint research, internships, graduate fellowships, in-house short courses and consulting. Intellectual property rights and publication issues inevitably arise and must be resolved. Industry benefits by acquiring new technology and from hiring employees who have "real-world" experience in their academic portfolio.

PANEL DISCUSSION ON COLLABORATIVE HUMANITIES AND CROSS-DISCIPLINARY WORK IN CHEMISTRY

Maria Carlson
Director, Center for Russian & East European Studies
University of Kansas

Richard L. Schowen
Higuchi Biosciences Center
University of Kansas

- Grantsmanship has not typically been fostered in the humanities, but scholars are becoming more competitive as success in grant funding increasingly becomes an important hiring criterion.

- The National Endowment for the Humanities and the U.S. Department of Education allow projects that bring together humanists, social scientists and professionals. Collaborative humanities funding also comes from a variety of foundations and NGOs.

- As it concerns collaborative grants in the humanities and social sciences, the overt benefits to the institution are minimal; however, grants promote institutional visibility and prestige, and can provide valuable outreach that results in recruitment and development. Collaborative funding can also provide start-up investment for a special program that the university may not otherwise be able to fund. The four international studies centers at the University of Kansas are examples. Collaborative funding can enhance teaching and research productivity and take pressure off the institution by providing funds for conferences, library acquisitions and travel for teaching and research.

- Disciplinary boundaries are hundreds of years old. If we had no disciplines, we'd have more flexibility in research. Interdisciplinary research is necessary because in all fields, the easy work is finished and difficult problems defy easy categorization in the traditional format.

- Elements that contribute to functional and facile interdisciplinary scientific endeavors at the University of Kansas: the presence of supreterritorial research centers; and the absence of accounting barriers. Researchers are not responsible to any dean or chair, but rather to the research and the faculty at large. Also, grant income and publications do not need to be allocated among the organizational home territories of the researchers by an accounting practice that makes it a zero-sum game.

WOMEN IN SCIENCE

Deborah Powell
Executive Dean and Vice Chancellor for Clinical Affairs
University of Kansas School of Medicine

- To maximize intellectual resources in science and develop talent for the next century, the ranks must continue to include women and minorities. Recent estimates indicate that between the mid-1980's and the year 2000 the majority of growth in the labor force will come from the entry of women, people of color and immigrants.

- Women and minorities benefit greatly from role models and mentors who are senior members in the field. Affirmative Action has diversified scientific leadership in the nation.

- Women's career decisions are influenced heavily by family responsibilities. Newly flexible promotion and tenure policies help young women and men establish academic careers without having to postpone child rearing.

- When women take time off for family matters, they lose valuable networking connections. Re-entering is also difficult because the scientist's knowledge and skill base may be outdated. Many professional societies and federal agencies have begun to offer support and training opportunities for re-entry scientists.

PANEL DISCUSSION: ENHANCING SUCCESSFUL SCIENTISTS

Stephen C. Fowler, Senior Scientist
Steve Schroeder, Director
Schiefelbusch Institute for Life Span Studies, University of Kansas

- Proposals more than ever must include innovative approaches and demonstrate interdisciplinary or interlaboratory collaborations. The new criteria for the peer evaluation of research proposals at the National Institutes of Health indicates this. Also, grant proposals have to be four times as well informed as in 1968 because information in a field doubles every 15 years.

- To increase research productivity: link salary decisions directly to the desired research outcomes; and establish internal research accounts for active principal investigators.

- We should think big. Sustainability of life on the planet is a truly big idea in which each of us could probably find a challenging niche. For those of us in the heartland, we could focus on quality of life issues.

- Consilient goals imply working to unify knowledge rather than to fragment it. Consilient goals also imply sacrificing or delaying some individual priorities to promote a common goal. This includes encouraging students and faculty to train themselves across disciplines.

- To grow in research and development in this region, we have to do it with external funding. The federal funding situation is the best it has ever been in 35 years, and will likely get better. This is the time to mount a regional initiative.

- Our growth rate must keep pace with the "mega-universities" or we will fall behind in the competition for the best students, the best faculty, and the best scholarly support networks for the whole university. We have no choice but to compete.

- The Life Span Institute at the University of Kansas has competed successfully over the past 40 years by clustering 100 grant projects around areas of excellence in order to compete for larger center grants and program projects that in turn support individual researchers. See the principles of operation in the 1987 presentation by Dick Schiefelbusch.

PANEL OF PROVOSTS

David E. Schulenburger
Provost
University of Kansas

- We should discuss how to develop institutional focus–the one or two major ideas that can captivate and energize communities so that they become effective research machines. Dr. Crow indicates that a "niche" concept is being followed by Columbia University, which provides a valuable role model for us to emulate.

- There are enormous costs to maintaining parallel departments and center structures at a university; there are benefits to combining departments so that they have the critical mass to behave both like departments and interdisciplinary centers. Departments often will not help the University achieve a niche concept.

- We must not lose sight of our purpose–education. Education is the organizing principle of our activity and were it not so, our support and funding by state legislatures would be threatened.

- We must seek to increase externally funded research for the right reasons. We should not try to compete with private and non-profit research organizations that don't need a core of humanities and social sciences undergirding their purposes. We should not adopt goals strictly to bring in more research dollars without concern about the whole enterprise.

- The movement of journals to an electronic medium is likely to have effects that are difficult to envision today.

- Costs of research literature are still increasing at more than 10% per year and the result is increased cancellation of journals and decimation of monograph collections. This threatens the success of our research and teaching missions.

- The American Research Library Association is attempting to form new electronic journals to provide researchers with publishing outlets that are affordable to their universities. Web-based distribution effects a dramatic cost reduction and these benefits can be passed on directly to libraries and society members.

- A set of AAU academic officers is forging a plan that would put the researchers in control of disseminating their work via the World Wide Web, and might have the effect of rolling back journal prices. In this plan, the review process remains intact as currently conducted by the society, but it is separated from the typical publication process. Articles selected for publication would be posted on the web by the society and made accessible to all researchers and students. Another method might involve creation of a system–perhaps at the Library of Congress–where all manuscripts accepted for publication by journals would be placed on the web within 30 days of their appearance in print. Access could involve a minimal charge, with the proceeds split three ways–going to the journal, the author and the system maintaining the web site. This scheme would make all research literature available at a fraction of the cost we now pay and might stem the publication of works that are not really of interest to anyone.

PANEL OF CHANCELLORS

James Moeser
Chancellor
University of Nebraska-Lincoln

- Nebraska is beginning a bold initiative that will use new sources of revenue to create new levels of excellence without eroding core programs. The project requires a candid assessment of the status and quality of current programs, an assessment of special opportunities, and an analysis of major problems affecting the world or our nation that Nebraska is well positioned to solve. It also requires the vision and creativity to imagine what might be possible with enhanced resources. The intent is to move Nebraska forward in research and graduate studies in the next five years.

- Nebraska is in the second year of major reallocation of the state-aided budget. This has been debilitating. With new resources, the most significant from private philanthropy, Nebraska can now engage in a process that is not about dividing up existing resources to make short-term gains, but about new targeted investments for the future.

- Discipline and focus are key. Nebraska can be either a supermarket of average and adequate programs, or an institution with comprehensive offerings at the undergraduate level and some select areas of distinction in graduate education and research.

Robert Hemenway
Chancellor
University of Kansas

- Chancellors see the research mission in a broader political context; they carry the responsibility to communicate the values of research to legislative representatives.

- Foremost is the need to honor the state compact with public universities: to support the education of native sons and daughters. The research mission must be in synchrony with the broad educational mission.

- Our challenge is to create “premier learning communities.”

KEYNOTE ADDRESS

ORGANIZING TO RESPOND TO EXTERNAL RESEARCH OPPORTUNITIES: DIMENSIONS OF CONCERN FOR UNIVERSITY COLLECTIVE ACTION

Michael M. Crow
Vice Provost, Columbia University
Professor of Science and Technology Policy

Origins of the Research University

The history behind the development of the "research university" is long and rich. We can see the first signs of such an institution in the establishment of the University of Bologna and the University of Paris in the 1300s. While Bologna was established primarily as a professional school (law and medicine) and Paris grew out of ecclesiastical schools of the 12th century, after the Great Schism of 1378 these and other institutions came to encompass faculties of art, theology, law and medicine.

These institutions were important organizational innovations for the time, but they did not play a crucial role in the advance of knowledge as time went on, particularly during the 17th and 18th centuries. Retaining narrow and antiquated curricula, these institutions actually opposed the ideologies of the Enlightenment. Instead, scientific societies and academies developed to fill this void and to advance science. Through the 17th century, such organization played a critical role in self-sustaining science. The ideal of this model can be found in the Royal Society and the Académie Royale des Sciences. Hundreds of such societies emerged of various size and importance. From this, an international community of scientists began to develop.

After more than two centuries of atrophy, the university as an institution began a revitalization as it faced a more desirable political and religious environment, and as it absorbed the norms of open science developed by the academies. It is out of this revitalization that the new models of teaching and research developed in Germany, England and France.

And, while the elite American colleges were built originally to educate gentlemen in the ways of theology, languages and the classics, they too were soon subjected to the powerful influence of this international scientific community.

The Nineteenth Century

Before 1850, we saw a number of different strands of research university take hold; each peculiar to its own national history. England had Oxford and Cambridge, but it also had the Royal Institution of London which served as a center for both fundamental and applied scientific laboratory work in the Baconian tradition. France, under Napoleon, developed a suite of Ecoles that were designed to support the development of a strong engineering class and bureaucratic class. The German research universities grew up as full bodied institutions encompassing the literature and philosophy of the Romantic period and strong theoretical and empirical work in the sciences. And, by this time, other European science centers had emerged.

In America, we had little in the way of "research" going on during this period. Westpoint, as America's military academy, was a center of engineering excellence, but science had no place. Rensellaer Polytechnic was established in the 1820s modeled on the French Ecoles, but it did not embrace the sciences fully until it reorganized just before 1850. By the 1850s, some "scientific schools" were established within more traditional American colleges like Harvard, Yale and Columbia. These schools sewed the seeds for their later transformation into research universities, but the scientific schools were hardly welcomed into the institutions.

By the Mid-1870s, Land Grant universities had been established in nearly every state under the Morrill Act of 1863. Also, aspects of the German research university transferred to America with the establishment of Johns Hopkins in 1876. The model of the scientific school had spread throughout American colleges, and elective tracks had evolved allowing students to select concentrations in the sciences.

At the same time, Germany's research universities had risen to clear prominence in chemistry, physics and agricultural sciences.

By the 1890's, the American research university community had evolved into a structure much like today's. At that time there were 15 research universities. Illinois, Michigan, Minnesota, Wisconsin, and California developed state universities that had scientific and engineering research at their core. Columbia, Harvard, Penn, Princeton, and Yale had successfully evolved from being traditional elite colleges specializing in languages, religion and the classics into developing centers of scientific and engineering research. And Johns Hopkins, Stanford, and University of Chicago–each established as a research university–were joined by MIT and Cornell–with slightly different histories–to become the pack of more recently established schools focused on research.

World War II and Beyond

Immediately after World War II, a slightly different structure emerged in the American research university community. Illinois, Michigan, Minnesota, Wisconsin, and California continued as the public research universities. But other land-grants such as Iowa State, Penn State, and North Carolina State developed into institutions with considerable research capacities. Out of the traditional elite colleges and the newer research universities, Columbia, Harvard, Stanford, University of Chicago and Johns Hopkins emerged as the central private research universities. And MIT and the new California Technical took on a distinctive, more narrow character as major technical institutes. As such, one can discern not one American research university model, but several.

But this immediate postwar pattern did not keep the system from evolving. Indeed, massive postwar science funding, in tandem with considerable institutional entrepreneurialism, led to the development of entirely new institutions of research, such as, University of California at San Diego, Arizona State, State University of New York at Stony Brook, and Duke. Still others fit into this category.

In sum, many different brands of research university have evolved with distinctly different competencies in terms of types and fields of research. It is this variety that has made our national innovation system so robust.

The Changing Composition of American Industry

When American research universities were taking hold in the 1890s, the state of the world was very different. The state of our technological resources and know-how was very different. At that time, science was only a major input for a select set of industries in America, namely electrification, telegraphy/telephony, and in chemical inputs/processes for agriculture and steel. This list of dominant, vital industries illustrates this situation: machine tools, firearms, clocks, sewing machines, hardware, agricultural implements, bicycles, steel, electrification, telegraphy/telephony.

A century later, we see a distinctly different pattern. Science underpins innovation in virtually any major industry you can imagine. Microelectronics, biotechnology, advanced materials, telecommunications, CNC machine tools, civilian aircraft, computers (hardware and software). The list can be extended for some time. The evolution of these industries and associated fields of technology has much to do with the rise of the institutions of science a century before. Also, in many cases, these industries and technologies owe much to ongoing federal commitment to research performed in these and other institutions.

And, if we look into the crystal ball, we see emerging areas of technology that we can currently only imagine. And, they cannot even be imagined apart from major university research capacities in a range of related areas.

The Technology Development Continuum

In 1945, Vannevar Bush's famous report *Science The Endless Frontier* articulated a linear model of innovation wherein basic research advances at universities fueled applied research and development at firms. We see this here in the technology development continuum. While Bush had his reasons for characterizing the process of innovation in such a simplified way, his simplification missed several critical aspects of the nature of our research system.

First, as Donald Stokes pointed out in his book *Pasteur's Quadrant*, the distinction made in the linear model between basic and applied is not always useful. Stokes focused on a mode of fundamental scientific inquiry conducted by a research inspired by considerations of use, as did Pasteur. The distinction becomes even less useful when one considers a problem that Lewis Branscomb has noted–that fundamental technology development is no less fundamental than basic science, yet it has no place in the linear model.

In short, the linear model breaks down upon consideration of how innovation actually occurs. Moreover, the role it assigns to universities is contrary to that which history demonstrates. Universities have been involved in many aspects of scientific advance and technological change, only one of which is assigned to it in the linear model. The variety of universities in the American national innovation system have been involved in many different scientific and engineering activities depending on the industry, field of technology and the various social commitments made to these areas.

The Range of Research Types

If you take the standard set of departments at your top tier research university, you find a variety of science and engineering departments doing a wide array of activities. The core sciences are represented along with a large number of engineering disciplines.

With America's historic commitment to supporting agriculture through education and research, we find that many universities, particularly the land-grants, have developed an additional level of agriculture-specific disciplines. These disciplines are no less fundamental but are very applied in many ways. They are intimately related to areas of university research that are typically considered more in line with the model of a "research university." Where would entomology be without biology? And where would soil sciences be without chemistry? In this case, universities have housed a wide range of research.

Again, we see this phenomenon in our academic medical centers. They include an additional level of research specific to providing for a healthy population. The basic bio-sciences, clinical departments and medicine departments are intimately related to the standard university basic sciences and engineering disciplines. They are no less fundamental, but are often highly applied to particular problems. But, where do they lie on the linear model?

In the example of information technology, we see a set of disciplines that owe much to the rise of one specific technology–computers. Yet, they also owe much to the bodies of knowledge developed by the traditional university disciplines. Our ability to encode information in electronic signals, and then to process and compute these signals is a skill that has drawn upon scientific and engineering expertise in many fields, from physical chemistry and applied mathematics to applied physics. This work is highly applied, yet often quite fundamental. And, universities operate at the cutting edge, time and time again.

The case of development, both urban and not-so-urban development is almost entirely about applied work. However, universities have been involved in research into these matters for over a century. Research into the design and fabrication of new infrastructure has seen significant university involvement for quite some time. Urban planning, while not a science, has been a field of university research with great impact. Now, with the rise of information technology, new techniques in planning information systems are being pioneered in university environments. All of this is applied, but universities have been significant and valuable players.

Parallel Process Model of Technology Development

There are simple alternatives to the linear model that provide us with a more robust understanding of the tandem processes of scientific advance and technological change. This model demonstrates the two directional flow. It also demonstrates some of the complexities that exist beyond basic and applied research. In this model we do not even attribute one or another aspect to different institutional players or firms, because we know from our empirical studies that different areas of technology and different industries enjoy very different configurations of institutional and industrial actors. The research and development division of labor can vary widely.

While universities develop many different types of knowledge products embodied in innovations, articles and individuals, it is firms that are the organizations that have the comparative advantage in "making airplanes," "designing microprocessors," and otherwise producing goods and providing services. With their senses trained on particular markets and their competencies honed to particular niches, firms are the locus of much learning related to the advance of particular goods and services. But, their continued vitality often depends on the rejuvenating forces offered by university knowledge generation.

A range of university-industry interactions sustain long run technological change. Some are direct such as the diffusion of trained scientific and technical personnel embodying pertinent knowledge. Others are indirect such as the development of instrumentation and methodologies that are absorbed into industrial practice. Still others are vague such as access firms might have to university based knowledge networks for both infrastructural knowledge or an interdisciplinary mix of university researchers capable of solving complex problems. These interactions differ by fields of science, areas of technology, and industry. Yet, universities play critical roles in supporting innovation through basic science and a wide array of other modes of research.

Designing University-Industry Interfaces

The practical impact of various types of university-industry interfaces can vary by: 1) proximity, 2) the composition of science and engineering graduates, 3) the match between industry and university strengths, and 4) the institutions developed to mediate between universities and industries. These factors must be considered as one designs university-industry interfaces. If one hopes to use such interactions to facilitate particular impacts, one must understand the relationship that each of these dimensions has to their institutional design.

When trying to understand how to better organize your universities as institutions committed to catalyzing progress, you must design your institutions while aware of these dimensions. But, most important, you must decide what kind of university you want and the kind of impacts you would like to have. There are many options and a university can serve many purposes depending on how it is designed.

Freeman's "Three Phases" of Science Policy

Christopher Freeman has described the history of science and technology policy as one that can be understood in three phases. In his view, science and technology (S&T) policies often begin directed toward military purposes. As some nations progress, they begin to evolve a commercially-centered S&T policy, though it is usually built in addition to the original military S&T resources. And, for Freeman, some countries are beginning to evolve comprehensive S&T policies which focus in on a broader array of quality of life issues that can be tackled through science and technology.

Most would acknowledge that America exists somewhere in the second phase, though many openly object to such targeting of resources. And, most would contend that a broader focus on the quality of life exists only in America's distant future.

The accomplishment of this third phase will depend heavily on issues of institutional design.

Roger Noll's Thesis

Roger Noll believes that the decline in the growth of the federal commitment to science will lead to some lean years in university research. The impact, in his view, will be that these declining real dollars will favor the elite universities and that second tier institutions will be forced to seek industry funding to maintain their enterprises. Noll sees this as a negative force, with the implicit assumptions that universities best do basic research and that industry sponsored research will be more applied in nature. Perhaps. But, Noll fails to understand that universities do a wide array of different types of research and can legitimately contribute to many applied goals. It is the shape and nature of these university-industry interactions that will condition the qualitative characteristics of the outputs of these interactions.

General Environment and Interactions

Many aspects of a university's environment are advantageous if the university is entrepreneurial enough. There are options in how a university can evolve. However, if universities feel constrained to adhere to some model of an "American Research University" many of these options are overlooked. Universities have never adhered to a single form and it is often the relationships of universities to other segments of our society that distinguish them from each other. While this external environment is complex, it offers much potential for crafting universities with significant impacts.

How Do You Think about Organizing Collectively?

From all this, it seems that there are a series of questions one must ask when thinking about how universities might think about organizing collectively to seize opportunities in a changing environment.

What is the substantive vision?

What niche is each institution willing to fill?

What complementarities exist that could be exploited?

What new governance and business models will permit this?

How can business stakeholders be integrated into priority setting?

What will the new federal-state-institution relationship look like?

Only when we are willing to face these questions will we be ready to seize the opportunities posed by this new and challenging era.

RESPONSE

TO THE KEYNOTE ADDRESS

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

Our keynote speaker, Mike Crow, encourages us to think strategically, but only after we have made a situational analysis of our own institutions. We are to think of ourselves as architects, as designers.

He raises five issues today:

1. Institutional evolution is an ongoing process.

2. Variation, not replication, is the key to the university's survival.

3. Regional character, regional distinction of institutions is important.

4. Universities will move into the central role of societal transformation, primarily through their graduates.

5. Forces of change in the national research system are dramatic and are caused by a concentration of economic forces.

What might we do to respond to these issues? Dr. Crow suggests the following:

- Build a strong foundational academic core at each university.

- Identify niche areas for research focus. Each institution should identify large scale integrating problems that catalyze many faculty.

- Take more risks in order to move in these new directions.

- Cover subjects cooperatively with other institutions.

At this session there has been considerable misunderstanding of Dr. Crow's phrase "niches." Most of these difficulties can be avoided by defining "niche" as a unique area of distinction, a focus on research strength. The challenge to the university is to pursue niches that fit its institutional and regional character and possibilities. His examples of niches included the Columbia University Earth Institute and Photosynthesis Center and the planetary model theme at Arizona State University.

An example of an emerging niche at the University of Kansas (KU) might be called "quality of life." This niche combines aspects of the three largest Lawrence centers, the Life Span Institute, the Higuchi Biosciences Center and the Telecommunications Center–each represented at this workshop–as well as the focus at the KU Medical Center on the treatment of specific diseases and health care management. We observe that this theme fits well into Chris Freeman's three phases of science policy cited by Dr. Crow: 1) military, 2) commercial, and 3) comprehensive. The comprehensive phase constitutes the national objective to use science and technology to improve life.

Expanding on Dr. Crow's comments, we must emphasize *collaboration*, both within institutions and across institutions. Different strategies are needed for successful collaboration in these two contexts. At KU we are pursuing both kinds of collaboration. A situational analysis is necessary for each.

A first step in performing a situational analysis is to inventory the campus' research capabilities. Thus, even before arriving in Lawrence last year, I asked for lists of the top externally-funded researchers and the top externally-funded departments and centers. We found that, based on expenditures over fiscal years 1993-97, the top ten units produced about 60% of the total, and the top 25 over 80%. This type of information is important both for internal planning and for external communications to other institutions. For example, Jack Burns at the University of Missouri and I have been discussing our campus' respective research strengths as a basis for possible collaboration. My list compiled according to the criterion of external funding provides a brief, coherent, and useful basis for collaborative discussions.

As Steve Schroeder reminded us yesterday, institutional imprimatur can significantly aid individual research teams. It is especially important that inter-institutional contacts be made at all levels of the institutions–that high level institutional support for research collaboration be clear. This argument reinforces the need for leadership at all levels.

One practical implementation of Dr. Crow's comments about regional alliances would be to begin to create a strong and viable Midwestern "four corners" collaboration. This proposed collaboration would involve the senior research officers at the three universities represented today (Kansas, Nebraska, and Missouri) and to complete the quartet, Iowa State. An early item on the agenda would involve meeting at each institution in turn to learn more about collaborative possibilities. The time is right for change, for the creation of larger collaborations–and the presence of new players in some of these senior positions may help facilitate new endeavors.

Another example of regional collaboration is the Experimental Program to Stimulate Competitive Research (EPSCoR). Ted Kuwana, the State of Kansas NSF EPSCoR Director, mentioned yesterday the Great Plains Network linking the Dakotas south through Oklahoma plus Arkansas in an INTERNET II collaboration. A necessary condition for any university to be a future research player is adequate connection to the Internet and the Great Plains Network is a regional response to this common need.

Dr. Crow emphasized yesterday the "parallel process model of technology development." (See his slide on the Columbia Research website.) This is an provocative model. It expands Pasteur's quadrant by adding a technology base to the scientific base in Stokes' original formulation. Each may be thought of as examples of Pasteur's Quadrant with the respective independent variable of basic science/applied science and basic technology/applied technology. The next step is to think of a four dimensional "Pasteur's Hyperquadrant" with the above four independent variables.

We have heard here several examples of Pasteur's Hyperquadrant:

- Jack Burns spoke of a regional alliance involving the University of Missouri, Washington University, Monsanto, and the Missouri Botanical Gardens in a Plant Science Center. This is designed to be a "virtual colaboratory" and an incubator for biotechnologies, with telecommunications as a future possibility.

- Victor Frost, University of Kansas, reminded us that nationally a fourth of the real economic growth in the USA from 1993-98 has come from information technology and the Internet. Dr. Frost's work in telecommunications research and development covers several aspects of Pasteur's Hyperquadrant. His efforts involve collaboration between KU and Sprint, a Kansas company, with federal support from the NSF, DARPA and the Department of Defense.

Dr. Crow yesterday quoted Roger Noll's thesis that a (relative) decline in federal funding will favor the elite universities, and second tier institutions will be forced to seek industry funding to support their research. As federal funding shrinks, therefore, we see that it will become doubly important for smaller universities to combine forces to compete with the elite universities. These combinations may be among universities or may involve universities with other partners, but macro-level teaming seems the clear road to successfully competing for future federal funding.

I would like to conclude my response to Dr. Crow by listing the six questions he left for us to ponder. These were sub-topics within his overall question: How do you begin thinking about organizing collectively?

1. What is the substantive vision (for the region and for universities)?

2. What niche is each institution willing to fill?

3. What complementarities exist that could be exploited?

4. What new governance and business models will permit this?

5. How can business stakeholders be integrated into significant settings?

6. What will the new federal/state/institution relationship look like?

Dr. Crow reminds us that we are architects capable of designing our institutions. He leaves us with the paramount challenge to determine what our goals are and the processes by which we will achieve them.

MOBILIZING FOR NEW PARTNERSHIPS

Jack O. Burns
Vice Provost for Research
University of Missouri – Columbia

How do we, as mid-sized Great Plains universities, compete with the emerging "mega-universities" that are developing primarily on the two coasts of the United States? Institutions such as Johns Hopkins annually collect huge sums of money from the Department of Defense and NASA through their Applied Physics Laboratory. Similarly, the University of Washington is becoming a mega-academic-center for biotechnology. How do we challenge these universities for research funding? I propose a relatively simple approach for us to consider together–a strategy which can be described as *collaboration and focus*.

Let us first consider the power and potential of collaboration in strategic areas. This principle can be illustrated through the example of the Donald Danforth Plant Science Center (PSC) that was recently announced during ceremonies on July 31, 1998, in St. Louis. Four institutions in Missouri (the Missouri Botanical Garden, the Monsanto Company, the University of Missouri – Columbia, and Washington University) formed a unique partnership to address the age-old problem of "feeding the world" through basic research in plant science. Each partner has significant existing strengths and traditions in particular aspects of plant genetics, biology, and agriculture. Together, the partnership builds a collaboration that is unparalleled in both scientific expertise and alignment. We are unaware of another example of such a partnership that brings together a private university, a public land-grant university, a not-for-profit laboratory, and a for-profit corporation. An initial endowment for the PSC of nearly $150 million was assembled from primarily private foundations, including the Danforth Foundation and the Monsanto Fund, along with $25 million in tax credits from the state of Missouri.

The mission of the Plant Science Center is to:

- Contribute to human nutrition, health, and global sustainability by using innovative science to increase our understanding of plants, and applying that knowledge to improve productivity in agriculture;

- Promote practical application of new knowledge by facilitating rapid development and commercialization of biotechnologies;

- Contribute to education and training of students, postdoctoral fellows, scientists, and technicians from around the world.

The Center, located in St. Louis, will have a full-time staff of 100 with 15 individual principle investigator-led multidisciplinary teams. A 150,000 square-foot building will soon begin construction. We at the University of Missouri (MU) will interact with the PSC staff and facilities, in part, via a novel *virtual colaboratory*. With the recently installed vBNS computer network connection between Columbia and St. Louis (funded by National Science Foundation grants to MU and Washington University), we will have the bandwidth for videoconferencing between researchers' computer workstations and the capability for remote operations of laboratory equipment (e.g., electron microscopes) over the internet. The PSC and its unique partnership will help to forge an emerging biotechnology corridor between Columbia and St. Louis.

Although it is too early to judge the level of success of the PSC, it has already had measurable benefits to the partnership. This collaboration has opened unprecedented lines of communication between our institutions. For the first time, MU and Washington University are exploring new avenues for interaction and cost-sharing (e.g., vBNS) in areas aside from plant science including computer engineering, neurobiology, and social work. It has also led to significant new funding by Monsanto for emerging biotechnologies across the full spectrum of the Life Sciences which are under development in the laboratories of MU faculty. Our faculty at MU are more actively pursuing commercialization of technologies developed in the laboratory in partnership with Monsanto and other corporations, and via independent start-up companies.

I believe that similar possibilities exist for collaboration between the three universities at this workshop–Kansas, Nebraska, and Missouri. Possible areas for collaboration include computer networking, plant and animal science, food production, chemistry, and telecommunications. Over the next year, we have agreed to work together to assess the core research competencies in our institutions, search for common research themes, and assist faculty in communicating between universities.

Focus is an equally important strategy in building successful research enterprises at universities such as ours. We have neither the fiscal nor human resources to be all things to all people in research. We must focus our resources to form core strengths in research areas that uniquely match our location, our history, and build on resident expertise. In the case of Missouri, we have identified Life Sciences as one of several existing areas of strength upon which we hope to build world-class research teams. The MU campus has a strong tradition of interdisciplinary research in the Life Sciences across five colleges including Agriculture, Arts & Sciences, Human Environmental Sciences, Medicine, and Veterinary Medicine. Our strategy for enhancement includes:

- A commitment of $13 million as a permanent budget increment for Life Sciences research from the state legislature over the next four years. The General Assembly in Missouri has already approved the first year's funding which will permit new faculty hires, laboratory remodeling, and student/postdoctoral fellowships. At the end of four years, we hope to have hired 40 new tenure-stream faculty in the Life Sciences.

- An investment in a $49 million Center for Life Sciences Research. This building will house up to 300 faculty, postdoctoral fellows, and students. It will provide state-of-the-art laboratory space and facilities for research in strategically-determined areas within the Life Sciences.

- A National Center for Crop Genomics sponsored by funds from the state legislature and a major five-year grant from the National Science Foundation.

- The Danforth Plant Science Center endowed with funds from private foundations and Missouri tax credits.

- The MU-Monsanto grants program, a university-industry partnership, which is providing $2.5 million in grants across the Life Sciences to support research in faculty laboratories.

I believe that *focus and collaboration* will allow us to successfully compete in selected areas of research with the larger research universities. Through selective teaming of faculty between our universities and with industry, we have the potential to excel and to innovate.

Research in the university environment has taken on an enhanced significance to the nation as industry has reduced its investment in basic research. Today's economy is driven by technologies whose geneses often lie in university laboratories. This trend will only accelerate in the future. Thus, university research takes on a new, unprecedented importance for the economies of our states and our region. University research is quickly becoming an economic development tool of major importance. As such, this will cause the basic mission of our universities to evolve in significant new ways. Research and teaching will become even more closely aligned as we bring more students into our laboratories for "real-world" experience with sophisticated laboratory equipment funded by state, federal, and industry sources. We must become more adept at articulating the new role of research within our universities to our state legislators. Our recent experience in Missouri suggests that legislators can embrace a major strategic enhancement in university research and they are willing to fund it for the benefit of its citizens. However, *collaboration and focus* must be in place if we are to successfully sell these plans to the legislators and taxpayers within our states.

ISSUES FOR MEDICAL CENTER RESEARCH

A. L. Chapman
Vice Chancellor for Academic Affairs
University of Kansas Medical Center

In a medical center environment, it is critical to blend both basic (bench) and clinical research. The latter would include the application of new knowledge to the treatment of the patient. Application of new knowledge requires use of industry and business resources in production, manufacturing and distribution.

The initiation of new knowledge depends, in large part, on a strong basic research component in the medical sciences. The major funding for this type of research is generally dependent upon the federal government, particularly the National Institutes of Health (NIH) which approximates $13.6 billion in fiscal year 1998. It is of particular interest to comment on a recent report submitted to the NIH suggesting areas for future expenditure. This report was made by the Research and Policy Committee of the Committee on Economic Development in 1998 and was given to Harold Varmus, Director of the NIH. The Committee stated that it is essential to maintain the integral role of government in supporting basic research, as industry continues to focus on research and development with specific product-directed goals.

The Committee reported that:

- The return from basic science to the nation's economy has been substantially higher than the return to private firms;

- Basic research performed at universities is correlated with strong economic activities in their neighbors' locale, e.g., there are more than 1,000 MIT-related companies in Massachusetts with world-wide sales of more than $53 billion annually;

- Of some $63 billion that government spends on research and development annually, $18 billion goes to basic research compared to $8 billion spent by industry on basic research from a total of $133 billion in research and development funding;

- 73% of research publications cited by industrial patents were derived from government-related funding;

- The essential strength of the American system is the rigorous peer review process;

- The most important American institutions conducting basic research are the nation's 200 major research universities;

- The biotechnology industry has been the major beneficiary of the Bayh-Dole Act in 1980;

- University-industry relationships must be managed carefully and according to strict guidelines that protect the primary basic research mission of the universities.

Based on this report, the Committee offered certain principles to NIH for guidance:

- Retain investigator-initiated, competitive, peer-reviewed grants;

- Increase funds for innovative training and research partnerships involving business and industry;

- Incorporate fundamental disciplines including basic scientific and engineering research;

- Revitalize and adequately fund clinical research and its infrastructure, including clinical research centers;

- Expedite movement of new research findings from the laboratory and scientific journals to practicing physicians and their patients;

- Improve support for young investigators, including training grants and individual fellowships;

- Support construction of new facilities for research, particularly focused on sophisticated research equipment and facilities.

Clearly, positioning each of our institutions to take advantage of federal and private grant/contract funds requires changes as well as internal investment. One such initiative at the KU Medical Center included the formation of a non-profit foundation–the KUMC Research Institute–in 1992. Its purpose is to improve working relationships with the private sector, improve service to the faculty, and provide additional sources of revenue through an internal grants program.

Achievements of the KUMC Research Institute include:

- Favorable responses from investigators who appreciate the increased flexibility of grant funding;

- Financial self-sufficiency because the Research Institute does not require state support;

- Development of three divisions: Grants Management, Technology Development and Clinical Trials;

- $520,000 disbursed in awards to faculty through the peer-reviewed small grants program in the last fiscal year;

- 100 invention disclosures received from faculty, including patenting and licensing;
- Formation of six companies based on faculty-derived technology;
- Development and management of a research incubator building;
- Purchase of eight acres of property adjacent to the Medical Center campus and donation of three acres to the state for the Center for Health and Aging Building;
- Potential commercial development of the remainder of the property in support of the research mission;
- Management of 160 clinical trials.

In conclusion, to improve the research environment, it is critical to include a non-profit foundation as part of research management at the institutional level. However, this is only one small step in addressing the needs of any medical center. It is clearly necessary for research universities to position themselves for growth through expanded funding from federal and private sectors. Those institutions that have demonstrated recent success in increasing their institutional rankings have received a significant influx of funds from state and/or private sources. This has generally resulted in new buildings as well as additional support for the research faculty.

THE EPSCoR CHALLENGE:

AN ISSUE OF RESEARCH COMPETITIVENESS

Ted Kuwana
Regents Distinguished Professor of Chemistry
Project Director, K*STAR NSF EPSCoR Program
University of Kansas

When Mabel Rice asked if I would participate in this year's Merrill Conference, I was pleased to do so since I would have an opportunity to learn about the role and direction of research among institutions in our region. I was also delighted to talk about EPSCoR–and many of you know that I am an enthusiastic believer in EPSCoR.

What is EPSCoR?

EPSCoR, an **E**xperimental **P**rogram to **S**timulate **Co**mpetitive **R**esearch, is a federal-state partnership program. It began nearly two decades ago when a few senators in Congress questioned the uneven regional distribution of federal research and development dollars. They argued that our nation was better served if such dollars were more evenly distributed so that research could also thrive in their state institutions of higher learning. Legislation provided funds to the National Science Foundation in 1980 for EPSCoR to begin with the states of Arkansas, South Carolina, Maine, West Virginia and the Commonwealth of Puerto Rico. Alabama, Oklahoma, Vermont, North Dakota, Wyoming and Nevada followed in 1986 and shortly thereafter in 1989, the states of Idaho, South Dakota, Louisiana and Mississippi. Kansas and Nebraska were the last to be designated EPSCoR states in 1992–for a total of eighteen states and Puerto Rico. Congress expanded EPSCoR-like programs to six other federal agencies in 1990: Department of Defense (DOD), Department of Energy (DOE), Department of Agriculture (USDA), the National Aeronautics and Space Administration (NASA) and the Environmental Protection Agency (EPA). The total budget for EPSCoR has grown from $8-10 million in 1990 to nearly $100 million in 1998 with NSF continuing to provide about 50% of the total.

What is the Distribution of Federal R&D Dollars to States?

The 20 states with the largest total of U.S. research and development expenditure collectively account for 87 percent of the research and development conducted nationwide; the 20 states with the smallest share for just 4 percent of the total.
John Jankowski, Director, NSF R&D Statistics Program (1996)

From the FY 1996 federal budget, EPSCoR states received less than 8% of the $12 billion funded for research and development (R&D) at universities and colleges. In 1998, two universities, University of Washington and John Hopkins University, garnered more than $850 million in Federal R&D funds–about the same amount as the collective total of the EPSCoR states! EPSCoR's focus is thus on the research competitiveness of states for those dollars.

How Competitive is Kansas and its Neighbors for Federal R&D Dollars?

Table 1 lists the federal Research and Development (R&D) academic obligations to Kansas and its neighboring states. First, let's look at how the EPSCoR states of Kansas, Nebraska and Oklahoma did during the period from 1991 to 1996. Kansas went from $50.89 million to $80.37 million, while Nebraska changed from $42.82 million to $65.11 million, and Oklahoma $33.15 million to $79.51 million. On a per capita basis, these translate to $31 for Kansas, $40 for Nebraska and $24 for Oklahoma. Oklahoma increased its dollars by a whopping 140 % while Kansas and Nebraska advanced at 58% and 40%, respectively. The 1996 per capita average for the 50 states was $46. Our neighbor, Colorado, sets the benchmark for the region by garnering $279.79 million in Federal R&D obligations for a per capita of $75 in 1996.

The per capita difference indicates that nearly $40 million of Kansas' federal tax dollars for R&D are lost, notably to states on the East and West Coasts and our neighbor like Colorado. So, research competitiveness is an economic issue as well. How long will it take for Kansas to catch up to the national average? At the current yearly rate of increase (9% for Kansas and 5% nationally) it will take at least another decade.

The regional institutional data are tabulated in Table 2. The dollars listed are the total R&D expenditures, which include both the federal dollars and those from other sources. Perhaps what are most interesting about the data are the difference in the percentage change of R&D spending from 1991 to 1996 among institutions. For those institutions in the upper range, what factors made the difference? More important, what will it take to sustain and continue gains? Should institutions bring on-board more faculty in the areas of science, engineering, math and technology–or should the emphasis be on large multidisciplinary research programs? EPSCoR, although limited in funds compared to the total R&D funding to institutions, has experimented with several initiatives, including some to influence the politics to get things done.

Can EPSCoR Make a Difference?

Perhaps we can try to answer this question by looking at the programmatic components and examples of outcome of the Kansas NSF EPSCoR program, K*STAR (Kansas Science & Technology Advanced Research). A key theme of K*STAR from the beginning has been emphasis on fostering partnerships. I believe that K*STAR has helped forge an unprecedented linkage among science, engineering, mathematics and computer science researchers. Cooperation among faculty and administrators of the three Ph.D. granting regents universities of Kansas State University, University of Kansas and Wichita State University was not commonplace earlier. A paradigm shift has occurred so that collaboration is expected and not the practice of few. Strong alliances have evolved among university, state government and the private sector. All of these sectors are now represented on key oversight and governing bodies of EPSCoR. As a consequence, Kansas EPSCoR remains well supported and stable, unlike EPSCoR in many states. Between 1992 and 1998, K*STAR received $9.050 million from Kansas, through KTEC (Kansas Technology Enterprise Corporation), to match the $9.060 million received from NSF EPSCoR.

At the national level, there are two organizations working for EPSCoR. The first is a law firm in Washington, D.C. retained by the Coalition of EPSCoR States to work on legislative matters. For example, recent goals have been to increase the Department of Defense EPSCoR (called DEPSCoR) to $20 million per year and National Institutes of Health EPSCoR to $100 million per year (from the current $5-$8 million). The other organization is the EPSCoR Foundation, a not-for-profit corporation, formed to promote EPSCoR and to provide direct assistance to states, as needed. The $20,000 per year fee paid to the Coalition by each EPSCoR state and Puerto Rico provides funds to support these organizations.

For K*STAR, there are two grants currently pending at NSF EPSCoR. The first is a $750,000 proposal to support the phase-out of current programs with funding from October 1, 1998 to September 30, 1999. The second is a $3 million proposal to begin a new infrastructure-based K*STAR program for three years, commencing on January 1, 1999. The NSF EPSCoR awards are negotiated as cooperative agreements, not grants. Thus, the programmatic components and budgets are subject to negotiation on a yearly basis during an award period. This yearly budgeting creates administrative headaches and faculty frustrations with regard to spending and reporting deadlines.

K*STAR has adopted two umbrella strategies for improving the state's grant competitiveness: first, support of meritorious, peer/merit reviewed projects–many patterned after the big science, research-team model–and second, improvements to infrastructure, including human resource development and equipment acquisition. The latter has provided more than $4 million in equipment purchases. In addition, K*STAR has provided support for research workshops, statewide conferences, named lectureships and faculty development initiatives, including some focused on women, minorities and the physically challenged.

In addition to the umbrella strategies, K*STAR has:

- Promoted the concept that a strong research base in science, engineering, math and technology (SEM&T) provides the basis for long-term economic development;
- Utilized EPSCoR as an agent for promoting basic-research at Kansas' three research universities;
- Assessed and sought prioritization of Kansas' institutional SEM&T strengths; and
- Assessed EPSCoR's impact on an on-going basis.

Have these initiated any changes? For example in 1994, Kansas through KTEC, adopted a model that positioned basic research as a key to the state's economic development plan. This model is a systems approach to economic development designating EPSCoR as a key stimulus of the state's basic research enterprise. The Kansas Science and Technology Council, that helped influence the KTEC plan, was organized as a part of K*STAR. Deliberations of the Council with KTEC were responsible for the formation of the Futures Fund, which has provided the State's matching dollars for EPSCoR and also funded meritorious EPSCoR-like projects that met the state's strategic technology priorities. From 1992 to 1998, this Fund received $16.035 million from the Economic Development Initiative Fund (EDIF), as appropriated from the State's lottery revenues. With Governor Grave's approval, the legislature has appropriated $3.67 million from EDIF to KTEC for FY 99.

Examples of EPSCoR Projects and Initiatives

In the case of larger research projects, success requires substantial prior strategic planning including a plan of implementation and tracking of outcome. Planning is an on-going process–it must continue throughout the life of a project and have flexibility to alter the course if needed. Faculty members are reluctant to plan, prioritize and set timelines for projects. A warning flag is when a principal investigator of a project does not prioritize and focus resources but instead allocates on a basis of "something for everyone, but not much for anyone." I have learned the hard way that such a project is not self-sustaining. There must be a central research theme with a focus to which participants agree and can contribute, otherwise the enterprise does not have the cohesion to continue without EPSCoR. It is like an old NSF model where researchers banded together to justify a grant to fund a multi-user instrument. In essence, it becomes a mini-grant program where individuals do their own thing rather than working together for the common good.

In contrast, a K*STAR project where prior planning and cooperative effort has paid off is Dr. Shih-I Chu's *Center for Advanced Scientific Computing*. A statewide ad-hoc committee of stakeholders was convened for planning. This project led to the installation of an SGI/Cray Origin 2000 supercomputer at the University of Kansas in March 1997. It has spawned related initiatives, including the six Great Plains Networking (6-GPN) for Earth Systems Science and the designation of the Kansas Association for Networked Supercomputer Applications (KANSA) as one of the NSF supported National Computational Science Alliance (NCSA) partners. The 6-GPN states include the EPSCoR states of North and South Dakota, Nebraska, Kansas, Oklahoma and Arkansas. The 6-GPN is an example of a project where none of the participating states had a large enough footprint to be a player in building a high-speed telecommunication network to connect to INTERNET II. They banded together to obtain a $1.47 million NSF EPSCoR grant, and with matching support from states/institutions, built a high speed network that became the *first to connect to INTERNET II*. This achievement is an example of local, state, regional and national agendas coalescing and being prepared to take advantage of opportunities as they appeared.

The high-speed telecom network enables institutions to develop *virtual* organizations to tackle "Grand Challenge" problems, like those being envisioned in the Earth Systems Science initiative. Some 80 researchers of the 6-GPN states have already met under the auspices of AAAS (funded by NSF EPSCoR), at the South Dakota EROS center to look for areas of common research interest. EROS has one of the largest repositories of Landsat data. With such data, it is possible for a unit, like the Kansas Applied Remote Sensing (KARS) program, to do high resolution imaging of the earth's surface. KARS can, for example, focus on Western Kansas and predict crop yield several months in advance of harvest. Such predictions are beneficial to the farmer and relevant to the commodities market. Another Earth Systems Science workshop is being organized, again under the auspices of AAAS, for November at KU to do the next phase of planning. Other applications are also being explored. For example, K*STAR with Oklahoma EPSCoR is co-funding a workshop on aviation weather hazards at KU this October to explore collaboration among regional research institutions and the FAA weather centers. Commercial aviation companies as well as the military are very interested in being able to predict macro- to micro-weather conditions for flight safety.

In addition to the large programmatic projects, there are three other significant initiatives: one to mainline tenure-track junior faculty; another to provide "venture" capital to new entrepreneurial activities; and a third to support the development of large-scale grants. The first is the K*STAR First Award program. It provides up to $50,000 each to junior faculty members to help them become grant competitive earlier in their careers. Priority is given to faculty who submit a grant proposal to NSF prior to or simultaneously with their submittal to K*STAR. Funding decisions are based on recommendations of a peer review panel that rank-orders proposals according to NSF merit criteria. Since 1995, 31 faculty have been funded for a total of $1.19 million. To date, these faculty have garnered a total of some $7 million in external grant awards and another $5 million in multi-investigator grants. About $7 million in grants is still pending. First Awards represents a highly leveraged investment.

EPSCoR has pushed for a paradigm shift to get faculty to use First Award funds to hire postdoctoral researchers early in their careers rather than waiting for them to become established before doing so. Often, new faculty feel that, since they had just finished being a postdoctoral fellow prior to becoming a faculty member, they were still unqualified to direct postdoctoral researchers. Thus, a prevalent Kansas paradigm was for new faculty to get 1-3 graduate students within two years, begin a research project and perhaps be in a position to submit a research grant by their 3rd year as a faculty member. If the grant were awarded, the research program would really get underway during the 3rd and 4th year, perhaps in time to have publications for a tenure decision by the end of the 5th year of appointment. Now, K*STAR, like many research competitive institutions, encourages faculty to submit their first grant proposal to a federal agency within the first year of appointment and no later than the 2nd year. The faculty member's department is asked to formalize a mentoring process to assist faculty as part of the First Award. Grant success is also enhanced by visiting granting agencies and getting to know program officers so that faculty learn first-hand about the requirement for success; i.e., grantsmanship. The program officers in turn associate a "face" with a grant proposal, often important in borderline decisions.

In 1997, NSF EPSCoR instituted a "co-funding" program to assist regular NSF programs to fund grants that are borderline or "on-the-bubble." The State's Project Director has the responsibility to certify those grants that fit state/institutional priorities to qualify for co-funding. Priorities have included the mainlining of junior faculty (e.g., CAREER grants), consortia grants from K*STAR's cluster projects, large programmatic grants such as IGERT, KDI, S&T Centers, and multi-disciplinary or regional collaborative grants. Kansas received slightly more than $1 million in co-funding in FY98. The NSF EPSCoR FY99 co-funding budget will be $15 million so that a total of $30 million will be available when the regular program match is included. Kansas should garner $2 million to $3 million in co-funded grants during FY 1999.

Another NSF EPSCoR initiative is its "standard" grant, which provides up to $500,000 over two years to support one-time innovative research projects. The $1.47 million 6-GPN award, mentioned earlier, was such a grant; a larger amount was awarded since there were 6 states involved. Earlier in 1995 a grant of $325,000 was awarded to Dr. Azadivar of Kansas State University (KSU) to establish the Manufacturing Learning Center. This center was modeled after a teaching hospital; engineering students, both undergraduates and graduates, served as "interns" to conduct research on problems defined by Kansas manufacturing companies. Fees paid by the companies assist in covering operational costs. More than 200 research projects with over 120 Kansas companies have resulted. It is an excellent example of a project serving Kansans. Azadivar's center recently won a $800,000 NSF award to become self-sustaining. In 1996, a standard grant of $644,000 was awarded to Dr. Demarest and Dr. Frost at KU to establish the Lightwave Laboratory. This grant has been leveraged to more than $4 million with private sector funds and other grants. A grant for over $2 million is currently pending at NSF. The technology of this laboratory will pave the way for *ultra*-high speed telecommunication capabilities for the future. The most recent FY 1999 "standard" grant of $500,000 over two years went to Dr. Madanshetty at KSU to establish the Non-Contact Diagnostics Laboratory in Manufacturing. Faculty from KSU, KU and Wichita State University are involved in the research of this laboratory, which has industrial applications. A state match of more than $500,000 for these four "standard" grant projects has been provided by KTEC from the Futures Fund. A characteristic of all these grants is the partnering of universities with the private sector.

What's Next?

The stresses and challenges faced by faculty to be competitive researchers and competent teachers have been discussed by Dr. Eli Michaelis and Dr. Tom Taylor in the 1997 Merrill Conference Report. Their reports reflect the concerns felt by faculty today, especially in establishing and maintaining grant-funded research programs. Many perceive that they are competing for a smaller pool of money so that the success rate for awards hardly justifies the effort. Although this perception may not be true, it serves as a reality for many. Added to this scenario is an emerging idea that future growth will rely on larger programmatic grants that are multi-investigator and multi-disciplinary. A faculty member, who recently served on a review panel for NSF Science and Technology Centers, said that successful grants were those with collaborative linkages on a national or even global scale. If such is the scenario required to grow the research enterprise, how can EPSCoR states compete? One avenue is via strategic planning. K*STAR can assist by providing grants to support planning activities involving: a) multi-investigator and/or multi-disciplinary research grant proposals; or b) grants in response to or in anticipation of an NSF Request for Proposal for a major initiative such as IGERT, KDI, S&T Centers or other significant programs. Funds could support planning seminars and workshops; bringing outside consultants; getting writing and editorial help; and covering travel expenses to visit agencies and potential out-of-state collaborators.

KTEC, in justifying state matching support, says institutions must prioritize their agendas and put larger investments in fewer high potential payoff areas. While agreeing, the one caveat is that it is never easy to identify which individual or group or research area will bring forth the next breakthrough technology. What is most important is the creation of an environment that fosters scholarly inquiry and provides the infrastructure to conduct leading-edge research. The proposed Phase III K*STAR Cooperative Agreement seeks to address the latter by funding new faculty hires and the acquisition of multi-user major instrumentation. A total of $2.86 million over three years, beginning on January 1, 1999, is proposed for these two infrastructure components. K*STAR program publication (RFP-98-1R, August 1998) describes the guidelines for proposal preparation and their submittal deadlines. Funding decisions are based on recommendations made by an external peer/merit review panel, which reviews all proposals.

K*STAR subcontracts the Institute of Public Policy and Business Research (IPPBR) to conduct yearly assessment of the Science, Engineering and Math Infrastructure at the Three Universities (KSU, KU and WSU) in Kansas. This assessment focuses on the demographics of these institutions including the number, rank and salary of the science, engineering and math (SEM) faculty; the distribution of faculty according to age, women, and cultural diversity; the number of SEM degrees awarded; and grant activity (number submitted, number awarded and dollar value). IPPBR also conducted two additional assessment studies in FY 1998. One was a case study of four institutions of comparable size to KU that had significantly improved their grant competitiveness during the previous decade. The other resulted from a survey of faculty and interviews with administrators on issues dealing with institutional research support and barriers. The survey included questions on EPSCoR. If you are interested in obtaining a copy of these reports, please contact the K*STAR office. *

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* IPPBR Research Papers: Sixth Assessment of the Science, Engineering and Math Infrastructure at Three Universities in Kansas.

1. Report #243 on Demographics and Grant Activity, December 1997.
2. Report #247 on Case Studies of Four Peer Institutions, June 1998.
3. Survey of Faculty and Interview of Administrators, expected publication in early 1999.

EPSCoR states like Kansas, Nebraska and Oklahoma have made significant relative gains in their research enterprise during the period of their tenure in the EPSCoR program. These gains have been made at a time of modest growth and expansion in the federal research and development funding. The question is whether EPSCoR states can sustain gains during the next several years. Although legislation has been introduced to Congress to double the Federal research and development budget by year 2008, we are entering a period economic uncertainty. Many states have recently augmented federal funding with legislated state initiatives. Examples are Nebraska's yearly $12 million Research Enhancement Initiative, Oklahoma's distinguished professors program, and Kentucky's $110 million distinguished professors initiative. Such initiatives are critical at a time when start-up funds and salaries for new faculty may not be competitive when compared to those offered by research intensive universities. Another challenge is the retention of junior faculty who have achieved high research profile, and are either close to or have recently been promoted to associate status. Although salary is always a concern, faculty retention is more dependent at this level on the institutions' ability to provide an infrastructure that adequately supports research and teaching. The role of EPSCoR in helping to address these challenges will rely on the vitality of the partnership between national, regional, state, and local stakeholders.

Table 1.

FEDERAL RESEARCH AND DEVELOPMENT ACADEMIC OBLIGATIONS BY STATE * (in millions of dollars)

State	**FY91**	**FY96**	**%Change**	**per capita FY96**	**Pop.** (M)**
Colorado	$ 182.92	$ 279.79	53	$75	3.75
Missouri	181.89	293.25	61	55	5.32
Iowa	124.81	168.90	35	59	2.84
Kansas	**50.89**	**80.37**	**58**	**31**	**2.57**
Oklahoma	33.15	79.51	140	24	3.28
Nebraska	42.82	65.11	52	40	1.64
U. S. Total	$9,008.00	$12,068.00	34	$46	260.00

* Source: NSF/SRS, Survey of Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions, Fiscal Year 1996.

** Population data from 1995 Census.

Table 2.

R&D EXPENDITURES IN SCIENCE AND ENGINEERING AT NEIGHBORING UNIVERSITIES BY SOURCE OF FUNDS, FY91 - FY96 * (in millions of dollars)

Institution	FY91	FY96	FY96 Rank	% change	FY96 Feds	FY96 State & Local Gov.
U. of Colorado	$161.97	$251.30	21	55	$177.52	$ 5.30
U. of Iowa	124.06	178.23	41	44	105.65	5.74
Iowa State U.	134.66	151.91	45	13	54.90	43.71
Colorado State U.	80.47	126.70	60	57	74.93	21.98
U. of Missouri	96.75	123.13	62	27	33.40	16.20
U. of Oklahoma	79.78	109.07	75	37	42.68	14.39
U. of Nebraska	87.53	102.46	77	17	32.35	36.75
U. of Kansas	65.98	100.65	78	53	41.86	7.62
Oklahoma State	67.49	82.96	92	23	25.03	15.36
Kansas State U.	53.01	71.22	108	34	24.77	29.84
Wichita State U.		9.90	NA		2.20	3.00

* Source: National Science Foundation, Academic Science and Engineering: R&D Expenditures, Fiscal Years 1991 and 1996. Detailed Statistical Tables, Table B-35, NSF-96-308 (Arlington, VA, 1996).

* FY91 and FY96 dollars do not include industrial, institutional, and other sources.

BUILDING SUCCESSFUL INDUSTRY/UNIVERSITY PARTNERSHIPS IN INFORMATION AND TELECOMMUNICATION SCIENCES

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Introduction: Background and Statistics

During the last decade, advances in the information and telecommunication technology (IT) industry have moved this field of investigation to the forefront of research initiatives. Nationally it is recognized as a critical technology. It has also been identified as one of the strategic technologies for the Kansas economy.

The traditional economic strengths in Kansas are agriculture, aviation, energy, and biotechnology. The IT industry now also represents a strong segment of the economy and supports all other major segments of that economy. Communication industries employ about 20,000 individuals in Kansas, with industry giants such as Sprint currently employing more than *12,000 and expanding.*

The statistics are real. Economic growth in the United States during the 1990's has been fueled by information technology. Twenty-five percent of real economic growth in the U.S. between 1993 and 1998 came from IT and internet-related technologies. Add to this the fact that more than 7.4 million people work in IT and earn an average of $46,000 annually. Significant growth is expected to continue due to expansion of e-commerce, the Internet, and associated services.

The Information and Telecommunication Technology Center

For more than a decade, the University of Kansas has been recognized internationally for its academic and research programs in IT, and a significant track record has been forged with the leaders of the telecommunications industry. The Information and Telecommunication Technology Center is dedicated to providing an interdisciplinary research environment, to attracting and graduating outstanding students, to leveraging resources from the public and private sectors, and to developing and transferring technological innovation to the private sector.

The Center currently employs nearly 100 students from electrical engineering, computer engineering, computer science, and mathematics. Twenty associated faculty and sixteen full-time staff researchers support the Center's activities. Its unique facilities are distinctive. The Center has state-of-the-art laboratories focusing on high-speed networking, lightwave technologies, and wireless and digital signal processing.

Since the early 1990's, the Center has invested approximately $16.5 million in research, development and commercialization activities. It has been designated a State Center of Excellence and is supported by the Kansas Technology Enterprise Corporation. Additionally more than thirty percent of the Center's funding comes from the private sector including companies such as Sprint, NEC, Nortel, Hughes, and TRW. Another forty percent of the Center's income is generated by Federal research projects.

To a great extent, the Center's success is due to solving telecommunications and information technology research problems through integrated solutions. The IT research field includes more than simply the fiber or the facilities that enable the flow of information; it includes the networks and human capabilities, matched with services such as voice, data and video, and ultimately, the applications people use to gain value from the data they receive.

Models for Industry/University Interactions

Serving the private sector is a significant aspect of the Center's mission. There are a number of models for industry/university interactions. Here are a few examples:

- Direct sponsored research: Primarily conducted by faculty and students on campus, this research is private-sector driven and fully underwritten by the company.

- Joint Research: By engaging the experts in the company with university faculty and students, joint research leads to mutually satisfactory outcomes for both partners.

- Internships: Short-term projects conducted over the summer at the company's location. Internships introduce students to the private sector; often these are more effective when combined with an ongoing relationship during the regular school term.

- Graduate fellowships: Collaboration by faculty and the private sector staff often allows for development of a project or thesis topic for fellowship students.

- In-house short courses: Organized for the benefit of private sector companies, short-term courses give visibility to faculty and allow companies to increase the expertise of their employees in a certain area.

- Consulting: Faculty often provide limited consulting on short-term specific problems.

How do Industry/University Partnerships become Win/Win?

Industry benefits by acquiring the technology developed by the Center and licensing it for use. In many cases, time and money savings can be documented. Industry benefits significantly from those employees who enter the workforce familiar with both the process and the issues because they tackled “real-world” assignments in school. Finally, by working with Universities, the private sector gains a deeper understanding of the potential impact of impending technological innovations.

What are the Benefits to the University?

Students benefit by focusing their research on “real” industry problems. Faculty benefit from bringing the latest research results and industry directions into the classroom at the both the graduate and the undergraduate levels. In addition, research that is underwritten by private sector companies provides substantial overhead return to the University. And in the end, the University is providing “service” to the community.

Lessons Learned

From our experience in working with industry over the past fifteen years, we have found that it takes years of groundwork to establish working relationships with private sector companies. An important way to open a new door occurs when former students move into positions of responsibility and can champion the value of working with a University.

Concerns regarding intellectual property rights are always present but not insurmountable. When undertaking a project with industry, there are always issues and concerns that must be settled at the onset. The first and by far the most crucial is the question of intellectual property rights: who owns it and what is the patent application process?

Publication issues must also be settled. The university must have the right to publish the results of the research, with prior review by the industry to check for proprietary information. Publication must occur in a reasonable amount of time. We have found that publication issues can be resolved through close cooperation between the industrial partner and the University researchers.

Credibility is everything. It is important to establish realistic milestones, meet the milestones, and deliver abundantly on results. In the beginning, it is important to surpass the company’s expectations. It is not unreasonable to expect close supervision by the private sector company; they are there to gain knowledge from the process.

It is important to maximize the company’s opportunity to work with the students and evaluate them for future employment.

Industry leaders understand and support the concept of leveraged funding. They want to see this occur with organizations such as KTEC, NSF, and the University.

And finally, if quality, cost-effective work is delivered, the reputation of the University can spread within the corporation.

Successful industry/university relationships take time to nurture and are subject to the shifting tides of company focus, fortunes and the general economy. From a long-term investment perspective, these relationships not only directly improve the competitive position of the companies involved but also play a significant role in preparing the next generation of technology leaders.

RESEARCH OPPORTUNITIES AND THE HUMANITIES

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Scholarship in the humanities and "soft" social sciences that is funded for the purpose of collaboration exists in a context significantly different from that of scientific research. Humanities also applies the term "collaborative" more broadly to mean projects that may be international (involving American scholars and foreign counterparts) and/or interdisciplinary (involving projects that draw on the various disciplines in the humanities, social sciences, professional schools, and occasionally the hard sciences). Despite the gradual increase in such collaborative and institutional efforts, the bulk of humanities funding remains based on individual projects and individual grants.

It makes sense to discuss humanities funding quite separately from science funding. There are some similarities, of course, but the humanities have different types of funding, different resources, different constituencies; moreover, different expectations and "mythologies" are at work in seeking money for the humanities. Science faculty come through the graduate school ranks knowing that their grant activity is forever a factor in their professional lives. Success will be rewarded and failure will have its inevitable consequences. The same has not been universally true of the humanities. Some humanities scholars have traditionally had contempt for what they perceive as the commercial marketing of ideas or an attack on their academic freedom by the granting agency. Humanities faculty may be unconcerned about the application of their research, or its value outside their narrow specialization, and may not care if it is ever funded.

More recently, many junior scholars and graduate students in the humanities have discovered that the realities of contemporary academic life will include grantsmanship, both individual and institutional. They are aware that institutional resources are becoming more scarce and competition for positions is becoming more fierce. For example, the ability to compete successfully for grant funding is viewed more and more often as an important hiring criterion. Humanities scholars increasingly also realize that only grant funding will subsidize release time for completing a major project, exploring new territory, and working on larger collaborative endeavors at their own institution and with colleagues elsewhere. Grant funding will also pay for international travel to conferences. Humanities scholars have reconciled themselves to this notion. It is a recent but important shift in attitude.

Ironically, funding for the humanities has not grown despite increased interest by the faculty in seeking grants. Funding for the National Endowment for the Humanities, for example, has remained more or less flat for the last five years. Nevertheless, institutions can position themselves to take advantage of opportunities that arise and stand ready to respond effectively. Those opportunities in humanities funding, however, are going to be of a very specific sort.

The Nature and Sources of Humanities Funding

Humanities funding essentially comes in two varieties: individual and institutional. Most humanities funding remains individual; the scholar applies for a fellowship that offers release time, salary replacement, travel to research sites, and modest research costs. The individual advantages of such grants are clear: prestige in your field, career enhancement, national and institutional recognition. But the institution also achieves some advantages: a reputation for its research (racking up those Mellons, ACLSes, NEHs, and Guggenheims), proof of a nationally recognized, competitive, active faculty, and some small but not-to-be-disdained shrinkage funds.

Compared to the sciences, there is not a great deal of money for collaborative funding in the humanities; however, if one looks at opportunities not exclusively designated for the humanities, but rather involving broadly interdisciplinary approaches with a humanities component, the prospect improves somewhat. Primary funding agencies in this field remain the National Endowment for the Humanities and the U.S. Department of Education, both of which define the humanities very, very broadly and allow for projects that bring together humanists, social scientists, and professionals. The Hall Center for the Humanities at the University of Kansas, for example, defines its own mission in the same broad manner.

Relative to the sciences, little money is available to humanities faculty. To provide some context, compare grant awards by the National Endowment for the Humanities (NEH) and the Department of Education in fiscal year 1997. The NEH made 131 awards in their Collaborative Research Program with a total allocation of $5,425,337. The Department of Education allocates just over $30 million annually to its university projects that involve collaboration.

The NEH and Department of Education, however, are not the only games in town. Collaborative humanities funding comes from a variety of foundations, governmental agencies, and NGOs. * But there are less well known entities that could be developed. These include: A large number of regional trusts, societies, and foundations, with flexible profiles and varied funding patterns.

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* These include, but are not limited to, the American Antiquarian Society, American Philosophical Association, Educational Foundation of America, Carnegie Corporation, Council of American Overseas Research Centers, The Fulbright Program (American Council of Learned Societies and Center for the International Exchange of Scholars), Folger Institute, Ford Foundation, Getty Center for the History of Art and the Humanities, Guggenheim Foundation, Huntington Library, Institute for Advanced Studies in the Humanities, International Research and Exchanges Program, Mellon, National Council for Eurasian and East European Research, National Endowment for the Arts, National Endowment for the Humanities, National Humanities Center, Newberry Library, Rockefeller Foundation for the Arts and Humanities (Bellagio), School of American Research, Smithsonian Institution, Social Science Research Council, Soros/Open Society Institute, State Councils for the Humanities , U.S. Department of Education, U.S. Information Agency, Woodrow Wilson International Center for Scholars, and the various humanities research centers (Texas, Stanford, etc.).

- A variety of foreign entities that open their competitions to citizens and institutions from other countries. These may be embassies, chambers of commerce, heritage groups, international foundations (DAAD, von Humboldt, Korea Society, Japan-America Foundation, Research Council of Norway, etc.) and special research institutes, banks, ministries of culture and education that support institutional collaborative projects.

For the time being, most collaborative humanities funding remains in the hands of governmental agencies. (This, by the way, is the case in many European countries as well.) This may change, especially if the Congress continues to attack discretionary programs, but new foundations may appear to pick up the slack. The case of the humanities is not helped by the somewhat parochial public attitude toward humanities in the U.S. nor by the ineffectual way that humanities scholars make their case with the public.

The Problems with Humanities Grants

The main problem with collaborative grants in the humanities and social sciences, from the university's point of view, is that such grants have:

- Low or non-existent overhead. The NEH Collaborative Research award, for example, which has a ceiling of $200,000, limits IDC to 10%, but not to exceed $5,000; the Department of Education IDC is set at 8%; the Social Science Research Council (which includes humanities in a number of its group and collaborative projects) usually awards none. USIA will at least negotiate, but has never given more than 25%, and then only for certain types of awards. Foundation funding in collaborative projects involving the humanities and social sciences also limits IDC.

- High cost-share, matching, or third party funds, in some cases up to 50%.

- Mandatory evidence, in some cases, of continued institutional support beyond the completion of the project.

So it would seem that most collaborative funding in the humanities provides relatively little to the institution. And if we consider only the short-term, bottom line in dollars and cents, that is absolutely true. There are, however, important, if less tangible, rewards. Such grants promote institutional visibility and prestige. That is important to the image of the institution as a major center of learning and research and should not be discounted. Such grants can also allow the university to meet particular goals articulated in its mission statement.

These might include, in addition to the traditional teaching and research mission:

- Internationalization of the curricula, faculty, and students in a meaningful, productive, and non-superficial way. If the mission of the university is indeed to "prepare our students for lives of learning and for the challenges educated citizens will encounter in an increasingly complex and diverse global community," as the mission for the University of Kansas (KU) states, then collaborative projects, which involve both students and faculty, are a good way to institutionalize this particular value.

- Outreach and service. Outreach is the dissemination of knowledge, public programs, and cultural enrichment to business, government, educational, or community constituencies. (This is central to the service mission of a state institution.) Outreach has pay-offs in three areas: publicity, recruitment, and development. Humanities, the "soft" social sciences, and the professional schools can generate considerable visibility, given very little support.

- Support for long-term program building by the university.

Collaborative funding can provide the "start up investment" for a special program the university may not otherwise be able to fund or maintain exclusively on the institutional budget. The international area centers (Russia and Eastern Europe; Latin America; Africa; East Asia) at KU are a good example of how collaborative funding in humanities and the social sciences was used to create and maintain the presence of area studies. As a result, KU has four nationally recognized area studies centers and academic programs to match, with a relatively small expenditure of institutional funds.

Collaborative funding can extend the strength of the base on which other programs can be built. Collaborative grants can provide resources to leverage other funds. For example, the KU area centers have had success in pursuing grants with the Business School because they were able to use their center grants as leverage, as an existing strength that gave credibility to the proposed interdisciplinary project.

Such funding can enhance teaching and research productivity in a number of ways by:

1) Providing additional opportunities and resources for faculty enhancement and development;

2) Fostering interaction among faculty members who would not otherwise work together; properly focused, this can create a sense of institutional unity, identity, and mission among participating faculty, particularly across schools; and

3) Attracting new faculty to an active and lively intellectual environment and retaining them at the institution.

Collaborative funding can also take some of the pressure off the institution by providing:

1) The cost of domestic and foreign travel for research and teaching;

2) Salary replacement for administrators and faculty, thereby releasing shrinkage to the institution;

3) Additional money for supplies, communications, library acquisitions, videos; and

4) Funding for workshops, conferences, and other reputation-enhancing events at the institution without using institutional funds.

Maximizing Results

Given this reality, what should we be doing to get maximum results in the mid- and long-term? Some things to consider:

- Educate humanities faculty not only about what opportunities are out there, but also about why collaborative funding is a good thing for the humanities, for their institution, for their own departments, for their students, and for themselves. Along with this, be realistic about what is worthy of funding and what is not; not all humanities faculty are going to be doing fundable research and that is fine. Instead of expending energy to change their minds, put energy into supporting those who do research that can be funded.

- Assist humanities faculty in identifying funding opportunities and help them through the sometimes arcane process of application. With desktop access to Internet resources such as the Community of Science, Yahoo Grant Search, SRA Grantsweb, as well as access to information about writing proposals, this is a lot easier than it used to be. The University of Kansas is getting better and better at this. Less than a decade ago there was nothing. Now we have the Humanities Resource Center, housed in the Hall Center for the Humanities and partially funded by the division of Research and Public Service, and the support services provided by the KU Center for Research, Inc.

- Improve the reward structure for successful grantsmanship in the humanities by:

  1) Providing bridging funds for faculty on individual grants and recognizing that even with the expenditure of bridging funds, money comes back to the institution as shrinkage.

  2) Making start-up or matching funds available. One of the features of humanities funding is high cost share or matching. As institutions begin new development campaigns or reinvent research centers, it would be good to think about funds that could be used for a third party match. This does not involve a great deal of money, since the humanities are, on the whole, "a cheap date."

  3) Rewarding success in institutional grant development and institutionalizing such rewards in tenure and merit evaluation.

- Encourage interdisciplinary cooperation among humanities and social science faculty within the institution and seek links among institutions. Many funding agencies specifically seek consortial projects that will have impact beyond a single institution.

Some of the most interesting opportunities, by the way, are coming up in agencies seeking collaboration among all three branches: humanities, social sciences, and natural sciences, or between humanities and the professional schools.

- Find ways to overcome the anti-policy and anti-applications bias of those humanities faculty who tend to be overly theoretical and parochial in their over-specialization and who tend to look down on partnerships with local, regional, and national business, educational or government constituencies. This is easier to say than to do. Humanists sometimes resent the fact that most funding is basically applications-based. Abstractly "adding to the greater body of knowledge" in a narrowly-defined discipline is not the only compelling justification for research. There is middle ground. Many faculty members can meet their own priorities for scholarship and still contribute to specific outcomes and applicable results that fit in with the missions of foundations, government agencies, and NGOs. In the humanities, "outcomes" as they relate to higher education are likely to be strengthened academic programs and curricular development as well as policy recommendations and the training of specialists.

- Remove barriers (in terms of budgeting, payroll, bureaucracy, etc.) to inter-institutional or consortial cooperation.

- Do not waste time in pursuit of grant opportunities that are wrong for the institutional mission or profile. Build on institutional strengths and put resources, both human and financial, in the right places.

THE END OF INTERDISCIPLINARY RESEARCH

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Introduction

The call for interdisciplinary research efforts is one of the very small number of truly interdisciplinary phenomena in American universities today. For example, the awe that attends the pronunciation of the term *interdisciplinary* is equally profound among practitioners of the "hard sciences" and among scholars in gender and ethnic studies. Otherwise these camps share only the most devout suspicion of the methods, motives, and general probity of the other camp. Yet without detectable exception, both groups and all those between and on orthogonal axes, including such mixed exotica as engineers, pharmacists, journalists, and belle-lettrists, offer limitless devotion at the altar of the interdisciplinary.[1]

This circumstance is surely odd. For a simple, minimal definition of *interdisciplinary* is "having no coherent relationship to the normal scholarly organization of universities." Yet we see university scholars one and all calling for the pursuit of research by a method the defining characteristic of which is a radical mismatch to the organization of scholarship within which all of these scholars were educated, within which they are educating their students, and–as we shall see–to which they can manifest the fiercest of loyalties. I should like to address this conundrum after a necessary pause for clarification.

Terminological Interlude

There seem to be three common terms abroad in discussions of research that fails to align itself within established disciplinary lines: *multidisciplinary*, *interdisciplinary*, and *cross-disciplinary*. For purposes of this article, I would like to adopt definitions of these terms that follow from but do not correspond precisely to the usages reviewed and advocated by Epton, Payne, and Pearson (1983, pp. 1-9). These definitions should be useful but do not play any large role in the considerations addressed here:

multidisciplinary: the research is executed independently by specialists working in their own disciplines, and the multidisciplinary product of the research is obtained by integration of their finished results.

interdisciplinary: the research is conducted by a team of investigators from different disciplines, working together and bringing their disciplinary skills and information to bear on the investigation at the most primitive level.

cross-disciplinary: a particular task within a research project calls upon specialists in different disciplines each to contribute collaboratively to completion of the task by bringing their specialized capacities to bear.

These definitions are illustrated in Figure 1, which portrays various aspects of the research, development, and technology transfer activities associated with a most demanding project, *four-alarm sushi*.

Four-Alarm Sushi

Multidisciplinary:

Mexican cook makes salsa;
Japanese cook makes sushi;
Combination: four-alarm sushi

Interdisciplinary:

Japanese cook and Mexican cook get rice, peppers, tuna, tomatoes, seaweed, etc., drink a case of beer and end up with four-alarm sushi

Cross-disciplinary:

Marketing of four-alarm sushi requires collaboration of lawyers who know raw-fish products with lawyers who know multi-alarm products.

Figure 1. Research and development modalities in the field of four-alarm sushi. In a multidisciplinary approach, the independent products of disciplinary specialists are integrated. In an interdisciplinary approach, specialists cooperate at a primitive level. Cross-disciplinary task completion is illustrated by legal problems in the marketing of four-alarm sushi, which is expected to pose monumental challenges.

In the present article, we restrict our attention to the interdisciplinary modality, which carries the challenge to traditional academic organizational schemes to the most troubling level.

The Disciplinary Conundrum

The necessity of interdisciplinary research arises from the level of difficulty of the research problems currently under attack. In all fields, the easy work is finished and ambitious scholars are confronted with problems that perniciously defy easy categorization in the traditional disciplinary format. Chemists can no longer find a significant research subject that is purely chemical in nature. Instead, they are forced by the problems they wish to solve to consider information and to apply skills that traditionally derive from physics, biology, engineering or more distant areas.

It is an intrinsic feature of this argument that scholarly disciplinary lines have not shifted to accommodate the shifts in information and skills that are demanded for the solution of current research problems. In fact, taking the organization of the "hard sciences" as an example, the disciplinary lines of biology, chemistry, and physics (deriving in the case of biology and physics from ancient Greek philosophy) began to emerge in their present form in European and American universities during the Romantic Era of the 19th century. Much of the difficulty that university scholars experience in laying aside their disciplinary loyalties for research purposes comes out of emotional traditions that reflect the atmosphere of Romanticism in its fullest flower.

Romanticism and Scientific Disciplines

The project of the Romantics, beginning in the 1790s, "after the rationalism and decorum of the Enlightenment" to "save the overview of human history and destiny, the experiential paradigms and the cardinal values of their religious heritage," in part through "a reversion to the stark drama and suprarational mysteries of the Christian religion" was not without influence among natural scientists (quotations from Abrams, p. 66). The co-evolution of Romanticism and the developing organization of the subdisciplines of chemistry is illustrated in Figure 2.

The great figure of 19th-century German chemistry, Wilhelm Ostwald, recognized so clearly the role of Romantic thinking not only in the organization but also in the conduct of science that he divided scientists into "Classicists" and "Romantics." The Romantics, declared Ostwald, show the following characteristics (Rodnyj & Solowjew, 1977):

- They work fast and move rapidly from problem to problem.
- They tend to be the founders of great schools of disciples (Ostwald cited Liebig, with pupils and influence reaching beyond Germany to England, Russia and the USA).
- They become not only active combatants but also passionate propagandists for their ideas and viewpoints.
- They favor broad and multifaceted problems but must defer to the Classicists in matters of depth and fundamental significance.

It is not hard to detect here in a scientific context the dark side of the Romantic character, in which "suprarational mysteries" tended toward extreme tribalism, racism, nationalism, and jingoism, with the catastrophic sequelae described in part by Mosse (1964). Such irrational emotional devotion has not been absent from the disciplines of scientific organization. Every scientist will recognize the incompletely jocular strain of fierce loyalty expressed in the *Fest-Cantus*[2] John Read sang with his fellow students at the University of Zurich during their Christmas party in 1906 (Read, 1947, p. 277):

Then shout with voices in alliance:
"Prosperity and growth to Science!"
And cry with all your energy:
"Long life to Chemistry!"

A Subdisciplinary Chronology

Annales de chimie et de physique	**1789**
Journal of the Chemical Society	**1841**
Z. für analytische Chemie	**1862**
Z. für physiologische Chemie	**1877**
Z. für physikalische Chemie	**1887**
Z. f. anorganische u. allgem. Ch.	**1892**
Journal of Organic Chemistry	**1935**
Biochemistry	**1961**

Figure 2. Development of the chemical subdisciplines, as reflected in the foundation of subdisciplinary journals, during the Romantic Era (data in part from Neufeld, 1977). Lavoisier's journal, the *Annales*, published both chemistry and physics at the time of the French Revolution, but by 1841 the *Journal of the Chemical Society* was concentrating on chemistry alone. The German chemical press (*Z. = Zeitschrift; allgem. = allgemeine*) began the fragmentation into the occasionally warring tribes of analytical, physiological, physical, and inorganic chemistry. The apparently late foundation of the *Journal of Organic Chemistry* in the USA is merely indicative of the domination of organic-chemical papers in the general chemical journals throughout most of chemical history, while *Biochemistry* simply re-names physiological chemistry.

The powerful loyalties that attach to the scientific disciplines and their individual subdisciplines are thus of at least a partially irrational origin (some rational contributions will be considered below). Such loyalties, seemingly inexplicable but freighted with a heavy emotional weight, may thus explain the unusual survival properties of those hardy perennials, our scientific disciplines, that have kept them flourishing so long in the university hothouse.

In fact, the disciplines have flourished in the very face of attack by their own research objects. The shapes of research challenges in both fundamental and applied science, and in all the shades of overlap between, have stubbornly declined formulation along disciplinary boundaries.

Thus we have the strange phenomenon of interdisciplinary research. It is fundamentally occasioned by our unwillingness or inability, as university scholars, to give up the traditional modes of scholarly organization and to adopt instead more modern and flexible alignments that have more coherence with respect to research demands.

The End of Interdisciplinary Research: the Elimination of the Scientific Disciplines?

To the extent the highly doubtful foregoing analysis has any validity, the appropriate course of action for mobilizing the sciences for research opportunities in the next century would appear to be simple and clear.

For maximum flexibility and effectiveness in addressing new research opportunities, the scientific disciplines, which are emotion-laden and archaic remnants of Romantic irrationality, should be eliminated.

Is this in fact a project that is either possible or desirable? Some facts suggest that the elimination of scientific disciplines from the fabric of university organization is neither possible nor, if it were possible, desirable. These facts are:

- **Traditional scholarly alignments provide a valuable engine for the nurturing and validation of expertise that we cannot do without.**

  Every discipline provides its practitioners with skills that are vital for research success in interdisciplinary research. For example, problems of molecular structure determination call upon chemical skills and the solution of such problems in the interdisciplinary context commonly presupposes the availability of a chemically trained practitioner. Similarly, cell culture problems are most likely to be successfully addressed by persons trained in biology, etc.

  In fact, the traditional disciplines and subdisciplines within them have evolved an informal but enormously functional and efficient scheme of division of labor so that expertise is produced and validated in a reliable manner.[3] As we cannot readily dispense with expertise, we cannot dispense with scientific disciplines without an address to this problem.

  Furthermore, the overall validation of educational and research functions within the traditional disciplines is often provided by professional organizations for which no analog has been invented to take their place in the imagined post-disciplinary world.

- **Education in the physical and biological sciences, as it is currently constructed, depends upon a specific model of the disciplinary division of labor, the "vertical" model described by Westheimer.[4]**

> According to the "vertical" model, a future biologist cannot be launched on the serious study of biology without first acquiring a sufficient basis in chemistry to understand the molecular basis of biology. In turn, the student cannot acquire this chemical basis without a grounding in physics, which further presupposes command of a certain amount of mathematics. In the American academic world, this entire process of acquisition proceeds within the university disciplinary context, none of the requisite information or skills being presupposed upon arrival in the university. The scheme works well but predicates the existence of academic departments in these traditional areas. In our imagined post-disciplinary paradise, we have yet to describe the solution of the educational problem posed by the disappearance of the disciplines.

Thus a number of reasons can be advanced that suggest the elimination of the traditional disciplines is not the facile project one might have imagined.

This is not to say that changes in disciplinary organization, if not the actual elimination of disciplinary boundaries, are unknown. Indeed, the ethnic and gender studies departments referred to at the beginning of this article commonly are composed of scholars whose own doctoral degrees are likely to have been obtained in more traditional fields. On the technical side, environmentally oriented departments have frequently been assembled, with a corresponding composition of members with training in specific, traditional disciplines.

Not uncommonly members of such novel departments hold simultaneous appointments in departments that call upon their traditional loyalties. This fact might be interpreted as indicating a type of missionary activity at work, with the traditional metropolitan disciplines loosing their more adventurous populations into the interdisciplinary jungles. Alternatively, it might be thought that a well-founded consideration of the probable eventual fate of non-traditional departments in universities gives reason for their inhabitants to develop and maintain, along with their holdings in the colonial enterprise, a purchase on some higher and drier ground.

Changes in disciplinary organization even within the "hard sciences" can occur. My own university affiliation is in part (perhaps the other parts represent higher and drier ground) to a department currently in the process of incorporating members from the traditional areas of Biochemistry, Cell Biology, Physiology, and Microbiology. The amalgam will probably be known as "Molecular Biosciences," a name that displays not only the wit of brevity but also the generous rationality of its members.

Even when changes in disciplinary alignments do occur, however, the wily mutability of research problems tends to outrun the pace of realignment, and the call for interdisciplinary cooperation continues. Thus the question:

Short of the elimination of the disciplines, how can an effective and flexible response to research challenges be mounted, i.e., what are the factors that favor interdisciplinary research?

Waiting for the End of Days: Nurturing Interdisciplinary Research

I would like to call upon three decades of participation in interdisciplinary scientific work at the University of Kansas to identify some of the features that have made the activity functional and facile at that institution. I deliberately concentrate on features that ought to hold equally well in any institution, and I omit personal qualities of the investigators. I claim these two items to be most important:

- **The presence of supraterritorial research centers.**

  Much of my own work has played out in the Higuchi Biosciences Center, its component centers, and its predecessors. 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.

  I hasten to add that I do not claim that the chief value of the supraterritorial feature is that it avoids the feral territorial instincts or Romantic irrationality inherent in the make-up of department chairs or college deans (here I can be seen climbing rapidly to higher and drier ground). In fact, what the research enterprise is exempted from is the *rationality* and *sense of responsibility* that are typical of chairs and deans (quite high, quite dry). At Kansas and indeed at most research universities, chairs and deans are frequently afflicted by critical unmet needs with large, strong constituencies and very short time-lines. The supraterritoriality of research centers removes the research enterprises within them from being balanced against such demands. When it is considered that in interdisciplinary work, a number of chairs and deans must simultaneously be involved, the supraterritorial quality becomes vitally significant.

- **The absence of sharp accounting practices.**

  I have already referred to the conflicts with effective interdisciplinary work set up by questions of how grant income and publications, for example, will be allocated among the organizational home territories of the participating researchers. Such problems can readily be elevated to the fatal level by internal accounting practices that insist on making a zero-sum game of such divisions. Then every collaboration across disciplinary lines tends to be preceded by a series of acrimonious negotiations the bitterness of which is described by Kissinger's Dictum.[5] The merciful absence (to date) of such practices at the University of Kansas has made it an institution very friendly to interdisciplinary research. In institutions where the critical accounting decisions on this point have not been made (surely few indeed), it may be worthwhile to be alert to the Algorithm Problem. At some point, research-management software is written in which is embedded an algorithm that allocates grant income and other productivity measures among university entities. Once the software is implemented, changes become impossible so it is vital to raise the alarm in advance. Otherwise, the critical decision is made at 3 a.m. by a teen-age computer-science student, her nervous system jangling with caffeine, who has been hired as a minimum-wage programmer. The decision thus made then has a serious determining effect on the research future of the institution: if the accounting is generous and clever and does not create a zero-sum game, the future is bright. Otherwise, dismal.

Summa

Interdisciplinary research will end, when and if university faculties can abandon the traditional lines of scholarly organization. Factors that are of the utmost irrationality and of the utmost rationality suggest that the third millennium may be an early date for this occurrence. Before then, 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.

Acknowledgments

In addition to the debts to which I have confessed in the text and footnotes, the bibliography lists a number of other sources of relevant information.

Endnotes

(1) An appropriate recipient of these devotions would be the deity Hermaphroditus. Robert Graves (*The Greek Myths,* Penguin, London, 1960, vol. 1, p 68) notes that the mother of this interdisciplinary being succumbed amorously to its father after the latter had witnessed her trapped by her husband in dalliance with still another man. This is the requisite attitude for interdisciplinary work.

(2) The translation is Read's, from the original:

D'rum ruft mit voller Lungenkraft:
"Es lebe hoch die Wissenschaft!"
Und schreit mit aller Energie:
"Hoch lebe die Chemie!"

The scansion is thus unimproved in the German.

(3) I am much indebted for this insight to Professor Daryle Busch of the Department of Chemistry, University of Kansas, during our occasional discussions of the value or lack thereof of subdisciplinary divisions in the discipline of chemistry.

(4) Professor Frank Westheimer of the Department of Chemistry and Chemical Biology at Harvard University has made this point eloquently: Westheimer, F.H. (1994) Deciding how much science is enough, *Journal of College Science Teaching*, *23*, 203-204.

(5) "Academic politics is so bitter because the stakes are so small." Attributed to the one-time American Secretary of State and long-time academic Henry Kissinger.

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WOMEN IN SCIENCE

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Women are a presence in science, certainly in the United States and in Europe. In 1994, 46% of new U.S. doctoral degrees were awarded to women. Many national scientific societies are or recently have been headed by women and women are or recently have been directors or deputy directors of large federal science agencies including the Department of Health and Human Services, National Institutes for Health and the National Science Foundation. Women scientists are Presidents or Chancellors of major research universities. Minorities are still seriously under represented in many areas of science and in leadership positions but there are more minority males and females now in leadership positions in universities and in the federal government, including the U.S. Surgeon General, formerly the director of the Center for Disease Control.

Despite this obvious and dramatic difference over the past two decades there are significant problems for women and minorities in science. I'd like to touch on three areas in this brief talk:

- Mentoring
- Career Pathways and Obstacles
- Affirmative Action

Mentoring

Mentors are important in career development, and planning for young scientists. Role models in a somewhat different way help careers, often by example, with strategies for achieving a balance of professional and personal goals. Mentors and role models both are usually more senior individuals and until recently there was a distinct lack of senior women and minorities in science to serve these functions. Although non-minority men have served as successful mentors for young women and minorities for a long time, they are not as effective as role models. Also for many men, mentoring of younger male colleagues has been easier and more spontaneous. Often this has happened in informal settings–going out for a beer, playing sports. Even when senior women were available in academic departments or labs, they were often so busy balancing their own family and professional lives that they did not have time to spend with younger colleagues. (Also we should note, until recently there were very few senior women.) Consequences of this have been inequality of tenure awards to women and the more frequent finding of women in the junior academic ranks as well as non-tenure academic tracks. It has greatly helped to have more senior women to serve as mentors and role models in recent years.

A number of societies including AWIS, AMWA, AAUW and many science specialty societies have recognized the importance of effective mentoring and have developed formal and informal mechanisms to facilitate this. Recently an email based mentoring program for female engineering and science students called Mentor Net began national pairing of undergraduate and graduate students with mentors working for a large number of companies with start-up funding from AT&T and Intel. Mentor Net grew out of a 2 year pilot project for female engineering students at Dartmouth and this year plans to match 500 students from 25 schools with 500 mentors. It should be possible to develop similar university based programs on an institutional level or as a regional consortium.

Career Pathways and Obstacles

Family considerations impact the careers of both men and women; however women's careers are usually more directly influenced by decisions to marry and have children. Childbirth, pregnancy complications and breastfeeding are uniquely women's issues, and in many families responsibility for childcare falls to the woman. In some cultures, women's careers are regarded as secondary to those of men. Newly flexible promotion and tenure policies have helped young women and men establish their academic careers without having to postpone child rearing. However many women in both the past and present have interrupted their careers to produce and raise their children. Many of these women plan to re-enter the scientific workforce at some point, only to find a number of barriers to this re-entry. These include significant financial responsibilities, outdated knowledge and skills, and loss of networks.

Financially, not only are the increased expenses of returning to graduate school or training programs a cost, but also the older woman is often faced with mortgages, college expense for children, medical expenses for family or aging parents, etc. Likewise the re-entering scientist may often have family concerns such as young children, older adolescent children, or aging parents which limit the choices and time that can be devoted to career rebuilding. Many women seeking to re-enter scientific fields find their knowledge is outdated as is their skill base. This problem is really unique to science and technology fields but may seem insurmountable without appropriate help. Networks of scientific colleagues established during graduate and postgraduate training often have disappeared by the time a woman decides to reactivate her career in science. These networks are critical for keeping current in one's area of science, for mentors and role models, and for career opportunities. Many professional societies and federal agencies such as ORWH and NIH have begun to offer support and training opportunities for re-entry scientists. ORWH offers a fellowship program for fully trained re-entry men and women as a supplement to existing NIH grants. Clearly universities have a responsibility and opportunity in this arena as well.

Affirmative Action

In a speech given to a national science foundation conference on Women in Science on December 14, 1995 (and in a subsequent essay written for *Science No*w in March 1996) Radcliffe College President Linda Wilson made the following comments. "The scientific enterprise cannot thrive in the future unless it is open to all segments of the population. The native intellectual capacity for significant and sustained contributions in science, math and engineering is present in all groups in the population: male and female; white, Native American, African-American, Asian American, Hispanic American; and across all socio-economic groups. Diversifying the pool of scientists, mathematicians and engineers is necessary to ensure excellence in these fields. Drawing only or primarily on a narrow segment of the population will inevitably diminish the capacity for excellence." She goes on to note that we will not meet our national goals unless we recognize the diversity of our human resources and unless we bring the diverse members of the population into full partnership. She states that "as a nation we have been squandering talent, partly through ignorance of its existence, but partly through reluctance to share power and responsibility. Affirmative Action is a necessary step and a fair step if implemented wisely." Other scientists have also recognized the dangers to science in current trends with Affirmative Action. In an editorial in the March 29, 1996 issue of *Science*, Dr. M.R.C. Greenwood, Dean of Graduate Studies and Vice Provost for Academic Outreach at the University of California-Davis and former Associate Director of Science in the Office of Science and Technology Policy writes: "This is a time of extraordinary paradox. Just as we begin to reap the benefits that diversification of the scientific leadership of the nation is bringing us, we are also faced with a new popular perception that the tools that helped to open our doors and our eyes were wrong, that they created 'preference' not 'equalizers.' Drawing more women and minorities into science is no longer so much about writing the wrongs of the past as it is about developing talent for the next century. Recent estimates indicate that between the mid-1980's and the year 2000 the majority of growth in the labor force will come from the entry of women, people of color and immigrants. In an international, stridently competitive 'information age' we have to mobilize all the latent talent in this new workforce. Scientific leaders from diverse backgrounds … are desperately needed because their presence will help inspire others to follow their lead."

The recent challenges to affirmative action programs may indeed be as these women predict, detrimental to the progress made by women in their scientific careers and possibly even more devastating to the careers of minority scientists who have not yet reached sufficient numbers to form the important mentoring networks necessary for scientific success. We will lose so much if we do not actively encourage and support access and diversity. Young women and minorities, contemplating careers in science, must see others who will show them it is possible. It has been stated that women often experience the institutional climate of science as chilly because for women there is value in a balance between intellectual challenge and supportive relationships. For women, often, the community and environment in which they work is as important as the projects on which they work. This balance between career and community, may be what promotes women's creativity in science and makes all of us examine questions in different ways. To quote President Linda Wilson again "we now seem to have supply and demand imbalances for scientific personnel, but that is partly because we have had too narrow a view for the roles to be played by those trained in science. We need a more robust design." She ends with the following sentiment: "my view of the future is optimistic because I see the opportunities to restructure and reshape our expectations. I am utterly convinced that a key to advancing our society lies in advancing women. But I am also convinced that the path must involve concerted, sustained attention to the development of partnerships and deeper communication–between men and women; across boundaries of cultural, racial and socio-economic differences; across disciplines and institutions; and among the sectors of our society. We need to bridge the gaps between scholars and educators, policy makers, the media, the business community, grass root organizations, and the public at large."

In summary, women are an extremely valuable resource in science. Programs that have been put in place over the last decades have been effective in moving women into senior levels of scientific careers were they can serve as effective mentors and role models for younger women coming up the ranks. They have also moved women to the forefront of discussions about science on a national and institutional level. Although advances have been made in a similar vein for minorities the progress has not been as great. Because science, especially biotechnology, biomedical science, engineering, mathematics, is so important to the future economy of this country we cannot afford to disenfranchise any of the creative minds of the next generation. Women still face difficult choices between having a family and building a career, and advances are still threatened by the potential loss of important support programs including Affirmative Action. It is incumbent on all us within the universities to recognize both how far we have come and how far we need still to go.

ENHANCING SUCCESSFUL RESEARCHERS

AMIDST THE INFORMATION EXPLOSION

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Civilization advances by extending the number of operations which we can perform without thinking about them. Alfred North Whitehead

The foregoing aphorism, composed by one of the great British thinkers of the early 20th century (Whitehead, a colleague of Bertrand Russell, was a mathematician, scientist, and philosopher), highlights both the importance of thinking and the value of inventing ways to free us from elementary operations (e.g., digging a ditch with a shovel) so we can spend more time thinking. During our recent cultural evolution, we have built machines that can perform billions of operations per second without our attention. The time we have saved by not having to perform what we now think of as trivial operations (e.g., doing arithmetic with paper and pencil) has been devoted increasingly to thinking. And a great deal of this thinking has been applied to the development and archiving of information aimed at further enhancing our ability to "perform operations without thinking about them!" Through positive feedback these processes have produced an information explosion. Pundits estimate that the amount of information in any field doubles every 15 years. In the sciences the rate of growth of new information seems almost overwhelming to the individual scientist.

The rate of growth of information related to our survival and well being is many orders of magnitude greater than the rate of evolution of our brains–our organs for processing information. The biological determinants of our brain's information processing capacities probably hasn't changed much in the last 50,000 years. Yet the volume of information we are expected to acquire and manipulate per unit time has increased dramatically. Thus, we cannot expect biological evolution to have much of an influence on our ability to adapt to these increasingly information-rich environments we find ourselves in. Whoever it was that said we only use 10% of our brain's capacity was speaking about him or herself for there is no scientific basis for such a claim! Thus, we cannot expect to cope with massively increasing amounts of information by simply using the previously unused 90% of our brain's capacity. We now know that information overload can lead to stress, and stress, as shown by Sapolsky's work, can actually kill hippocampal neurons, i.e., brain cells that are crucial for memory. So the information explosion may be self-limiting if we do not develop coping methods compatible with our biological limitations. One of our adaptive behavioral responses has been specialization into ever more narrow content areas. This too, may be self limiting if we do not take measures to ensure communication across the specialty domains (i.e., tower of Babel will ensue, etc.).

As scientists, we are certainly caught up in the information explosion, and as I was thinking about these matters, I could not suppress my urge to collect some data–something tangible to go by. So I decided to compare, in terms of information content per article, two issues of the *Journal of Comparative and Physiological Psychology*, one issue from April 1968 and one from April 1998 (the journal changed its name to *Behavioral Neuroscience* in about 1980). This is a 30-year time span; according to the rule that information doubles every 15 years, during a 30-year interval information will increase four fold. In order to compare the two journal issues, I computed the average number of authors, figures, pages, references and tables per article. The data are shown in the following table. These data show that the size of the article in 1998 is much larger than in 1968. The number of references increased more than four fold (a ratio of 4.7)

Variable Name	1968	1998	Ratio (1998/1968)
Authors	1.7	3.1	1.8
Figures	2.4	7.9	3.2
Pages	6.0	13.6	2.3
References	12.2	57.6	4.7
Tables	1.4	1.0	0.7

during the 30 year interval, a result roughly consistent with the 15-year rule. I conclude that current publications in *Behavioral Neuroscience* reflect a lot more information, thinking, scientific energy, and collaboration, compared to 30 years ago.

Over the past 30 years, just as there has been an escalation of standards for high quality scientific publication, there has also been a concomitant increase in the difficulty of securing funding from the National Institutes of Health (NIH) and the National Science Foundation (NSF). At NIH, the Division of Research Grants (DRG) has recently changed its name to the Center for Scientific Review (CSR), and along with its name change, the criteria for the peer evaluation of research proposals have been made more demanding. The new criteria focus attention on five dimensions that research proposals should address: significance, approach, innovation, investigator, and environment. What is new in these criteria is the explicit mention of innovation. In addition, collaborative arrangements are explicitly mentioned in regard to the research environment. More specifically, the verbatim descriptions for innovation and environment are:

> "Innovation. Does the project employ **novel** concepts, approaches or methods? Are the aims **original and innovative**? Does the project challenge existing paradigms or develop **new methodologies or technologies**?
>
> Environment. Does the scientific environment in which the work will be done contribute to the probability of success? Do the proposed experiments take advantage of unique features of the scientific environment or employ useful **collaborative arrangements**? Is there evidence of institutional support?"

These criteria make it clear that proposals, more than ever, must include innovative approaches and demonstrate interdisciplinary or interlaboratory collaborations.

Not only do contemporary grant proposals have to be four times as well informed as in 1968, the proposals also should contain explicit evidence for innovation and collaboration. Innovation and collaboration are believed by peer reviewers only if they are already demonstrated in the proposal with evidence from pilot studies. As you probably know, the forging of collaborative arrangements requires time-consuming discussions and new learning. Learning new material, while satisfying to most scholars, is usually quite time consuming compared to keeping up in your own specialty area. In order to collect the pilot data needed to address the demands for innovation and collaboration in today's grant proposals, one needs both time and money.

As most of you know, the challenges of maintaining an ongoing, funded research program are daunting. As we researchers accept this challenge we have to acknowledge that the process of doing research is much like a cottage industry in that the required operations cannot be performed without thinking about them! Thinking takes time. My perception is that most of the successful researchers that I know mostly live a zero sum game in terms of time. A new activity can only be added to the schedule if some other activity is deleted.

Given the current research climate, how can we enhance research productivity of the already successful researcher? In general, the mid-career scientist needs help with time and money! The Principal Investigator needs to concentrate on the creative, thought-based tasks that only he or she can do. Other tasks should be assigned to support staff. Concurrently, the principal investigators need additional resources for developing collaborations and innovations.

Although I can think of dozens of specific types of staff support and services that could be improved at KU and probably at most state-supported research universities, I want to suggest to you just two modifications of university operations that I think would have the biggest effects on increasing research productivity while having the least adverse impact in terms of cost of implementation. My two suggestions are: (1) link salary decisions directly to the desired research outcomes, and (2) establish internal research accounts for active principal investigators.

Linking Salary Decisions to Research Productivity

The core concept here is obvious, namely, rewards (reinforcers) increase the frequency and intensity of the behaviors that are perceived to produce the reward. If the decision is made to link salaries to research productivity then the implementation should consider the following points:

- The linkage should be specific and explicitly stated.

- The necessary evaluation component of implementation would benefit from judgements drawn from outside of the traditional departmental framework. Given the diverse specializations of researchers within some departments, expertise for judging research productivity (including quality) may possibly be found outside of departments rather than within them. In addition, although it is presumed that departments adhere to the conventional 40%-40%-20% formula for allocation of time to teaching research and service activities, respectively, there is no assurance that such a formula is adhered to because departments sometimes (often?) have values or missions that conflict with this formula.

- The research centers or institutes are one likely source of the needed extra-departmental peer evaluators of research productivity.

Advantages of linking salaries to research productivity are:

- Directly linking salary increases with research productivity will help maintain current levels of activity by successful principal investigators.

- Higher salaries would almost certainly improve recruiting of research scientists.

- Faculty perception of administrative efficacy would increase. To be understood, this point requires explanation. By not having a clear system of rewards for research success the administrators are deprived of a source of behavioral control related to research growth and maintenance. For the faculty that have their time largely controlled by research and the grants process ("largely controlled" means that evening and weekends are devoted to the research effort), the current incentives are extramural, not intramural. The local university administration is sometimes perceived as having little to give the researcher. Those with the money (i.e., NIH, NSF) and those peer reviewers who largely decide who gets the grant money do not reside on the campus. One way for the university administration to exert more influence is to make it clear through explicit responses that they do have resources to devote to the enterprises that they want to grow. In my view, a major reason that university administrators are sometimes perceived as having little influence is the poor financial support available from the state governments so the administrators haven't had enough money to stimulate change. And at the same time, the federal government continues to escalate its control by providing grant dollars or by threatening to terminate them unless expensive compliance issues are addressed.

- Some faculty who only recently became inactive in research may renew their research efforts. I emphasize "recently became inactive" because I think those long inactive simply will not be able to restart, primarily because the amount of new information to be mastered will be overwhelming.

- The probability of retaining the best faculty will increase. The efficiency of such faculty will also increase because they won't have to use their valuable time trying to develop offers elsewhere as a means increasing their salaries. Also, important collaborations can be broken up when a key researcher departs, and thus the departure can have an effect on research programs well beyond the loss of one valuable person.

Disadvantages of explicitly linking salary decisions to research productivity:

- It will be unrealistically expensive to do so.

- Anti-research forces on and off the campus will have a clear target to attack.

- The teaching-research conflict may be intensified unless the "different-roles" model of faculty activity is adopted. The different-roles model means a departure from the 40%-40%-20% standard formula of time allocation for the faculty. Most often, this means that those who prefer teaching activities over research activities will do more teaching than research (e.g., 70%-10%-20%, for teaching, research and service, respectively).

- Explicitly linking salary decisions to research productivity will probably produce salary differentials across disciplines that are even greater than the large discrepancies we currently have (e.g., classics vs. computer science).

Establishing Internal Accounts for Principal Investigators

My second suggestion for enhancing the research productivity for already successful researchers is to establish internal research accounts for principal investigators (P.I.s). Let me explain this idea by addressing three questions. Where would the money come from? Procedurally, how would the money be dispersed? What are the advantages and disadvantages of this idea?

Where will the money come from? The money, of course, would almost certainly have to come substantially from indirect cost reimbursement (overhead), but some portion could be drawn from the state-allocated part of the research budget (if there is any) or from private donations.

Procedurally, how would the money be dispersed? Two non-mutually exclusive methods come to mind.

Method 1: Upon actual submission of an NSF, NIH, or similar grant, the P.I. would automatically receive 5% of the year 01 budget to pursue the research aims of the grant.

Method 2: Funded investigators should receive yearly 10% of the indirect costs given to the university by the funding agency.

If only one method is selected, then I recommend Method 1 because this procedure will directly stimulate proposal submissions. Even successful researchers very often do not receive funding upon the first submission, and the odds are known to be low, about 1 in 5. A major proposal, requiring 150 to 300 hours to prepare, is more easily initiated if at least some payoff is a certainty.

Advantages of having internal accounts for P.I.s are many. These include:

- Submissions of grant proposals will increase because P.I.s and prospective P.I.s will know that writing the proposal is not an all-or-none gamble (related specifically to Method 1).

- The P.I. will have the flexibility to invest this money in the best possible way for the vitality of his or her research program.

- No justifying documents need be created for obtaining or using the money. This saves time!

- The money can be spent immediately when new opportunities arise.

- Because the accounts will be able to accumulate assets, SAVING and PLANNING will be amplified. Saving and planning are limited in the current extramural grant climate.

- Recruitment of research scientists will be improved.

- The funds will be used to strengthen specific laboratories. Building a laboratory's capabilities and survival chances are tantamount to building the university's research capability.

- The money can be used for developing pilot data with interdisciplinary collaborators, thereby making future proposals more competitive.

- The P.I.s fund will serve as the source of bridging funds to keep projects or personnel active when competing renewal proposals are not funded on the first submission.

- Important travel opportunities can be pursued without having to spend one's personal money and without having to approach administrators for ad hoc handouts (which saves everyone's time).

- Extra resources in the laboratory will increase the probability of bringing undergraduates into the research program.

Disadvantages of creating such accounts can also be anticipated. Some of these potential disadvantages are:

- The P.I.s will spend the money unproductively. This seems very unlikely because one of the strongest motivators for most research scientists is the desire to keep his or her research program on track. One of the scientist's most powerful rewards is the sense of discovery that arises from new and unexpected results from the laboratory's experiments. When scientists are cut off from direct access to the discovery experience, they often think about retiring–or becoming administrators.

- A few successful P.I.s will begin to exert unwelcome influence over their department or research center. This potential problem can be illustrated by a fictitious scenario. Imagine that Professor Rakus Markle amasses $150,000 in his internal account. When a faculty vacancy is to be filled, Professor Markle says "If, from among the three finalists we have identified, you hire Dr. Laser White, who could contribute greatly to my laboratory's capabilities, I will contribute $75,000 to Dr. White's start-up costs." Of course, this could happen, but the question is whether more good than harm would result from the consequences of having internal accounts.

- Such accounts under the control of the P.I. will lead to redundant equipment purchases or other redundancies of effort and thus be inefficient compared to "central" control of the same amount of money. This point is most frequently debated in the context of large equipment purchases (instruments that require a dedicated staff to operate them), and seems valid under circumstances where several laboratories can share the equipment and no single laboratory can commit the necessary resources. However, when smaller instruments are involved (e.g., a microtome or a stereotaxic instrument) the advantage of having immediate access to the instrument often far out weighs the cost of duplicating the instruments across several laboratories.

- Interdisciplinary research will actually be inhibited rather than stimulated. The P.I. may turn inward with the extra resources, but the new NIH review criteria, with their emphasis on innovation and collaboration, should act as a strong counter force to any such tendency.

- Administrative efficacy will be diminished because of the redistribution of funds. For example, a dean trying to create a start-up package, may fall short because he or she did not have the extra 10%. This is a distinct possibility, but I suspect that the 10% in the hands of the P.I. will have a greater overall beneficial effect on research productivity than the same amount in the hands of a higher level administrator who is usually thinking about issues more global than those that affect individual laboratories. In trying to attract new researchers to the university, it should not be forgotten that the already-present successful P.I.s need to be maintained as the base upon which subsequent growth occurs.

- The existence of such accounts for scientists will depress the non-science faculties. While there is some truth to this criticism, it can be pointed out that grant programs are available to non-science faculty.

- What amounts or percentages would be appropriate for grant applications ineligible for indirect costs? Policies would have to be developed to address this issue.

- P.I.s may pad their budgets to increase returns to the account (especially under Model 1). This, does not seem likely given the sophisticated acumen of NIH study sections to detect and eliminate any unnecessary budget items. In addition, experienced P.I.s know in advance that perceived over-budgeting will undermine confidence in the P.I. and reduce the proposal's score.

- The rate of low quality proposals will increase, with attendant harm to the reputations of the P.I. and the institution (under Model 1). This could occur. But most Ph.D. faculty are usually quite motivated to do their best once an intellectual challenge is accepted.

Addressing salary issues and establishing internal accounts will enhance the research productivity of successful researchers as they continue their careers in an environment where both competition and information are expanding at unprecedented rates.

HOW TO ENHANCE SUCCESSFUL SCIENTISTS

Steve Schroeder
Schiefelbusch Institute for Life Span Studies
University of Kansas

In my view, a worthy goal of this conference would be for our regional universities to work together and go for some big ideas. I know that the natural tendency is to think small. Big ideas tend to upset everyone. But, we have seen from Jack Burn's presentation on virtual centers at the University of Missouri how powerful big ideas can be. Such ideas must be executed with care and perspicacity because of all of the different rules and regulations of different institutions and state governments, but they are possible, and they can be potent.

A Vision for the Future

I recently read a very interesting book by E. O. Wilson, the great naturalist, while I was on vacation. It was entitled, *Consilience: The Unity of Knowledge* (Wilson, 1998). The concept of consilience is:

"A jumping together by linking of facts and fact-based theory across disciplines to create a common groundwork of explanation. The consilience of inductions takes place when an induction, obtained from a class of facts, coincides with an induction obtained from another different class. This consilience is the test of the truth of a theory (pp. 8 & 9).

Wilson then goes on to apply his notion to the sciences, to the humanities, to the arts and to religion. His point is that we must cast a wide inter-disciplinary net if we are going to save our planet. We are not exempt from evolution. We are part of it. He then mobilizes data from world population growth rates, food production capacity, and loss of important ecosystems to illustrate how interdependent these systems are. Sustainability of life on the planet is a truly big idea in which each of us could probably find a challenging niche. Perhaps bringing this idea down to the realities of the Heartland where we cherish our quality of life and our living circumstances could be an idea that we could work on together for our region of the country.

What can We do as a Regional Consortium?

Consilient goals should be consistent with our long-term quality of life and the survival of the Heartland way of living. We should use our collective intellectual resources to set common goals that we could not accomplish alone. Such a strategy implies that sometimes we may have to sacrifice or delay some of our individual priorities to promote a common consilient goal. That, to me, is the real core of interdisciplinary teamwork. Sometimes individual researchers, especially successful ones, might find it difficult to do. Achieving such a consensus will challenge the ingenuity of our administrators in research and development.

What can We do at our Respective Universities?

Academic freedom at a university is a time-honored tradition which requires that individuals be encouraged to pursue their own original ideas. At the University of Kansas, I call this Kansas Individualism. Kansas has a long populist tradition that needs to be respected and celebrated. Nevertheless, consilient goals imply working to unify knowledge rather than to fragment it. Research facts and theories need to be consistent not only within but also across disciplines. This means that we will need to encourage students and faculty to train themselves across disciplines. Richard Schowen's presentation was a beautiful illustration of that, and he said it far better than I could have.

How can Consilience be Achieved in our Respective Units?

Incentive Systems. Maria Carlson's presentation was an excellent analysis of the required incentive systems, and I do not need to repeat these. I was struck by how similar they are in the humanities as well as in the natural and social sciences. That is a consilient cross-validation.

Some Basic Reality Factors. Our research and development budgets, at the University of Kansas (KU) at least, are likely to remain relatively flat in the near foreseeable future. The University of Missouri seems to be doing much better than KU or Nebraska. Perhaps we should study how you do it.

A corollary is that, if we wish to grow in research and development, we will have to do it with external funding. This will be a challenge, but a good one. The federal funding situation is the best it has ever been in my 35 years of grantsmanship, and it is likely to get better in the next few years. We will never have a better chance to mount a large regional initiative than we have right now.

A second corollary is that, even though we will grow, our *growth rate* must keep pace with the research mega-universities, or we will fall farther behind in the competition for the best students, the best faculty, and the best scholarly support networks for our *whole* university. That, in the end, could be our undoing. We have no choice but to compete.

Operations Principles. Within the Life Span Institute (LSI), we have competed very successfully over the past 40 years by developing consilient areas of excellence. Our general strategy is to cluster our 100 or so grant projects around these areas of excellence in order to compete for larger center grants and program projects that in turn support individual researchers. We have been able to do this while at the same time supporting the loner who wants to do his or her own thing. However, once an investigator becomes part of a larger research program and sees the intellectual as well as fiscal benefits, we do not need to do much persuading and cajoling.

Our principles of operation at LSI are based on a paper on research administration written in 1987 by my predecessor, Dick Schiefelbusch. It is still the best paper I have ever read on the topic, so I am providing it for your reading pleasure. The principles are simple in conception but difficult in implementation, mainly because of the frailty of human nature. I can readily attest to this after eight years of struggling to follow them. They are:

1) A research administrator should give the greatest effort to securing favorable outcomes for colleagues.

2) A research administrator's greatest obligations are to be informed, committed, and persistent in pursuit of consensus goals and objectives.

3) A research administrator should strive to balance the functions of change, efficiency, and good will.

I commend Dr. Schiefelbusch's paper to you to see how these principles are implemented. It follows here in its entirety.

RESEARCH ADMINISTRATION *

R.L. Schiefelbusch
Director Emeritus, Schiefelbusch Institute for Life Span Studies
University of Kansas

There are several disclaimers that I am inclined to make at the beginning of this paper on research administration. The first is that when I began my work as an administrator I knew almost nothing about administration and I was a moderately untrained researcher. Essentially I was a clinician and had, as I subsequently discovered, some skills as a counselor. I never intended to be an administrator and had some difficulty admitting to myself that I was one. Joe Spradlin was the first colleague who forced me to sit, look him in the eye and say, "I am an administrator." Sy Rosenberg, the first director of the Parsons project, was the first to point out the discrepancy between my verbiage–my disclaimers–and my behavior. He said, "You say you know nothing about administration but you don't act that way!"

Perhaps this reluctance and my still apparent tendency to issue disclaimers, says something but I have never quite decided what that something is. (Perhaps this is the best place for my first "aside" comment, Whatever you are, idiosyncrasy and all, is what you must use in your own career development. They are just a bit more apparent if you are an administrator.) More important, perhaps, is the obvious fact that I have enjoyed the past 32 years and have a sizable army of competent helpers, supporters, advocates, and volunteer trouble-shooters to prove that administration is, after all, not that difficult. Also, I have learned that there is honesty in humbleness and validity in extending credit to those you have gained credibility from. I have always been poignantly aware that at all times I was only one among many, and that often in critical situations I was not necessarily the most significant *one*.

In this presentation I shall try to present:

1) A philosophy of administration;

2) Some guiding principles;

3) Some specific orientations to the Kansas scene; and

4) Some suggestions (not necessarily in that order).

* This paper was given at the Human Development ProSeminar, University of Kansas on October 16, 1987.

Administrative Philosophy

A few years ago I had an enjoyable lunch with the retiring (forced out) executive director of a national, professional organization. He explained in considerable detail why he thought he had lasted so long and why his opponents had not been able to oust him until now. He said he had been successful because he had kept a tight surveillance on everyone and because he had not been soft with the application of regulations. He also explained that employees tend to "goof off" (his term) unless there are strict accounting of their use of time and their daily or weekly productivity.

This concept of employee deception and adverse motivation, I must say, is directly counter to my own view of administrative procedure. I found myself listening to a lecture on administrative structure designed to prevent what the administrator regarded as the natural tendencies of intelligent, carefully selected colleagues to act like immature deceivers.

In my opinion there are positive consequences in positive expectations. Also, I have found policing and managerial surveillance to be counter-productive. I advocate support rather than control, encouragement rather than structured demands, and positive as compared to negative consequences. The generic term I use is *functional* rather than *structural* administration.

The danger of a tight assignment of administrative controls is that it requires a hierarchy of administrative responsibilities. This leads sometimes to less able or less creative or, perhaps, less understanding appointees supervising or sanctioning more gifted peers. The inevitable frustration of having to report to and gain permission from someone that you do not respect far outweighs the possible advantages of having supervisory overviewing of the entire operation. So, I advocate a lateral rather than a hierarchical model of administration. I favor a model where anyone is free to contact anyone else if there is a reason to do it. For instance, if in developing a plan, a design or a paper the author should ideally have access to the best consultant available in the setting. I find that if this practice can be maintained, the entire operation tends to function at the level of its most able members. Able people, of course, must guard their time and protect their schedules, but if they are relatively open to discussions about research, they too gain from the traffic of ideas.

It is likely that all of us or any of us may become or already are research administrators.

Wherever there are two or more people working on a given project there must be some "administrative agreements" about procedure and outcome. To a degree, at least, the agreements must be sought on the basis of intellectual equality. Both should be enthusiastic about the prospective plan. In larger arrangements of people the same requisites should apply. Work styles cannot be easily monitored but productivity can be judged and, more importantly, can be used as the rationale for idiosyncratic as well as standard work routines. The leadership in large research groups is seldom uni-dimensional but is, more often, multiple in design. That is, different people encourage and help each other. Nevertheless, there is an essential link to the director's office that must exist for various people in the research operation. This link must provide for an understanding about status and concomitant support. I have at times described this as a covenant–an agreement in principle that is characterized as an open "contract" which is refined through ongoing experience. The essential basis of such a living agreement is honesty. Deception can destroy the basis of such an agreement system. I accept the premise that intelligent negotiators cannot successfully lie to each other. Truth or validity is multidimensional and so are the detection systems of its participants. Probably one is, at first, alerted by deception and becomes more attentive in subsequent encounters leading finally to confirmation. Such a conclusion by either participant leads to an impaired working relationship.

In similar respects, a research administrator should disclose information fully to colleagues. When one's working colleagues know or believe they know all the relevant information relative to their status or their arrangement they are likely to be more open to and supportive of the system. Again, deception is a poor strategy of research administration.

Guiding Principles

From the beginning of the experimental analysis of behavior movement I observed a rather striking tendency for researchers to apply behavior principles correctly and effectively in direct management of research projects. They were especially precise in arranging the contingencies that they were outside of. So long as a stimulus/response system could be managed by the experimenter as the recording observer, the paradigm was clearly perceived and applied. However, when one was involved in the "experiment" directly, it was a vastly different paradigm. Researchers do not generally respond to casual social contingencies or informal professional exchanges with the same firmness of functional responding that they arrange for in their experiments.

This brief statement reflects the preferred locus of control for applied behavior analysts as well. However, there was a perceptible shift to a larger range of functional control during the 60's and early 70's where the experimenter became a teacher, a group home manager or a youth center director. Here we had the first efforts to create functional conditions within an arranged system, that could be replicated, refined and, in some instances, successfully disseminated.

In these projects the experimenters, who might also be considered the project administrators, used their own behavior as a functional part of the experiment. Such measurable features as attention, praise, or positive checklists were used contingently. These efforts were often elaborately formalized or might be left to "incidental" designing, but the group effect could be determined by outcome measures that were sufficiently precise that they could serve as a guide for further refining of the environmental arrangement (that included the experimenter).

More recently, Steve Fawcett and colleagues have designed approaches to community development research. They attempt to gain information from community members to determine their priorities and thus to consider the variables that should have priority in their research planning. They are, of course, in a position to negotiate about possible community projects and eventually to help in the development of such projects.

This responsive process probably comes the closest to the functions of research administration.

Research administration is a constant developmental process that involves mutually chosen priorities, group decisions, group initiatives, shared risks and shared benefits. It cannot be said that the group works for the administrator any more than the administrator works for the group. Sometimes it is even difficult to determine who is the administrator and who is the group. What is apparent is that there is a group of consenting adults working toward selected and defined objectives. This recurrent scene of group enterprise characterizes a successfully administered research organization. A condition of group behavior within a successful organization that most clearly determines effectiveness is that good decisions are made consistently. How do you know a good decision from a bad one? By its outcome effects and by the enthusiasm of the group during the interim before the outcome is known.

A good research group is open, engages in free exchange and enjoys a positive climate of agreement and dissent. A good administrator is open to input, exposes self fully to decision-making and the risk-taking requisites of the group, and seeks expert opinions and competencies that often transcends those that he or she brings to the tasks.

In the ongoing enterprise, the delayed outcome is faced with a positive style and the not infrequent crises are used as challenges to improve the efforts of the participants. I noticed repeatedly in the early-high-risk years of the Bureau that I could trace most lines of progress back to some crisis context where we gave something close to a maximum effort. I also find that in more prosperous times we may sow the seeds of subsequent failure.

I understand that there is a strong issue in the management field that we could call crisis theory. Having never studied the management literature or having talked at length to experts in that field I can only speculate as to why crises are indeed times of opportunity. I have observed that when a research team nears a deadline, they work harder. When a project application fails, they seek guiding feedback and engage in stringent repairs. They even place a moratorium on personal feuds until the crisis phase is over.

As an administrator I notice that during crisis periods I have a more attentive group, a more resilient set of colleagues, and a higher rate effort throughout the contextual arrangement. People do not like fear but they do work more intensively under its influence. Perhaps that is why researchers should consider their development efforts, both group and individually oriented, to be a *challenge* rather than as a set of prerogatives. Prerogatives dissolve under conditions of crises but if construed as challenges could lead to further achievement at precisely the same time.

It is functional to be optimistic. One builds on positive plans and enlarges through repeated, or persistently confident efforts.

So, may I list a few guiding principles of research administration.

1) **A research administrator should give the greatest effort to securing favorable outcomes for colleagues.**

(If one's scientific goals are specifically defined as self-oriented achievements, that person probably should not be an administrator. However, I sometimes wonder how that person can expect to achieve those goals without giving something substantial to the career goals of colleagues).

2) **A research administrator's greatest obligations are to be informed, committed and persistent in pursuit of consensus goals and objectives.**

(Many of the most important outcomes derive from deep involvement and intense caring about colleagues and clients. If they do not matter a great deal you shouldn't undertake to be a leader).

3) **A research administrator should strive to balance the functions of change, efficiency and good will.**

(Change is necessary to organizational health and growth; efficiency is required because you are in an achievement oriented field; and goodwill is the oasis that you all draw on in time of crisis and famine).

4) **Through intense efforts to be supportive, nutritive, and attentive to others the administrator is the one who derives the most benefits.**

(I judge that if you truly think that the time you give to others is counter productive you will want to make short shrift of administrative chores. If you think otherwise, perhaps you might grow to become the kind of person that others reinforce in order to keep you doing it.)

REMARKS: PANEL OF PROVOSTS

David E. Shulenburger
Provost
University of Kansas

Mike Crow's challenge to our three universities to find research niches is one I believe we must hear and heed. I think some of the discussion since Dr. Crow's initial presentation has missed the point. Some of us have heard in his words the suggestion that Midwestern universities will *never* be able to compete head-to-head with large universities on the coasts and therefore must adopt a niche strategy. Careful review of the full presentation, however, shows that he in fact has designed a niche strategy for Columbia University. What he is calling for is an institutional focus–one or two major ideas that can captivate and energize the communities so they become effective research machines.

Dr. Crow's statement about the criteria departments should use when selecting new colleagues struck me as eminently logical and, at the same time, unnervingly innovative. He said that departments, when selecting new colleagues, should use as a selection criterion the greatest potential value to other scholars at the university for purposes of pursuing the university's niche strategy. In my experience, when departments get the opportunity to select a new colleague, they tend to focus on their internal needs. These needs are seldom identified with respect to the university, but rather concentrate almost entirely on the department. Our German research university heritage shows most plainly here. Discipline is paramount. I certainly know of a number of cases where departments at our university essentially have refused to pursue aims clearly needed for the university to succeed. Ultimately, persuading departments to act in order to advance the aims of the institution is very difficult, but necessary if we are to succeed.

Why do departments focus inwardly instead of on the university? Let me suggest three possibilities:

1) Because the university has not identified niches that are known to departments. If this is the case, it is clearly our problem as administrators. It does no good to identify niches if they are not communicated to the public and justified.

2) Departments pursue their own aims simply because they don't care what niches the university has chosen. Again, the German university model would be supportive of this second possibility.

3) There is some truth in both hypotheses. As in most phenomena of social sciences, I think the answer has to be number 3–both of the explanations are correct.

Richard Schowen receives the award at this conference for reinforcing my own prejudices about departments. In his brilliant discussion about centers versus departments, he essentially announced the thesis that centers function best for fostering interdisciplinary research while departments function best for pursuing educational ends. Dr. Schowen ended up finally waffling, suggesting that both the centers and departments have a purpose within the institution. I would like to focus just a little bit on departments and the disciplines that they house. Specifically, the word discipline has two meanings. The first, of course, has to do with the scholarly focus. The second has to do with discipline of thought. Clearly, it is important to the development of new scholars that they have this discipline of thought so that their work proceeds from an organized set of principles. Without this, it is hard to maintain that what we do is science.

Thus, while I accept Dr. Schowen's waffling–and the reason for his waffling–one has to recognize that there are enormous economic costs to maintaining parallel department and center structures at a university. For this reason, I have steadily pushed to reduce the number of departments at the University of Kansas so that those remaining would contain larger numbers of disciplines and have the critical mass to behave both like departments *and* centers.

In my six years as a chief academic officer, it has been this effort to reduce the number of units that has probably taken the greatest toll on me. Departments are academic homes to faculty members. Disrupting a department has the potential of disrupting the work of its members and threatening their security. Institutional costs are often a vague concept to a faculty member while the costs that are associated with change are quite real to the individual. Dr. Schowen described the merger over time of the biology-related departments at KU into a single entity. This, indeed, is a center-like unit that I now expect to do a wonderful job in both overseeing degree programs and generating interdisciplinary research. This migration, however laudatory, did not occur simply because its creation resulted in a more efficient and effective use of university resources. It occurred because Dean Sally Frost Mason and a few enlightened folks in the department really pushed for it to occur. I congratulate Dr. Frost Mason for that effort. I know it has been costly to her.

As I said earlier, the notion of selecting niches and enhancing the volume of research we do is attractive. However, one must not lose sight of our reason for making these adjustments. The purpose of each of our three universities is *education*. Notice that I did not say our purpose was teaching or our purpose was research–*it is education*. We were founded, and we have been funded, by our local legislatures so that we carry out that education. Victor Frost gave a presentation the other day on the tremendous success of his institute. I have had the opportunity to describe the success of that institute to Regents and others in recent days and invariably during the description, it becomes obvious that it would be impossible for the University of Kansas to train high level personnel for the telecommunications industry if Dr. Frost weren't doing the research that he is. The research that he does is essential to the training of masters and doctoral students who will eventually go into both universities and the telecommunications industry. Thus, a point I want to make–and make quite strongly–is that research is a by-product of our universities. Research is not the main endeavor of our universities.

This is not at all to denigrate the role of research in our institutions. It is simply to make clear to us what the organizing principle of our activity has to be. That organizing principle has to be education. Were it not so, our support and funding by state legislatures would be threatened.

There is a tendency for centers to become focused on research instead of education as a goal, to create staffs comprised of post-doctoral fellows and adjuncts in an effort to accomplish as much research as possible. It is possible for an institute or center to forget that education is the goal of the institution in which it resides. Good, healthy centers, like the three represented here, have significant post-doc and adjunct staffing, but all have a very large component of doctoral and masters' students.

Thus, while it is important to increase the volume of externally funded research on our campuses, it is important to do so for the right reasons. If we attempt to out-compete private and non-profit research organizations by becoming like them, we succeed at our own peril. Such organizations don't need a core of humanities and social sciences undergirding their purposes. Such institutions never give tenure to their researchers. They don't because such add-ons and personnel practices add to costs without generating more product. Such add-ons and personnel practices are essential to our identities as universities; for us to adopt goals strictly to bring in more research dollars without concern about the continuation of the whole enterprise will produce, at best, a Pyrrhic victory.

Thus, what I am describing is really a question of balance. Clearly, our teaching is important, as is our research, but our primary end is education. We have to see both the research and the teaching that we do as contributing to that end.

Finally, Mike Crow's suggestion that research volume will continue to concentrate on the two coasts is worrisome to me. I don't think that this concentration is in our country's best interest. I agree fully with the argument that research should go to those universities where the intellectual capital is, but I also believe that researchers will go to those universities where the economic resources are. There is value in keeping a geographic spread of intellectual capital throughout this country. So long as we have two senators from each state, I don't believe the political process will permit a complete concentration of intellectual capital and research dollars on the two coasts.

Let me switch to another topic. As many of you know, in the past year I have been concerned and involved in national movements dealing with the cost of research literature. I am concerned about research literature because it is both an output of our research and educational activity and an input to it. In spite of everything that has been done in the past year, costs are still increasing at more than 10% per year–a rate far greater than any university's library budget is increasing on a sustained basis. The result is increased cancellation of journals and decimation of monograph collections so that we can maintain an ever smaller number of journals. This situation is clearly undesirable and threatens the success of our research and teaching missions.

Two major efforts are underway to deal with this cost increase. The first is sponsored by the American Research Library Association and goes under the acronym of SPARC. This is an attempt to form new electronic journals that will provide researchers with publishing outlets that will be affordable to their universities. Their first venture is a journal that is sponsored with the American Chemical Society. Other journals will follow. Dramatic cost reductions occur when one goes to web-based distribution of the material, and these cost reductions can be passed on directly to libraries and society members.

The second experiment is by a set of AAU academic officers. A bold plan is underway to separate the review of journal articles from the publication of those articles. It works as follows. The review mechanism is set up by a professional society and all manuscripts are submitted to the review board. The review board judges whether they are "good science." If the manuscripts so qualify, they are put on a web-site maintained by the association and accessible to all researchers and students. Journals are then free to go to the refereed manuscripts on the web site and select for publication those that best fit their journal. This separation of quality review from publication makes the articles available in the public domain for all to see, whether or not they are published. If this venture succeeds, the fact that articles are publicly available will have to cause journals to temper, and probably to roll back, price increases, since articles will be available at no cost. While there is an advantage to ultimate publication in a major journal, these journals would lose their ability to compel large price increases from the academic community.

There is very powerful criticism of the AAU academic officers' proposal. The criticism is that essentially a monopoly review board would be set up in each profession. These entities conceivably could reduce innovation and ultimately harm the professions. I hope that this criticism can be dealt with, and the review and web-publication idea be given a chance to work.

During the past year, anti-trust authorities in the European Union and the United States have begun to look at major publishers. A merger that would have hurt the academic enterprise has been stopped in Europe, and the attention of the U.S. Justice Department to a few large publishers will, I hope, begin to change their behavior in this country. But still we have costs going up by 10% a year.

Ultimately, I believe that simple economics will force electronic distribution to replace paper. We can't continue to subscribe to journals whose costs go up 10% per year; scholars will find a way around it. The physicists, I believe, already have achieved this end with their electronic preprints. I think the story that was in the *Chronicle of Higher Education* in early July, pointing out that a number of journals wouldn't accept articles that had been previously in electronic form on the web, is notable simply because so few journals wish to be identified publicly with that stance.

While I believe that economics ultimately will win out, I would prefer that it be nudged along a little bit. My favorite nudging these days would be the creation of a system–perhaps at the Library of Congress–where all manuscripts accepted for publication by journals would be submitted and placed on the web within 30 days of their appearance in print. This system would have to be a mandatory one for faculty members at U.S. universities so that *all* articles would be placed there. Once placed on the web, articles would need to be accessible to anyone. I propose access in a somewhat unusual manner, say 15 cents per view. Let's give five cents to the journal, which would undoubtedly lose some subscriptions because its contents would be available (albeit with a lag) to the general public. Let's give another five cents to the Library of Congress to pay for the operation of the enormous web site, and let's return five cents to the author. The authors get nothing now. This scheme would make all research literature available at a fraction of the cost that we now pay. It also would produce other results. I imagine it would be somewhat humbling to the author who ultimately receives royalties amounting to 20 cents from the article, and it might well have the effect of stemming the publication of those works that are really not of interest to anyone, including the scientific community.

The movement of journals to an electronic medium is likely to have effects that are difficult to envision today. Ultimately, the cost is lower and the ability to do electronic searches will be enormously valuable, but we should heed individuals like Marshall McLuhan, who pointed out long ago that often the medium *is* the message. Research available in printed form is tactile, and appears to have permanence. We have all grown to love paper, books in particular. It is a little more difficult to love an electronic version and a little more difficult to treat it as permanent. I suspect having research in that form will have advantages and subtle psychological disadvantages. I am not about to call for restricting research to paper because the economics of that are lousy. But we should not go into this major change without recognizing that it will have significant ramifications on many levels.

REMARKS: PANEL OF CHANCELLORS

James Moeser
Chancellor
University of Nebraska-Lincoln

Mike Crow's call for a niche strategy is not unlike what we have been advocating at the University of Nebraska. We are now in the second year of a major reallocation of the state-aided budget in order to redirect resources toward major academic priorities. We are committed to a strategy of building excellence upon existing strengths. However, we have come to the point where I do not believe it is possible to create exponential change only with reallocation or redirection of existing resources.

I have told our faculty, it is time for a bold new initiative. Fortunately, I believe that we should be able to draw on some new sources of revenue to create new levels of excellence without eroding our core programs. I have accepted as the responsibility of my administration to identify new streams of resources to create a new fund for investment to build excellence in the future. We will put some real money on the table.

In turn, I have asked the faculty to provide the direction in establishing our major academic priorities, suggesting that we turn the question of the University's future into a research problem and assigning this to a team of faculty researchers. This project will require a candid assessment of the status and quality of current programs, an assessment of where special opportunities might lie, an analysis of major problems affecting the world or our nation that this University is well positioned to solve, and the vision and creativity to imagine what might be possible with enhanced resources or a reconfiguration of existing resources.

To help us chart the course for the future, I have appointed a select faculty task force to be chaired by the Senior Vice Chancellor to be the research team that will help design the university of the future. We are calling this committee the Future Nebraska Task Force. It will consider these questions:

- What are our areas of greatest strength or potential for future development where significant new investment would move a program or a constellation of programs up to a new level of excellence and reputation?

- What are the great issues, the great problems affecting the world and the nation that need to be solved?

- What problems or opportunities are unique to Nebraska or the Great Plains that should shape our agenda?

- Which of those areas should we claim as ours?
- What are the unique resources of this University in attacking those problems?
- What are the imperatives of our land-grant mission that define our research agenda?

Our premise is that excellence is best built upon existing strengths or in responding to special opportunities. This strategy may lead to greater focus in selected areas. We must temper this approach with several constraints. First, we must maintain an internal balance between and among the major segments of learning and research. We cannot become a technological institute. We must balance the hard sciences with the humanities, the arts, and the social sciences. And we cannot become so focused that we abandon our comprehensive mission.

Moreover, we must attain greater focus in our research mission without distorting the balance of our multiple missions. We must remain on course with regard to the renewed emphasis on teaching and learning, on excellence in our undergraduate programs, and we must remain faithful to our land-grant mission of engagement and outreach to the people of the state and the nation.

I have been intentionally imprecise with regard to the plan of operation for this task force. Like any good research project, the methodology and procedure ought to be developed by the research team, not handed down in advance. My only requirement is that the plan must be designed to create a strategy to move Nebraska forward in research and graduate studies in the next five years.

This effort will need to be coupled with intensified strategic planning within the colleges. In every college, we need to be asking the same questions I posed above. Ultimately, it will be proposals from the colleges, or from interdisciplinary consortia that cross college lines, that will determine where the investments are made.

These new resources are made possible through a variety of sources, the most significant being private philanthropy. We have made some enormous strides in private support in the last few months. In May, we announced what was then the largest gift in the history of the University, a gift of $32.2 million from Ed and Carole McVaney of Denver, Colorado, to create the J. D. Edwards Honors Program in Computer Science and Management. This gift is not an endowment, but will build the Esther M. Kauffman Residential Learning Center that will house the students in the program, special classrooms and computer labs, and living quarters for visiting faculty and a resident faculty principal. The remainder of the gift operates this new honors program for five years, providing full scholarships for students and support for faculty. The terms of the gift are such that, if we are successful in building the program we have envisioned, the McVaneys will continue to support the program at an annual cost of approximately $4.5 million per year. It is an open-ended, rolling commitment, with an assurance to the University that support will always be in place for five years in the future.

More recently, the University of Nebraska-Lincoln received a bequest of approximately $110 Million from the estate of Donald and Mildred Topp Othmer. This estate establishes an endowment which will fund a chair in chemical engineering and allow us to realize two of the stated objectives of Campaign Nebraska–new physical facilities for chemical engineering and expansion of Love Library.

While the first impact of this endowment may be seen in brick and mortar, the long-term impact on the campus will be on academic quality. The clear intent of this gift is to augment and enhance support from the state. It must not be used to supplant or replace the state's responsibility of basic support for our core missions. Rather, it will be reserved to create or enhance excellence in academic programs. Income from the Othmer endowment will be one of the principal sources of funding for the Future Nebraska Task Force process I just described.

In addition, I believe we can leverage new contributions as a result of the Othmer gift. I have challenged our deans to create within the next five years 24 new $1 million endowed university distinguished professorships by designating a portion of the income from the Othmer Endowment to match new contributions one-to-one; for every new commitment of a half-million, we'll dedicate the other half, thus doubling the effect of every new contribution. These positions will be filled by competitive national searches subject to our own rigorous internal review processes.

Through this combination of strategies, we can lay the foundation for excellence in the 21st Century. Quite candidly, part of my strategy is to energize and excite our faculty to use their creativity to help envision the university of the future. The process of reallocating and shifting resources, while necessary, has been debilitating and demoralizing. For every winner, there are several losers. With some critical new resources, and with a continued run of good luck in the form of stable support from the state (alas, this is not a given in Nebraska), I believe it should be possible for us to engage in a process that is not about dividing up existing resources to make short-term gains, but about new investments for the future.

Without losing sight of our comprehensive mission as the primary research and land-grant university for Nebraska, I believe it should be possible for us to position the university to have research and graduate programs that are among the finest in the nation or the world, if we have the discipline to use our resources wisely, targeting them to specific areas of strength and focus. And I use the word *discipline* advisedly. Already, since announcing the formation of the task force, I have been besieged with requests that I include excellence in teaching, or in outreach and service as worthy targets for investment. And politicians have already begun suggesting that these funds might allow for reductions in tuition or tax support for the university.

We must maintain our focus *and* our discipline. I intend to hold a firm position that these investments will be in research and graduate education, and not across the board there, but in targeted areas of excellence. I believe that the future of the University hangs in the balance–either a supermarket of average and adequate programs, or an institution with comprehensive offerings at the undergraduate level and some select areas of distinction in graduate education and research.

While no two institutions will follow the same road map to their destination, I am convinced that the universities of mid-America have much in common. I believe this is the right strategy for Nebraska, and I suspect, that our sister institutions will follow a similar path. I have told our faculty that I believe the greatest days of the University of Nebraska lie ahead of it. I hope the same is true for Missouri and Kansas as well.

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1998

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