THE STATE OF RESEARCH ENDEAVORS:

VIEW FROM THE FRONTLINES

CROSS-DISCIPLINARY CONFIGURATIONS OF THE RESEARCH ENTERPRISE

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The goal of my presentation is to present a view from the front lines with a focus on the role of interdisciplinary research in today's research University. Most of what follows is based on my own experiences, but I have also drawn from some published articles on the topic of interdisciplinary research.

First let me introduce myself. I am a neuroscientist, specifically a neurophysiologist, with over 25 years of experience in the field. For the last 8 years I have been co-director (with Steve Schroeder) of the Kansas Mental Retardation and Developmental Disabilities Research Center and Director of the Smith Mental Retardation and Human Development Research Center. Interdisciplinary research is very important to our Center and something we try to foster.

Let me begin by trying to define interdisciplinary research. Interdisciplinary research means different things to different people. Webster's dictionary defines it as "involving two or more disciplines or branches of learning (integrating two disciplines as part of a single, unified effort), while "multidisciplinary" is defined as "having two or more disciplines." There is a subtle distinction that is often made between interdisciplinary and multidisciplinary which may not be apparent from those two basic definitions. Interdisciplinary implies a merging or integration of multiple traditional disciplines toward a common goal or problem. It requires communication among the disciplines. To illustrate this further, a medical center would certainly be viewed as multidisciplinary since it contains multiple disciplines but none of the efforts within the medical center would necessarily qualify as interdisciplinary unless members of the different disciplines worked together as a team on a common problem.

Enough about such subtleties. I would like to move on to consider some examples of interdisciplinary research. Of course, one of the basic premises supporting the concept of interdisciplinary research is that the individual disciplines have grown too large and too complex for any one individual to effectively master. Nowhere is this more true that in modern biomedical science. Some of the best and most successful examples of interdisciplinary research in the field of biomedical research involve teams formed by molecular biologists working with either behavioral scientists or systems (integrative) scientists.

Molecular biology and molecular genetics have taken center stage in biomedical research. One of its aims is to identify genes and their function. Identifying individual genes and their location on chromosomes is largely the territory of molecular genetics, for example, the human genome project. However, attaching function to individual genes is a much more

difficult undertaking. This requires participation of individuals who understand and know how to test function and behavior. Gene knockout models are currently an excellent approach to understanding gene function. Procedures are used to disable genes. Offspring with knockout genes can then be studied functionally and behaviorally.

An excellent recent example of the power and elegance of this approach is the recent work of an interdisciplinary team led by Susumu Tonegawa, at MIT. His team developed a mouse knockout model to analyze function of hippocampus in spatial memory. They developed a method for brain region specific/cell type specific gene deletion. Combining state-of-the-art molecular biology, electrophysiology and behavior in an interdisciplinary group of 16 investigators from 4 institutions, they showed that mice with a gene knockout disrupting NMDA receptors in hippocampal pyramidal cells have deficits in spatial learning and parallel deficits in LTP (long term potentiation) and place receptive fields. LTP is believed to be a fundamental process in learning and memory.

Another example is the use of a transgenic mouse model to study mechanisms involved in neuronal injury from HIV infection of the brain. An interdisciplinary group led by Floyd Bloom at Scripps Institute, San Diego, was able to insert the gene for a viral glycoprotein (HIV gp120) into the normal mouse genome, hence the term transgenic. Gp 120 is a HIV coat protein. Behavioral studies were able to demonstrate some classic features of HIV neuropathology in the brain and behavioral scientists showed cognitive deficits in the same mice.

Now let me turn to some examples from out own center (See Figure 1). We have recently developed a program focusing on neuro-AIDS. This is a highly interdisciplinary team brought together to study the mechanisms of brain injury from retroviral (HIV and SIV) disease. We are currently developing a non-human primate model of neuro-AIDS. To do this not only requires the efforts of molecular biologists and virologists to manipulate the viral genome but also several other fields to identify and document the functional consequences of brain infection and the extent to which the disease matches HIV disease in humans. Another successful example within our Center is a collaborative project focusing on aberrant behavior in people with mental retardation. This program benefits from a union of human behavioral scientists with neuropharmacologists.

EXAMPLES OF INTERDISCIPLINARY RESEARCH at KUMC

Molecular biologists team up with behavioral scientists and systems scientists

Kansas MRDDRC – Neuro-AIDS program

Neurovirology – Bill Narayan	Neuroimaging – Sol Batnitsky
Neuroanatomy – Nancy Berman	Neurophysiology – Paul Cheney
Neuropathology – Ravi Ragahvan	Behavioral Studies – Paul Cheney

Kansas MRDDRC – Aberrant Behavior Program

Human Behavioral Studies – Rick Saunders Neuroscience (rat model) – Rick Tessel
Human Behavioral Pharmacology – Steve Schroeder and Dean Williams

Figure 1

Another important category of interdisciplinary collaboration involves teams of clinical scientists and basic scientists. These teams are particularly important in addressing research questions related to disease. Some examples within our center are given in Figure 2. The basic scientists benefit from the clinician scientist's knowledge and experience with the disease; the clinical scientist benefits from the technical expertise of the basic scientist. These collaborations can also serve an important role in training young clinical scientists in the use of rigorous research methods. Two examples of this within our Center are given in Figure 2 in which Steve Schroeder and S.K. Dey are serving as mentors for Jessica Hellings and Jeff Riese, respectively. Finally, these teams can often compete more effectively for large program project and center grants. A recent example involving members of our Center is funding of the Pepper Center grant from NIA focusing on recovery of function following stroke.

EXAMPLES OF INTERDISCIPLINARY RESEARCH

Clinical scientists team up with basic scientists

Multiple Sclerosis:

Neuropathology and role of iron - Steve LeVine
Clinical trial with desferol (iron chelator) - Sharon Lynch

Parkinson's Disease:

Neurophysiology - Paul Cheney	Neurosurgery - Steve Wilkinson
Neurology - Edwin Miyawaki	Imaging - Mike Gordon

Mental Retardation- Aberrant Behavior:

Behavioral pharmacology-Steve Schroeder	Child Psychiatry - Jessica Hellings

Embryonic Development:

Molecular biology - S.K. Dey	Neonatology - Jeff Riese

Pepper Center Grant:

NIA, Stephanie Studenski	Center on Aging, KUMC

Figure 2

Why do interdisciplinary research? Many of the reasons are already apparent from discussions above but I have attempted to summarize them below.

- Most penetrating cutting edge questions require an interdisciplinary approach.
- Large grants (Centers and PO1s) almost always require an interdisciplinary program
- Brings national recognition and visibility to the parent institution.
- It's rewarding and more fun to work within an interdisciplinary group.
- Funding agencies (NIH, NSF) emphasize the importance of an interdisciplinary approach.

The essence of interdisciplinary research is contained within center grants and program project grants. One benefit that hasn't been mentioned so far is the prestige that Center grants bring to the Institution. For example, the Kansas Mental Retardation Research Center is one of 14 such Centers funded by NICHD. This Center puts us in very good company with such Institutions as Johns Hopkins, Harvard, the University of Washington, Vanderbilt, UCLA, etc. Interdisciplinary approaches have also been strongly emphasized by funding agencies in recent requests for applications. Often these announcements require an interdisciplinary team.

The nature of the research enterprise in clearly changing toward a model of interdisciplinary and multi-institutional collaboration and partnership. Examining authorship of papers in the journal Science is testimony to this trend. For example, a recent issue (May 30, 1997) published 14 original research articles. Of these, 11 were interdisciplinary; 10 of these were actually multi-institutional. Only three involved individuals from one department. This trend was also reflected in recent comments by pediatric cardiologist Mark Rodgers, Vice Chancellor for Health Affairs, Duke University, when he said

> "The institutions that will succeed are those that can reorganize themselves to address scientific and educational questions in an interdisciplinary manner. The institutions that will have difficulty are the ones that keep the same rigid structure that prevents pollination among disciplines." (From The Scientist, 1995.)

I would now like to turn attention to the issue of how to do interdisciplinary research. There are many different approaches to interdisciplinary research. Many interdisciplinary collaborations are informal consisting of individuals from other fields serving on grants as co-investigators or consultants to fill a particular need. Formal mechanisms consist of research centers, program project and training grants. Important elements of successful interdisciplinary collaborations are listed below. It is most important that all participants make a unique and needed contribution to the program and that all benefit in a tangible way from the collaboration. All participants must also receive appropriate recognition for their contributions. Failure to recognize the participation and contributions of others can lead to very serious problems. Contiguous research space is not essential, but an important factor in the formation and development of meaningful and effective collaborations.

- Informal mechanisms (consultants, co-investigators, etc.)
- Formal mechanisms (centers, program project grants, training grants)
- Common research theme or problem.

There are several issues related to fostering interdisciplinary research which must be considered. Of course, many collaborations are investigator initiated and need little or no fostering. Others may require some form of facilitation. This may take the form of simply pointing an individual in the direction of another person who has the expertise they are looking for or it may involve much more ambitious undertakings such as organizing and submitting major interdisciplinary grants (center, program project and training grants). Resources are a very important element in the later. Organizing a major interdisciplinary grant involving 5-50 professionals from different disciplines is very labor intensive. Such efforts need to be supported with staff to organize meetings, etc. Funds to support pilot projects can also make the difference

between success and failure. Possible scenarios for the inclusion of various categories of researchers in an interdisciplinary effort include:

- Funded versus unfunded faculty.
- Formerly productive faculty member who can no longer obtain funding.
- Productive, successful faculty member for whom their maybe opportunities for collaboration.
- New faculty member collaboration or independence?

Caveat: Match making is a tricky business in life and in science!

Steven Benowitz considers some of the obstacles to successful interdisciplinary research in a paper published in The Scientist (9, No. 13, 1995). Successful faculty may view a new collaboration, regardless of how interesting or how rational it might be, as competing for time with their existing projects, and to that extent, compromising their current source of income. Another major issue is that although research centers target interdisciplinary research and are best prepared to foster its growth, most resources go to traditional departments. Resources consist of faculty positions and discretionary funds for research. If Centers are to survive and grow, this model needs to change. Centers need to have direct control over some positions and be provided with financial resources to have some impact on fostering research within the university environment. Institutions that do this will find that their Centers will flourish and compete successfully for major grants; institutions that ignore this will find that their interdisciplinary research programs and Centers will eventually fail.

Another major issue concerns publishing and tenure. The gold standard of accomplishment for a junior faculty member going for promotion and tenure is obtaining a federally funded grant as a principal investigator and getting the grant renewed. One problem is the amount of time available for this. The standard six year model is too rigid and offers too little time to effectively evaluate young faculty, especially those participating in an interdisciplinary research environment. Also, interdisciplinary research often involves participating in a program project grant with a senior investigator as the P.I. Such grants are often discounted in terms of importance by Promotion and Tenure Committees. This culture must change. Ultimately, egos and paranoia represent one of the most serious threats to long term, successful collaborations. All participants in a collaboration must feel that they are being treated fairly and given credit for their accomplishments. Other obstacles to interdisciplinary research include:

- Income issues: time spent developing collaboration may be viewed as non-productive.
- Distance barriers: different buildings, campuses, institutions.
- Overly competitive atmosphere inhibits sharing.

We believe that Centers are ideal models for interdisciplinary research. Several examples could be drawn upon to illustrate this belief, such as the KU Reproductive Biology Research Center or KU's Claude D. Pepper Older Americans Independence Center; I will focus on one, the Kansas Mental Retardation and Developmental Disabilities Research Center.

The basic model of a Center is one in which core technical services support the scientific, training and administrative activities of the Center. The scientific core support facilities are targeted to the mission of the Center and types of research that are conducted. These services are essential to the success of the Center. They provide technical expertise and training to a broad range of scientists in areas that help move research projects to the cutting edge. They also provide an ideal environment for young scientists, especially clinical scientists, because they offer a support system that is so important to the development of a successful scientific career in today's environment.

With this in mind, I would like to offer a formula or blueprint for a modern biomedical research center. Focus on a disease, condition or process provides a self evident mission and a mental anchor for lay people that is important in achieving an identity within the community. This can also prove to be very important in fund raising efforts. The center should contain a mix of basic and clinical scientists. Each brings important tools and expertise to the table and the most effective collaborations will certainly involve both. Dedicated space, while not essential, is a major factor in establishing the identity of the Center and provides a resource for the recruitment and retention of talented scientists. Partial funding of the Center's infrastructure is very important to the long term health and success of the Center. Federally funded center grants, in many cases, have not increased in the last 10 years in real or inflation adjusted dollars, and can no longer be expected to provide all the resources that are needed to run the center. Support for some of these services should be derived from other sources. Discretionary funds to support a range of center related research activities (pilot projects, interim support, equipment purchases, etc.) are also vital to the success of a center. There should be a shared commitment with departments for faculty positions.

Strengths of the research center model of interdisciplinary research are:

- Much more attractive for fund raising purposes.
- Center is designed to reach out to faculty in different disciplines.
- Brings people together who share a common interest in a particular problem.
- Provides a broader research experience for students.
- Overall, centers provide an ideal environment for research.

Most of these issues have been addressed, except fund raising. Compared to traditional departments, research centers can be very effective tools for fund raising.

Finally, let me conclude by drawing some conclusions from all this. First, I hope we can agree that there is continued and increasing emphasis on interdisciplinary research and that research centers provide an ideal environment for fostering interdisciplinary research. With this in mind, institutions should take a close look at their programs and ask if there is an area that would be enhanced by a more formal center/institute designation. It is also important to consider whether existing centers are meeting the goals for which they were established. There should be some periodic review of centers. Centers that are no longer productive or are no longer in step with current needs should be discontinued and the resources directed to more promising efforts. Centers should not continue to exist unless they are fulfilling their mission. At the same time, it is important to consider whether existing centers are being adequately supported. Without

adequate support as described above, it is difficult to expect a center to compete at the national level. A very important issue concerns faculty lines. Faculty are the most important resource a university has and if centers are viewed as important, faculty lines should be shared between centers and traditional departments. This will provide centers with some control over the direction of recruitments which is vital to the future the center. Recruitments should be targeted to build and strengthen interdisciplinary research groups that will support centers and be competitive for program project grants. Targeted recruitments can be designed to not only meet the needs of a traditional department but to also strengthen an interdisciplinary research group or center. Finally, research centers should represent a very attractive focus for fund raising. With limited potential for additional state funds and with most existing state funds going to departments, alternative sources of funds need to be pursued aggressively to support the needs of centers.