

ASEE Engineering Research Council Summit

Mentoring Young Faculty for Success: Rewarding and Encouraging Involvement in Cross-Disciplinary Research

Lynn Preston

Leader of the Engineering Research Centers Program

Directorate for Engineering

National Science Foundation

lpreston@nsf.gov

Fostering Cross-Disciplinary Research

- Personal reflections based on my career at NSF
 - Research Applied to National Needs, et al (70s)
 - Office of Interdisciplinary Research, early 80s
 - Fostering the field of bioengineering, early 80s
 - Developing cross-disciplinary research/education cultures in partnership with industry through Engineering Research Centers
- Personal reflections of ERC Directors who are:
 - Engaging young faculty in cross-disciplinary research
 - Fostering recognition and reward for their contributions

NSF Current View of the Value of Interdisciplinary Research

- **NSF places a high value** on interdisciplinary and multidisciplinary approaches because it believes **many interesting problems transcend traditional science and engineering disciplines**, although those disciplines are essential components of any research program.
- It is clear that the **most pressing problems of our world today require an interdisciplinary response**. Traditional lines between the disciplines are starting to blur as as engineers and scientists work together to build on our joint expertise and create new solutions.
- Some of the **most interesting challenges arise at the intersection of the disciplines—and lead to some of the most astounding technical advances as well**. The application of micro-electronics to health care and of information technology to molecular biology are two areas of intersection that are already having a profound affect on our lives.

Definitions of Terms

Multidisciplinary Research:

- Involves different disciplines that are not necessarily integrated

Cross-Disciplinary Research:

- The integration of the capabilities of different disciplines to address a major challenge in research or technology

Interdisciplinary Research:

- Long-term cross-disciplinary collaboration blurs the lines between the disciplines often leading to new fields such as bioengineering, photonics, MEMS

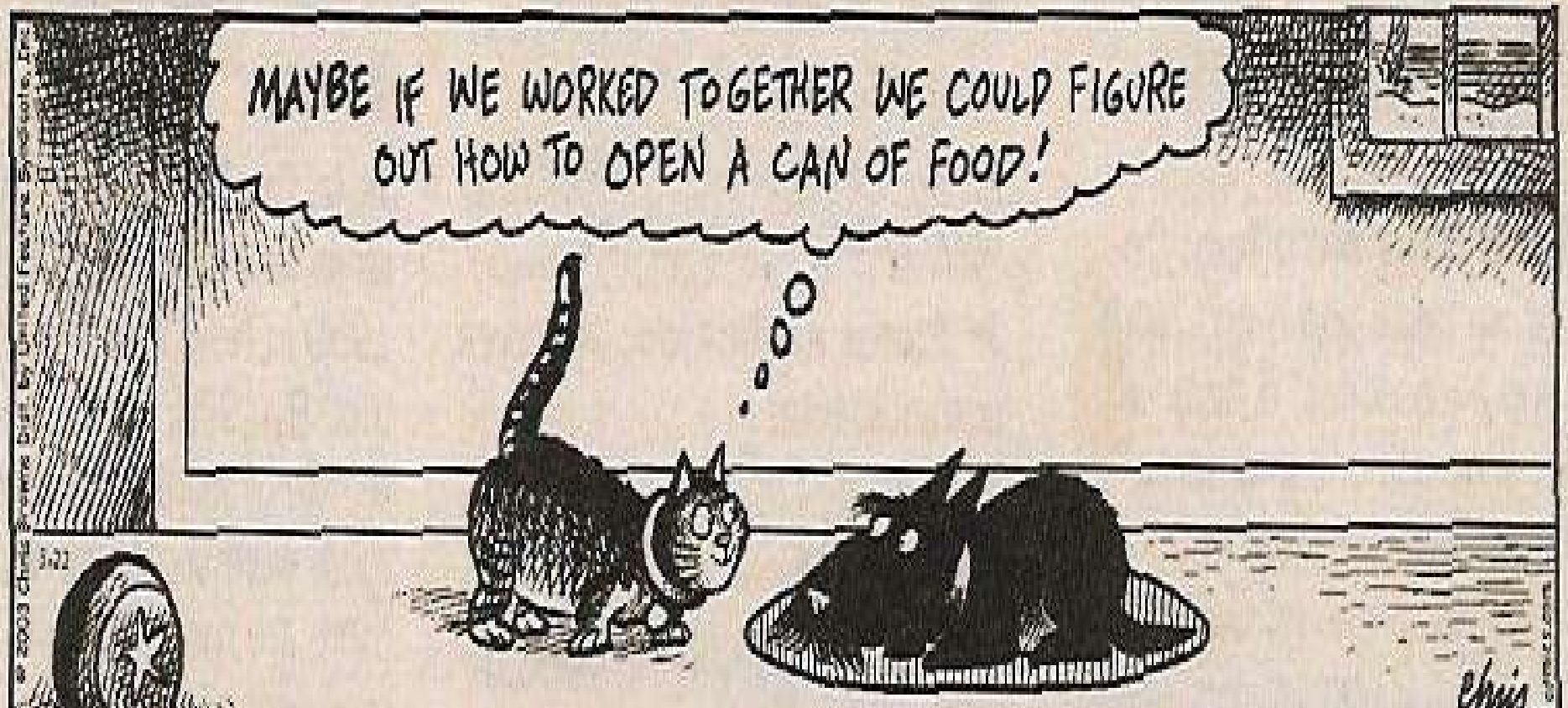
The Continuum from Cross-Disciplinary Research to New Interdisciplinary Fields

- **Cross-disciplinary research requires time in focused collaboration** to integrate methodologies, vocabularies, and analytical approaches of different disciplines
- **Leads to new ways of addressing and solving problems, new discoveries and advances in technology**
- Long-term collaborations often **lead to new conceptualizations** of what the source fields are and a change in the way problems are defined and addressed
- **Over time** the theoretical framework used to formulate research questions shifts in fundamental ways to **yield a new interdisciplinary field**
 - Biochemistry, neuroscience, bioengineering have emerged from these collaborations and become their own interdisciplinary mainstream fields

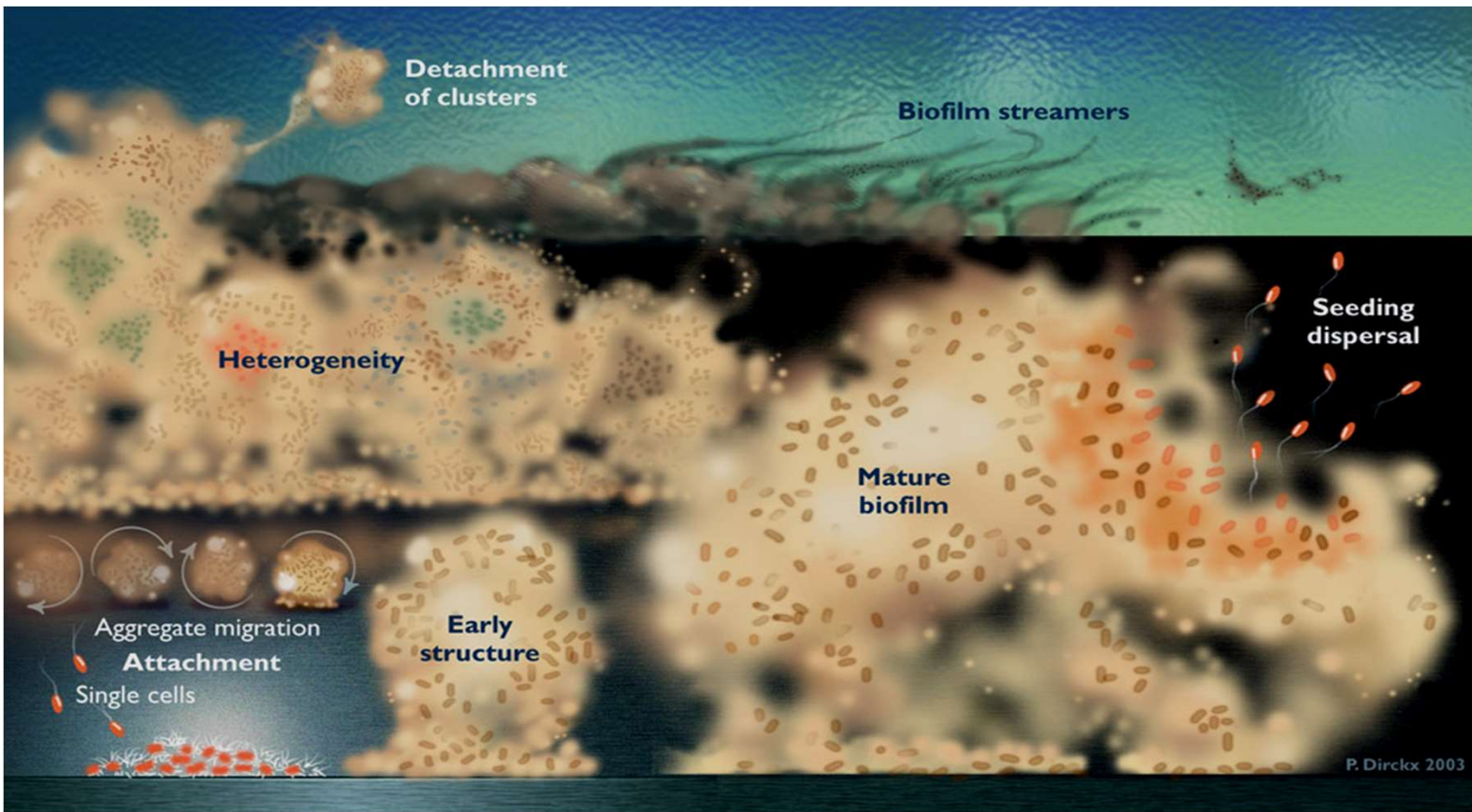
The Benefits of Cross-Disciplinary Collaboration

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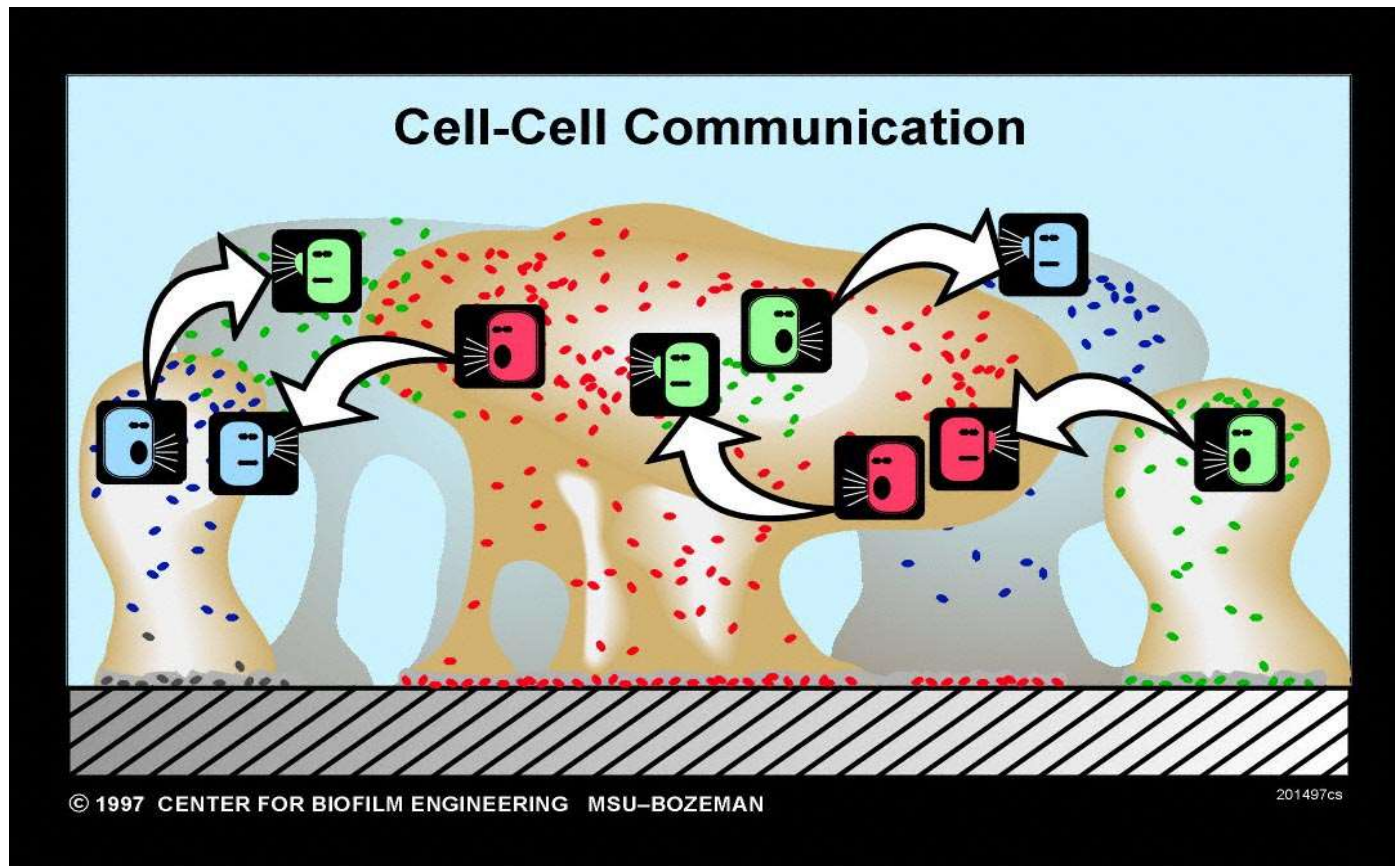
By Chris Browne



Montana St. Biofilm ERC Collaboration between Biologists and Chemical Engineers Yields New Discoveries



Cell-Cell Communication, Major Breakthrough in Understanding Biofilms



Cross-Disciplinary Challenges and Successes in ERCs

MIT Biotechnology Processing Engineering Center (Classes of 85 & 94)

Goal: Integrate biologists, biochemical engineers, and chemists to tackle bottlenecks in large-scale production of therapeutic proteins, and in the production and delivery of gene therapies

Achievements:

- ❑ BPEC research **transformed mammalian cell processing** to enable industrial production of new biotechnology drugs such as interferons for treating hepatitis and the protease inhibitors for treating AIDS
- ❑ The integration of biologists and engineers in BPEC led to a major **reform in engineering and biology education at MIT**, a new discipline of biological engineering, and a new division focusing on integrating disciplinary departments to advance bioengineering and biology

Cross-Disciplinary Challenges and Successes in ERCs

U. Of Michigan ERC for Wireless Integrated Microsystems (WIMS)

(Class of 2000)

Goal: Integrate electrical, biomedical, environmental engineers, and material processing engineers with chemists and MDs to advance WIMS for cochlear implants and environmental sensing systems

Achievements:

- Advancing a fully implantable, wireless **cochlear implant** with a high-density 128 site, 16 channel array, current technology has 28 sites limiting the range of hearing and external batteries.
- Advancing a **wireless environmental monitoring sensing system** using a 1-2cc micro gas chromatograph to detect hazardous gases and vapors with sub-part-per-billion sensitivity.

Cross-Disciplinary Challenges and Successes in ERCs

Clemson ERC for Advanced Fibers and Films (Class of 1998)

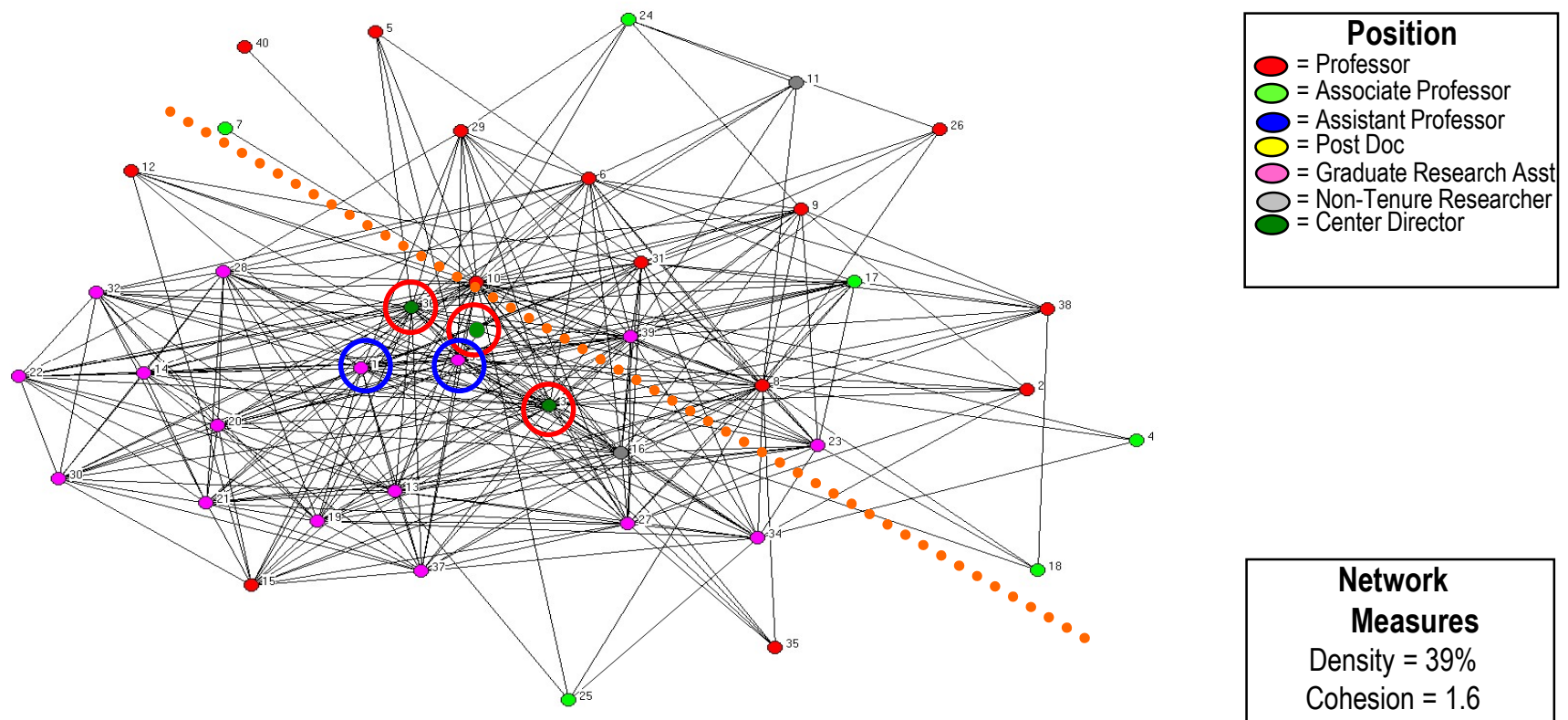
Goal: Integrate chemical, computational, mechanical, and computer visualization scientists to understand fiber and film processing at the molecular level; develop, simulate and visualize advanced processing technology to optimize manufacturing of fibers and films

Achievements:

- Internet-accessible integrated polymer process simulation modeling package providing a virtual laboratory for processing, permitting a wide-array of designs to be tested reducing the need for costly trial-and-error experiments

Network “Hubs” and Core Researchers

As is typical of all centers, Center 4 demonstrates how the network “hub” positions are occupied by “star” researchers but the central “core” is dominated by graduate students



Shows all CLOSE and COLLEGIAL connections by POSITION based on responses to the following survey item:

*“Please indicate the strength of your relationship with other center affiliates.”
(Diana Rhoten, Social Science Research Council)*

What are the Barriers that Confront Young Faculty Involved in Cross-Disciplinary Research?

- **Deep-seated cultural assumption** that research is better when faculty work alone, specialize and dig deeper and narrower to understand phenomena
- **Tenure committees are too often narrowly defined**, reflecting the subfields of a disciplinary department not the scope of the candidate's work
- **Lack of clear mechanisms to assess cross-disciplinary research performance**
- **Cross-disciplinary team work and publications are often not recognized** or discounted in value in tenure decisions
- Departments **credit young faculty for awards made in their names only**, leaving out projects funded by centers
- **Lack of mentoring and incentives for young faculty** who want to pursue cross-disciplinary research

Establish a Culture that Values Cross-Disciplinary Research (Deans and Department Chairs)

- **Reward risk taking and work at the interface of disciplines**
- **Promote an interdisciplinary research culture and give credit for team contributions**
- **Set up cross-disciplinary search teams** for candidates who can function at the interface of disciplines; **establish cross-department appointments** to assure cross-disciplinary activity
- **Require cross-disciplinary input** in tenure and promotion decisions and **train senior faculty** on how to assess cross-disciplinary input
- **Form centers and cross-department teams to foster collaboration**, be sure **center/cluster leaders are on tenure/promotion committees**
- **Create prestigious, competitive internal small “seed” grants** for young faculty to initiate cross-disciplinary research projects
- **Give equal weight** to cross-disciplinary and single discipline activities in tenure guidelines
- **Require a section on “Cross-Disciplinary Activities” on all annual faculty evaluation forms**

Mentoring Young Faculty in Centers and Groups

- **“Pull/Push” young faculty into centers** so they can benefit from the critical mass and “grow up” in an cross-disciplinary culture
- **Assign senior faculty experienced in cross-disciplinary research to mentor young faculty**
- **Give young faculty leadership roles at the project level** in a center so they lead, mentor students, and publish, with senior faculty in supporting roles
- Be sure young faculty have **multiple sources of support**
- Be sure they **publish** in journals respected by their home departments as well as those in the other fields they are working in

Recognition of Cross-Disciplinary Research for Tenure and Promotion

- Provide **project-level name recognition** for support from a center through subawards
- **Recognize that center funds are competitive** as they depend upon individual performance within the team, judged by the Center Director and the sponsor
- **Change the metric from the number of awards** for which the candidate is PI to the total number of students funded by external funds and the level of expenditure per person
- Require that **cross-disciplinary publications** include a **brief statement of the contributions of each listed author**

Tenure Committees for Candidates Involved in Cross-disciplinary Research

- Join faculty from the candidate's home department, with faculty representing the disciplinary breadth of the research and cluster leaders/center directors to provide input to the department(s) or
- Establish a two-phase process: Formal cross-disciplinary review feeding into departmental committee, can't be ignored by department
- Set up a 'mock tenure' process in year 3 of a 6-year process:
 - Determine concrete criteria for success;
 - Identify faculty within and outside the university who can provide; cross-disciplinary input;
 - Discuss process, criteria, and interim progress with candidate

What Can NSF Do?

- Continue to provide support for interdisciplinary research grants and centers
- Improve the review process for small grants for interdisciplinary research, many still fall through the cracks between programs
- Be sure post-award site visit review committees recognize by name young faculty who carry out outstanding cross-disciplinary research in centers to aid them in the tenure process
- Require that administrators have tenure policies that foster and reward cross-disciplinary research

Graduate Students and Young Faculty Point the Way to the Future

- Graduate students are increasingly exposed to cross-disciplinary research in their graduate studies and they look forward to continuing this work as faculty
- Not only are graduate students working at the interface of disciplines but they are also eagerly working at the interface of research and education

Focusing on the Wrong end of the Problem

It's the senior faculty that need the mentoring to understand how to value and reward cross-disciplinary research

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