EFRI Office Fall 2009 Update

Sohi Rastegar

Director, Office of Emerging Frontiers in Research and Innovation

NSF/ENG Advisory Committee Meeting

October 21-22, 2009

OUTLINE

- EFRI Description and Active Topics
- Early results
- FY 2009 Awards
- FY 2010 Solicitation
- FY 2011 Status (Community Input)
- Discussion Questions

EFRI - "One Slide Description"

✪ ***TRANSFORMATIVE*** ✪ ***NATIONAL NEED/GRAND CHALLENGE*** ✪ ***INTERDISCIPLINARY***

- Established on October 1, 2006, EFRI supports higher risk, transformative opportunities leading to:
  - new research areas for NSF, ENG, and other agencies
  - new industries/capabilities resulting in a leadership position
  - significant progress on advancing a "grand challenge"
- Successful topics would likely require:
  - small- to medium-sized interdisciplinary teams
  - the necessary time to demonstrate substantial progress and evidence for follow-on funding through other established mechanisms
- The current investment for EFRI totals $25 million for 4-year awards at $500k per year.

Post-EFRI Support
Possible Routes

- Possible routes
  - Centers Programs (ERC, STC, other)
  - New Program in a Division
  - Change/Restructure an existing Program
  - New Program at interface of Divisions
  - IDR opportunity

    http://nsf.gov/eng/general/IDR/index.jsp
  - Other Agencies

EFRI Active Topics and Personnel

FY 2007

Auto-Reconfigurable Engineered Systems (ARES)

Kishan Baheti, ECCS
Maria Burka, CBET
Bruce Hamilton, CBET
Glen Larsen, IIP
Abhi Deshmukh*,CMMI
Scott Midkiff*, ECCS
Stephen Nash*, CMMI
Mario Rotea*, CMMI

Systems that Modify Themselves

Cellular and Biomolecular Engineering (CBE)

Robert Wellek, CBET
Lynn Preston, EEC
Fred Heineken*, CBET
Jimmy Hsia*, CMMI
Lenore Clesceri*, CBET

How Cells Work: Uniting Engineering & Biology

FY 2008

Cognitive Optimization (COPN)

Paul Werbos, ECCS
Semahat Demir, CBET
Eduardo Misawa, CMMI
Stephen Nash*, CMMI
Lynn Preston, EEC
Kenneth Whang, CISE
Scott Midkiff*, ECCS
Fred Heineken*, CBET

Learning From The Brain

Resilient and Sustainable Infrastructures (RESIN)

Joy Pauschke, CMMI
Bruce Hamilton, CBET
William Schultz, CBET
Richard Fragaszy, CMMI
Barbara Kenny, EEC
Matthew Realff*, CMMI
Dennis Wenger, CMMI
Dagmar Niebur*, ECCS

Building Resilient & Sustainable Interdependent Infrastructures

FY 2009

Biosensing & Bioactuation (BSBA)

S. Chi Liu , CMMI
Y. Gianchandani, ECCS

Building On Nature

Hydrocarbon from Biomass (HyBi)

George Antos, CBET
J. Regalbuto*, CBET
D. Niebur*, ECCS

EFRI PDs: http://nsf.gov/staff/staff_list.jsp?org=EFRI&from_org=EFRI

■ Team Coordinators

* Former PD / IPA

WHAT DO YOU THINK?

NAE GRAND CHALLENGES

Make solar energy economical

RESTOR

Provide energy from fusion

Develop carbon sequestration methods

ARES

Manage the nitrogen cycle

Provide access to clean water

SEED

Restore and improve urban infrastructure

RESIN

CBE

Advance health informatics

Engineer better medicines

Reverse-engineer the brain

COPN

BSBA

Prevent terror

Secure cyberspace

Enhance virtual reality

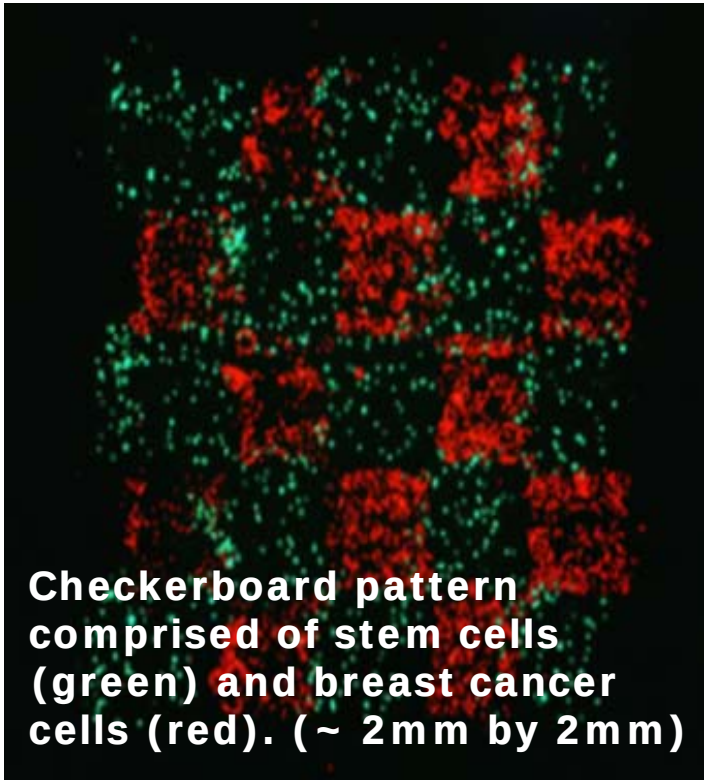
Advance personalized learning

Engineer the tools of scientific discovery

HyBi

Early Result
(CBE Topic)
An EFRI Technology

- Drop-on-Demand Rapid Prototyping
- Multiple Cell-types
- Allow in-vitro biologically relevant systems
- Cancer biologists can test relevant hypotheses

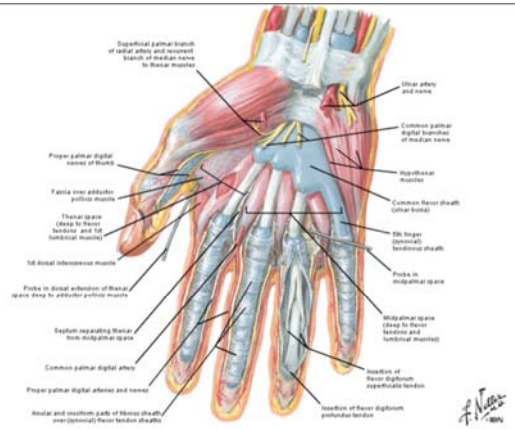


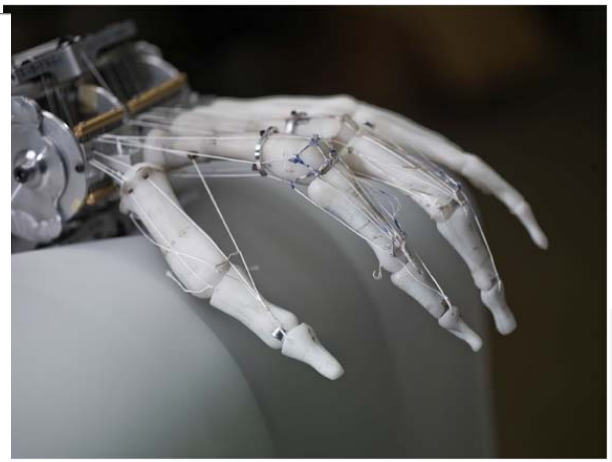
Checkerboard pattern comprised of stem cells (green) and breast cancer cells (red). (~ 2mm by 2mm)

Led by Karen J. Burg (Clemson University), with Didier Dreau (University of North Carolina-Charlotte), M. Ross Leadbetter (University of North Carolina-Chapel Hill), and Jason D. McNeill (Clemson University), entitled, Emerging Frontiers in 3-D Breast Cancer Tissue Test Systems" (0736007).

COPN | *Emerging Frontiers in Research and Innovation*
Fiscal Year 2008 Awards

Determining how the brain controls the hand





Biological vs. Robotic systems

Their differences are incidental to their evolution, and to the availability of materials, sensors, actuators, and information processing capabilities.

Machines and organisms are part of a continuum of solutions to the problem of interacting with the physical world.

Led by Francisco Valero-Cuevas of the University of Southern California, in collaboration with Chang Liu of Northwestern University, Yoky Matsuoka of the University of Washington, and Emanuel Todorov of the University of California, San Diego (0836042)

EFRI Grantee Meeting

- Latest Research Overviews at Grantee meetings website.
- Latest meeting held on March 5-6, 2009

http://www.abecker.com/nsf/efri/grantees09

- Next meeting is planned for March 18-19, 2010.

FY 2009 AWARDS

FY 2009 Awards

- Solicitation released in September 2008.
- **261 pre-proposals** were submitted on December 2nd, 2008.
- **81 were invited and 80 Submitted** full proposals by April 30, 2009
- **20 Awards made: 12 BSBA; 8 HyBi**
- **7 Awards were made possible by ARRA (Stimulus) Funds.**

FY 2009

Biosensing and Bioactuation (BSBA)

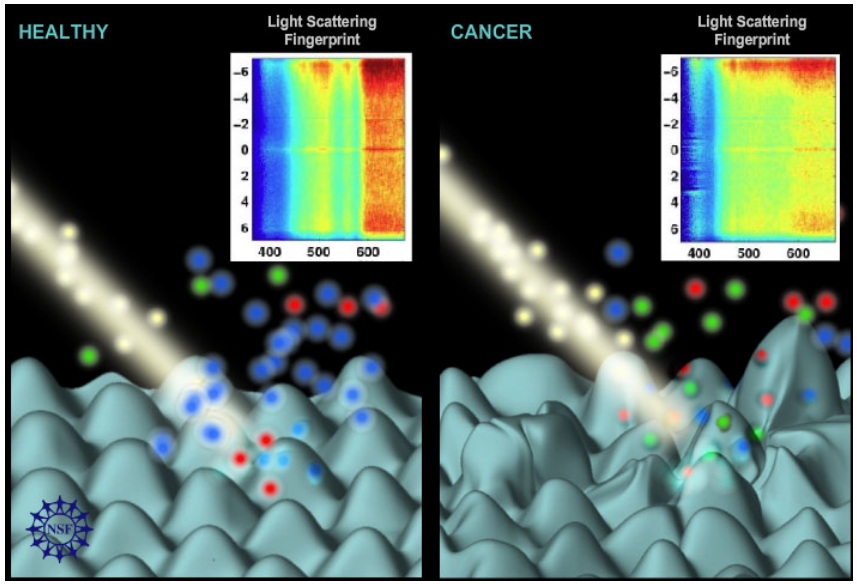
Key Idea: creating revolutionary capabilities in sensing and response for health, infrastructure, and the environment

1. Shedding light on cancer's origins
2. Creating intelligent eyes
3. Reading and writing brain information
4. A functional contact lens
5. Sensing immune cells
6. Creating an image with chemicals
7. Touch-sensitive artificial skin
8. Controlling fluids, insect-style
9. Fabricating fibers as powerful as butterfly proboscises
10. Designing artificial DNA
11. Patterning smarter materials after fish
12. Plant-inspired adaptive structures

http://www.nsf.gov/eng/efri/fy09awards_BSBA.jsp

Shedding light on cancer's origins

- The researchers aim to develop a technique using light (Partial Wave Scattering, PWS) to sense the complexity of cellular architecture at the nanoscale.
- They will use it to understand changes in cell structures due to cancer and their role in cancer progression.
- A non-invasive technique that works on accessible tissues could enable the ambitious goal of population-wide screening for a wide range of major cancers.

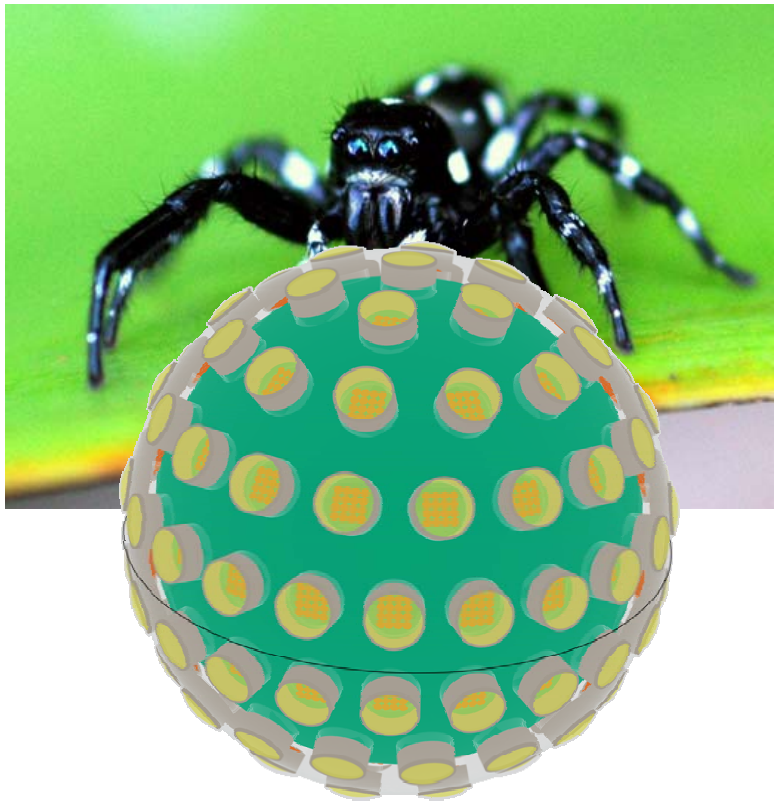


Credit: Nicolle Rager Fuller, NSF

Led by Vadim Backman, in collaboration with colleagues Hemant K. Roy and Igal Szleifer, all from Northwestern University (0937987).

Creating intelligent eyes

- Inspired by six types of natural eyes, they seek to incorporate elements of natural visual systems into integrated, intelligent, micro imaging systems without anatomic and physiological constraints.
- The new system may surpass natural and engineered systems, both in terms of imaging performance and brain-like intelligent control.
- Discoveries could impact endoscopy tools, optics and electronics, cameras, and artificial vision.



Credit, T to B: Godfrey R. Bourne; Hongrui Jiang and Xuefeng Zeng, Univ. of Wisconsin - Madison

Led by Hongrui Jiang of the University of Wisconsin, Madison. He will collaborate with Li Zhang and James Ver Hoeve, also at Wisconsin; Christopher Murphy of the University of California, Davis; and John Rogers of the University of Illinois at Urbana–Champaign (0937847).

FY 2009

Hydrocarbons from Biomass (HyBi)

'GREEN GASOLINE'

***Key Idea*:** obtaining hydrocarbons from non-food plants and microorganisms for renewable energy and chemicals

1. Getting the most from biomass
2. Breaking down lignin
3. Quick conversion of biomass
4. Fungal fermentation of cellulose for fuels
5. Optimizing fuel production, from algae to biorefinery
6. Algae processing made easy
7. Unlocking the power of biocatalysts
8. Cooking up hydrocarbons in a unique "pot"

http://www.nsf.gov/eng/efri/fy09awards_HyBi.jsp

Quick conversion of biomass

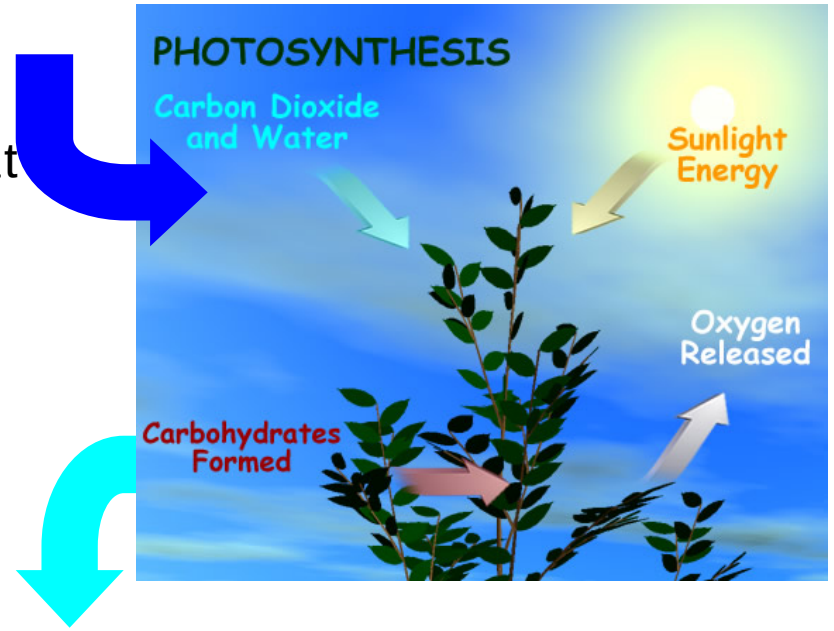
- Their objective is to develop catalysts and reactor designs for converting solid biomass directly into gasoline-range hydrocarbons while generating electricity.
- Understanding the underlying physical and chemical phenomena involved in catalytic fast pyrolysis (CFP) will help develop models to guide reactor design, scale-up, and optimization.
- The team will also integrate CFP into a power cycle, so that excess heat from the process can produce electricity.

Credit: Ben Barnhart

Led by George Huber, with collaboration from researchers Scott Auerbach, Stephen de Bruyn Kops, Triantafillos J. Mountziaris, and W. Curt Conner, all from the University of Massachusetts-Amherst (0937895).

Unlocking the power of biocatalysts

- Some plants, insects, and algae produce simple hydrocarbons from CO2 and solar energy, an ability that comes from enzymes acting as biocatalysts.
- The researchers will explore the genes and mechanisms behind such biocatalysts and how to integrate them into a host organism.
- Optimizing an organism with the ability to generate hydrocarbons and controlling its production could offer a new source of renewable biofuels.



Credit: Jacqueline V. Shanks

Led by Jacqueline V. Shanks of Iowa State University, in collaboration with Basil J. Nikolau, and Tom Bobik of Iowa State, Govind S. Nadathur of the University of Puerto Rico–Mayagüez, and Gordon Wolfe of California State University (0938157).

FY 2010 Solicitation

EFRI Topics Selected for FY 2010

1. **Renewable Energy Storage (RESTOR)**

2. **Science in Energy and Environmental Design (SEED): Engineering Sustainable Buildings**

CROSS-NSF AND INTERAGENCY COORDINATION-
NSF(ENG, MPS, CISE, SBE), DOE, EPA

RENEWABLE ENERGY STORAGE (RESTOR)

[Expected Example Transformative Benefits]

- Fundamental breakthroughs to overcome a key barrier (i.e., large-scale utilization) to broad utilization of renewable energy sources such as solar and wind

- New computational tools and intelligent systems to open up new paths for designing novel multifunctional materials with the desired physical and chemical properties

- Design of new nanostructures and metamaterials that enable high energy storage in compact form and can withstand extreme environmental conditions

Science in Energy and Environmental Design (SEED): Engineering Sustainable Buildings

[Expected Example Transformative Benefits]

- **To transform our engineering research to move the building industry towards a science-based energy and environmental design for engineering sustainable buildings.**

- **To transform the materials, devices and control systems used to produce, store and distribute alternative energy in buildings.**

- **To transform building systems design and management software to solve complex interacting-system problems with interoperable, integrated, and user-friendly computational tools.**

Important Dates
EFRI 2010 (NSF 09-606)

http://www.nsf.gov/pubs/2009/nsf09606/nsf09606.htm

- **Sep 17, 2009** Information Webcast
- **Oct 9, 2009** Letters of Intent Due (required)
  385 RECEIVED
  (265 SEED, 120 RESTOR)
- **Nov 13, 2009** Preliminary Proposals Deadline
- **March 31, 2010** Full Proposals Deadline
  (by invitation only)

FY 2010: Additional Exploratory Investment

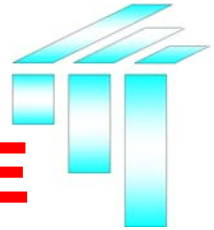
Building Engineered Complex Systems

NSF 09-610

- **To Develop a theoretical basis of engineered complex systems (where the emergent behaviors or structures are not evident from considering only the system's separate components)**.
- EFRI, CBET, CMMI, ECCS, and MPS/DMS and OMA
- $4M Total ($2M from EFRI)
- Deadline: January 19, 2010
- "seed funding" for small teams of innovative engineers and mathematical scientists.
- 2-year; $200K-$300K

FY 2011 Topic Selection

EFRI TOPIC SELECTION TIMELINE

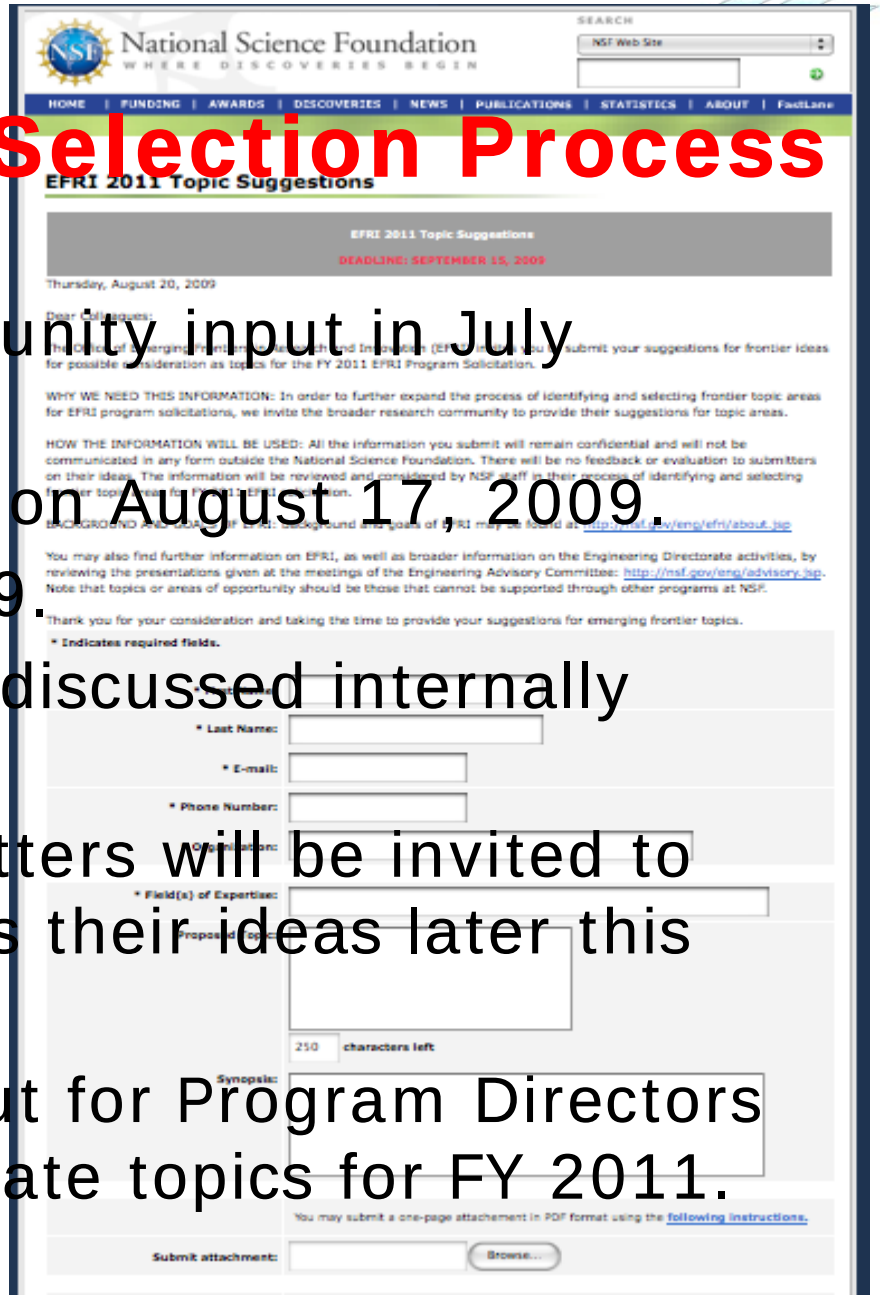


- Continuous Community Input (Publications, Conferences, AdCom, COVs, Panels, Workshops, …)
- Explicit Community Input through Website (Dear Colleague Letter; September Deadline)
- Fall Advisory Committee (October) **This meeting**
- Program Directors' Retreat (Jan):
  - **TOPICS ARE DISCUSSED AND CRITIQUED**
- ENG Leadership Retreat (March)
  - **TOPICS ARE FINALIZED**
- Spring Advisory Committee (April)
  - **TOPICS ARE ANNOUNCED**

Program Directors are the Kernel of Integration and Leaders for EFRI Topics

FY 2011 EFRI Topic Selection Process

- Issued DCL seeking community input in July 2009.
- Held Information Webcast on August 17, 2009.
- Deadline was Sep 15, 2009.
- 90 Submissions are being discussed internally with Program Directors.
- Selected (up to 10) submitters will be invited to NSF to present and discuss their ideas later this Fall.
- These will serve as an input for Program Directors in formulating their candidate topics for FY 2011.



Questions For Discussion

- **WHAT IS THE ROLE OF NAE GRAND CHALLENGES?**
- **Areas of emerging opportunity?**
- **REPEAT TOPIC?** - Should we allow previous EFRI topics re-compete in the following year or a subsequent one?