Where are the Emerging Frontiers of Research and Innovation?

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Directorate for Engineering

National Science Foundation

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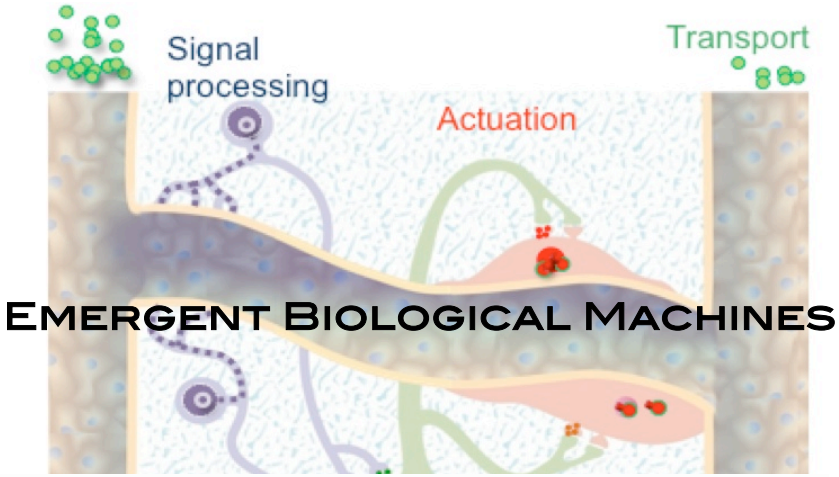
DuPont, Wilmington, Delaware
19 September 2013

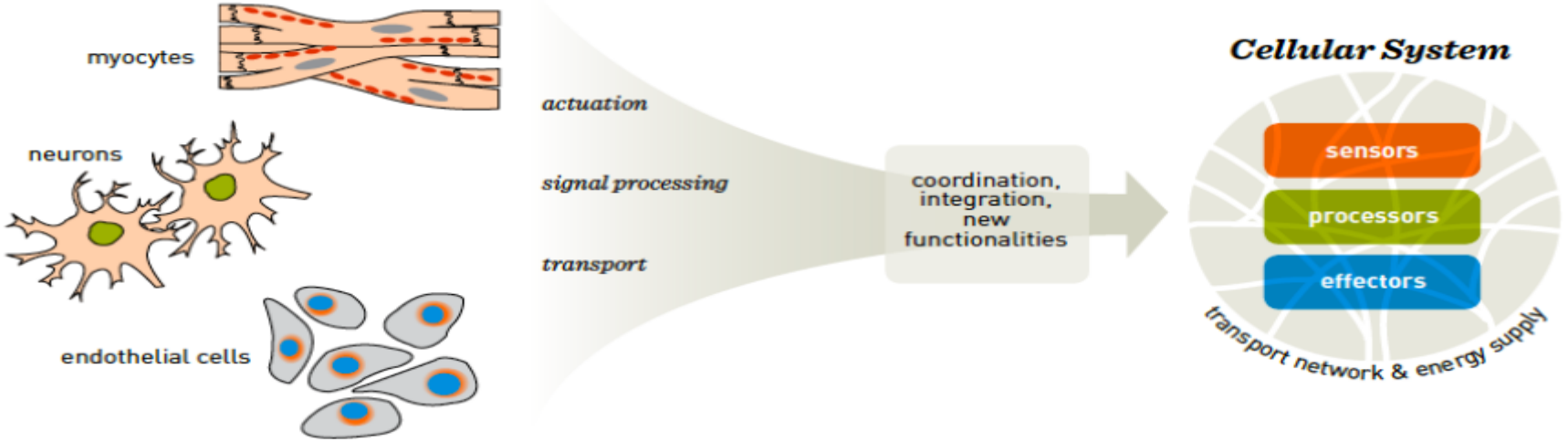
www.nsf.gov/eng/efri

STC on Emergent Behavior of Integrated Cellular Systems

- **Roger Kamm (MIT)**
- **CoPIs: Bob Nerem (Ga Tech), Jimmy Hsia (UIUC)**
- Major ‘high-risk, high-payoff’ investment by NSF



To understand the complexities of integrated cellular systems so that we can ultimately develop unified functional machines



EFRI- *In One Slide*

- **MANDATE** - Serve a critical role in helping the Directorate for Engineering focus on important emerging areas in a timely manner.
  - **COMMUNITY DRIVEN** - Engages the research community (through DCL) and ENG/NSF PDs to identify and fund a portfolio of projects in strategic emerging interdisciplinary areas that may not be supported with current NSF programs and in which ENG researchers play the leading role.
  - **PTR AND IDR** - Uses PTR (Potentially Transformative / High risk, High reward) and IDR (interdisciplinary) as criteria for project selection
  - **MIDSCALE BUDGET** - It is the main Midscale funding mechanism in ENG ($2M / 4-year projects)

- **EFRI TOPICS**:

FY 2007	Auto-Reconfigurable Engineered Systems (**ARES**)
	Cellular and Biomolecular Engineering (**CBE**)
FY 2008	Cognitive Optimization (**COPN**)
	Resilient and Sustainable Infrastructures (**RESIN**)
FY 2009	Biosensing and Bioactuation (**BSBA**)
	Hydrocarbon from Biomass (**HyBi**)
FY 2010	Science in Energy and Environmental Design (**SEED**)
	Renewable Energy Storage (**RESTOR**)
FY 2011	Engineering Multicellular and Interkingdom Signaling (**MIKS**);
	Mind, Machines, and Motor Control (**M3C**)
FY '12,'13	Flexible Bioelectronics Systems (**BioFlex**), Origami Design for the
	Integration Of Self-assembling Systems For Engineering Innovation (**ODISSEI**);
	Photosynthesis Biorefineries (**PSBR**)
FY'14	2-Dimensional Atomic-Layer Research and Engineering (**2-DARE**)

$32M
FY 14 Request

- **TOPIC LEADERS** - Program Directors from ENG Divisions in collaboration with PDs from other NSF Directorates and other Federal agencies when appropriate
  http://nsf.gov/staff/staff_list.jsp?org=EFRI&from_org=EFRI]

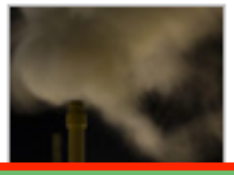
- **CONTACT** - Sohi Rastegar, srastega@nsf.gov, (703) 292-8305.
  http://nsf.gov/eng/efri and http://efri.org

NAE GRAND CHALLENGES

WHAT DO YOU THINK?

Make solar energy economical

Provide energy from fusion



Develop carbon sequestration methods

Manage the nitrogen cycle

Provide access to clean water

Restore and improve urban infrastructure

Advance he informatics

Engineer better medicines

Reverse-engineer the brain

terror

Secure cyberspace

Enhance virtual reality

Advance personalized learning

Engineer the tools of scientific discovery

RESTOR

SEED

ARES

CBE

RESIN

BioFlex

BSBA

M3C

COPN

2-DARE

HyBi

MIKS

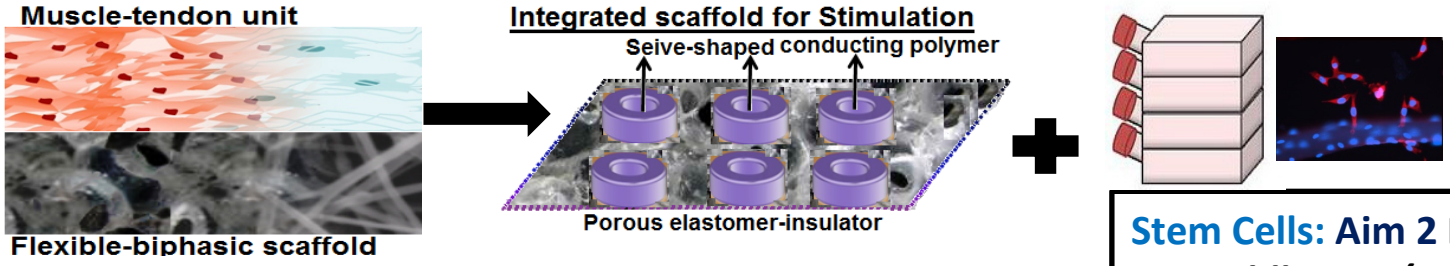
ODISSEI

PSBR

PI: Laurencin, Cato, M.D., Ph.D., Proposal # 1332329

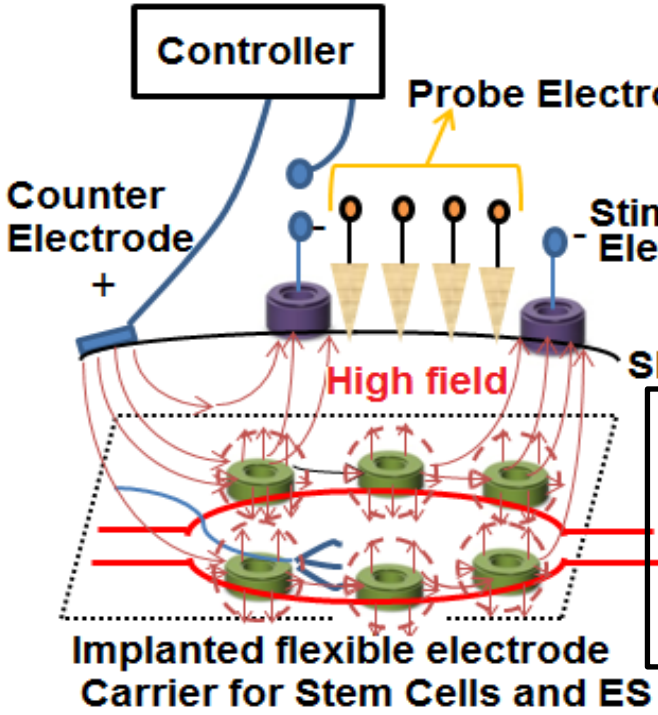
EFRI-BioFlex Full Proposal: "Electrically Stimulated Complex Tissue Regeneration"

Flexible Bioelectronics: Aim-1 and 3 Dr. Kumbar/Dr. Laurencin/Dr. Swami/Dr. Faghri/Dr. Khan



Stem Cells: Aim 2 Dr. Lo/ Dr. *Goldhamer/Dr. Carlson*

Animal Studies: Complex Tissue Regeneration: Muscle-Tendon



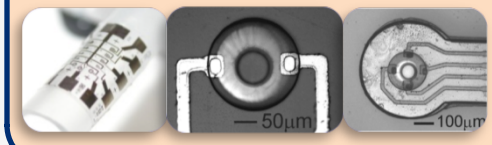
Animal Model : Aim 4
Dr. Laurencin/Dr. *Khan/ Dr. Kumbar/Dr. Lo*
Signal Processing/ES
Dr. Swami/Faghri

Purpose: The role of the bioelectronics system in enhancing muscle-tendon tissue regeneration will be evaluated using an integrated system comprised of a flexible biodegradable electrically conductive scaffold, stem cells, and an electrical device capable of applying electrical stimulation (ES) to the repair site.

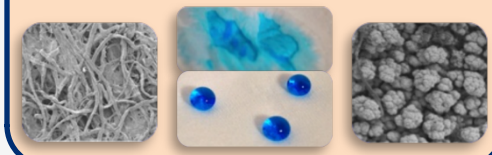
PI: Meng EFRI BioFlex: Hybrid polymer-paper based multi-sensor implants for continuous remote monitoring

Intellectual Merit

Science of Devices



Interfacial Engineering



Processing/Scaling-Up Techniques

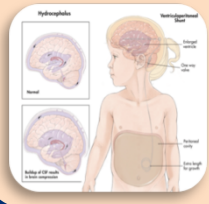
Active Sensors for Hydrocephalus

Polymer-Paper Multi-sensor Flexible

Wireless remote monitoring

Broad Impacts

Reduce Healthcare Cost for Hydrocephalus



$2B/year problem

Expand Wireless Healthcare

Center for Technology and Innovation in Pediatrics

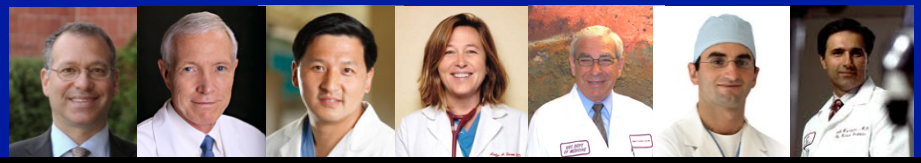
Educate Workforce of the Future

MESA Mathematics Engineering Science Achievement

Technical Team

Meng Gupta Weiland

Medical Advisors



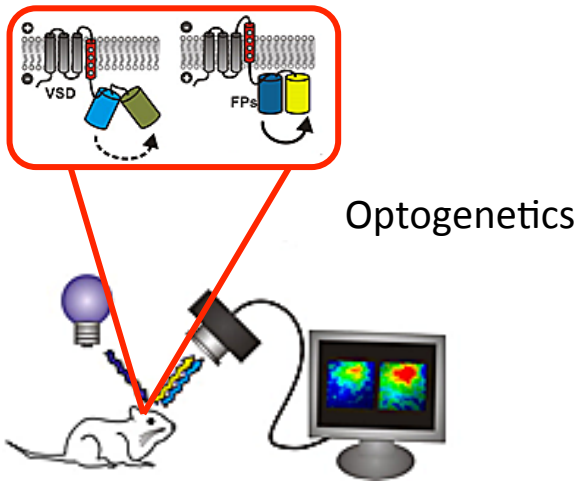
Krieger McComb Koh Saxon Crandall Liker Humayun

USC Viterbi School of Engineering

Children's Hospital Los Angeles — We Treat Kids Better

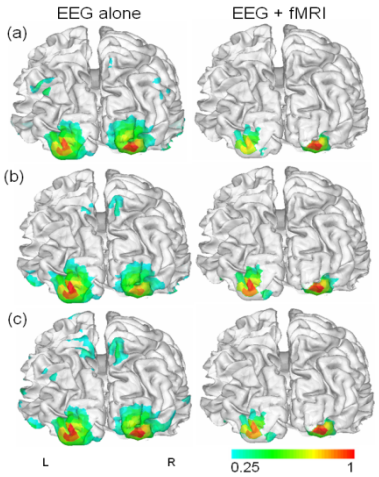
Keck School of Medicine USC

Neural Engineering and Human Brain Mapping



Optogenetics

Knöpfel T et al. J. Neurosci. 2010;30:14998-15004



Imaging Brain Electrical Activity

Im *et al*, J. *Neurosci. Meth*., 157: 118-123, 2006

- Technologies and tools to interrogate neuron activity at high spatiotemporal resolution
- Experimental methodologies and computational approaches to investigate brain structure and function and to repair damaged neurons and neural circuits

Vision:

-To incorporate engineering design and methods in advancing our understanding of the structure and function of neurons, neural networks and the brain

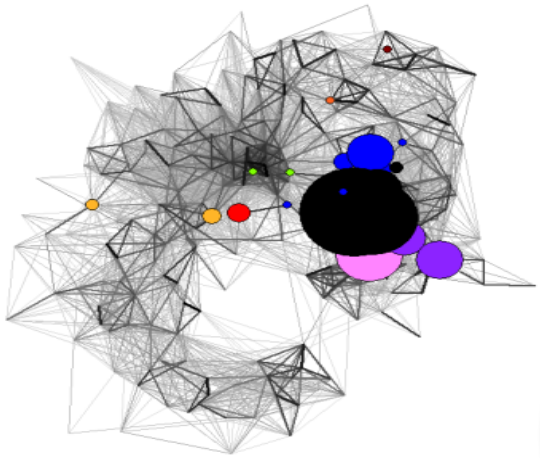
-To generate improved diagnostic methods and treatment modalities

Objective: To meet the major challenges and opportunities in mapping, modeling, and ultimately understanding the brain over the next 10 years and beyond, through advanced neurotechnology

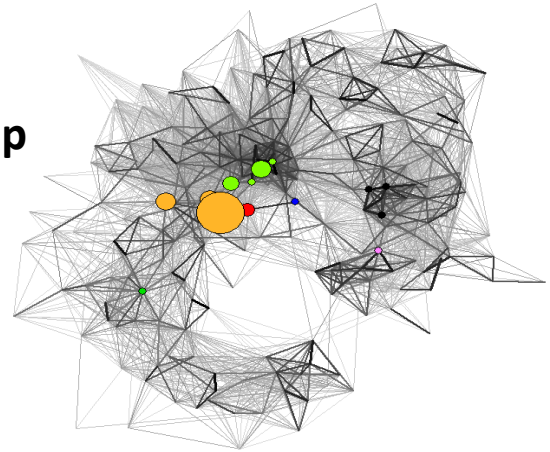
Profile of a Typical Successful Interdisciplinary Proposal

PIs vs Proposals 'Map' in relation to Web of Science

An EFRI PI Map



EFRI Proposal Map Led by same PI



Successful EFRI Pis typically engage co-PIs with expertise beyond their own to solve a complex interdisciplinary problem

EFRI TOPIC SELECTION

(next cycle: Fall 2014)

- Continuous Community Input (Publications, Conferences, Advisory Committee, Committees of Visitors, Panels, Workshops, …)
- Explicit Community Input through Website (Dear Colleague Letter)
- Fall Advisory Committee (October)
- EFRI Community Series Meeting (Jan)
  - **INCLUDED EXTERNAL EXPERTS THIS YEAR** (per External Evaluation recommendation)
- Program Directors Frontier Ideas Meeting (Feb)
- ENG Leadership Retreat (March)
  - **TOPICS ARE FINALIZED**
- Spring Advisory Committee (April)
  - **TOPICS ARE ANNOUNCED AND MADE PUBLIC**

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