



# ***EMERGENT BEHAVIOR OF INTEGRATED CELLULAR SYSTEMS: AN ENGINEERING APPROACH TO THE DESIGN OF BIOLOGICAL MACHINES***

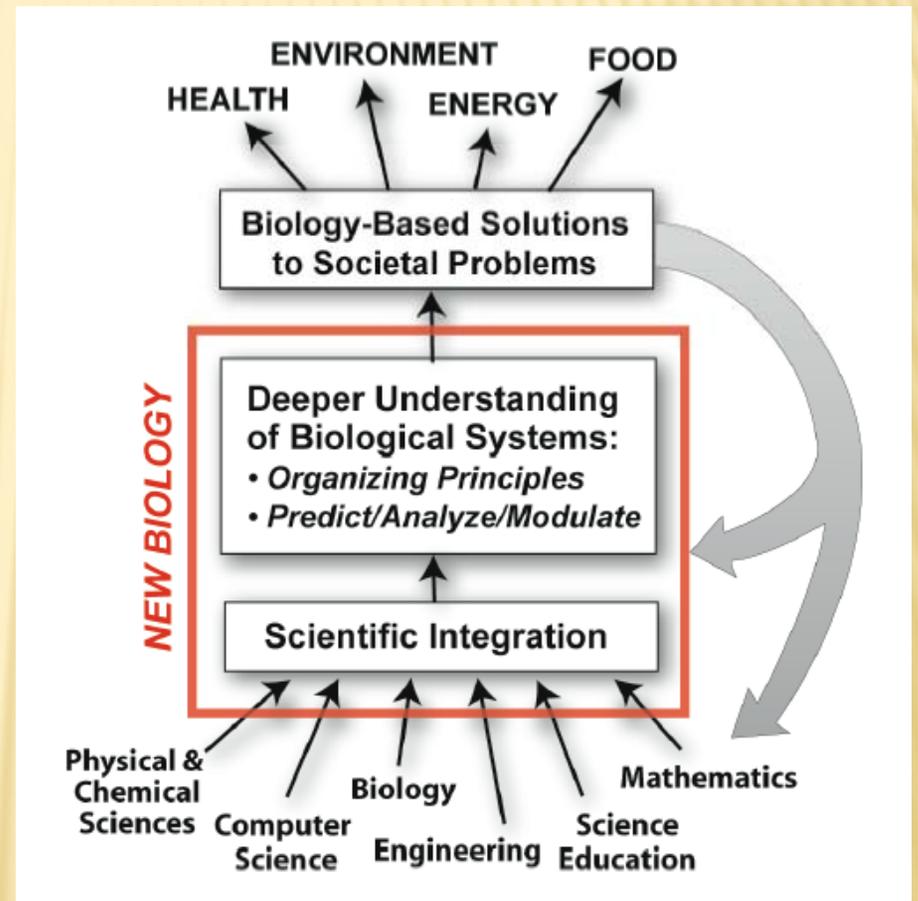
STC Directors' Meeting  
August, 2010

# A NEW BIOLOGY: ENGINEERED BIOLOGICAL SYSTEMS

“A New Biology for the 21<sup>st</sup> Century.” Report from the National Academies

[Despite] recent advances, there is still much to be done to move from identifying parts to defining complex biological systems.

[A] New Biology [is needed] to provide a framework to connect biological research with advances in other branches of science and engineering.



# OUR GOALS

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- ✘ To understand the complexities of integrated cellular systems so that we can ultimately instruct cell populations to develop into unified functional machines
- ✘ To educate a diverse generation of students well-versed in the “new biology”
- ✘ To inform and educate industry and the general public of the enormous potential for biological machines

# PHOTOS FROM OUR MAY RETREAT



# WHO WE ARE

Core institutions



The logos for MIT (Massachusetts Institute of Technology), IIT (Illinois Institute of Technology), and GT (Georgia Institute of Technology) are displayed within a green rounded rectangle. Lines connect each logo to the central Integrated Cellular Systems logo.

Minority-serving partners

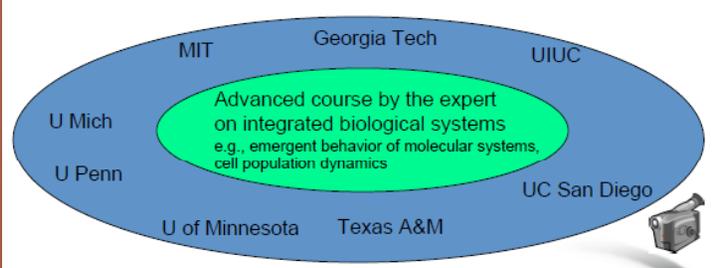


The logos for the City College of New York, UC Merced, and Morehouse College are displayed within an orange rounded rectangle. Lines connect each logo to the central Integrated Cellular Systems logo.



The logo for Integrated Cellular Systems, featuring a stylized molecular structure with orange, green, and blue hexagons and the text "Integrated Cellular Systems".

Teaching consortium



A diagram showing a central green oval labeled "Advanced course by the expert on integrated biological systems e.g., emergent behavior of molecular systems, cell population dynamics". This is surrounded by a blue oval containing the names of participating institutions: MIT, Georgia Tech, UIUC, U Mich, U Penn, U of Minnesota, Texas A&M, and UC San Diego. A small camera icon is in the bottom right corner.

International partners



The logo for international partners, featuring a circular emblem with the text "MOLECULAR MEDICINE · GLOBAL ENTERPRISE FOR MICRO-MECHANICS" and a stylized molecular structure.

# OUR ROOTS



GEM<sup>4</sup>

Proposed *Institute for Cellular and Molecular Nanomechanics (ICMN)*



2005

2006

2007

2008

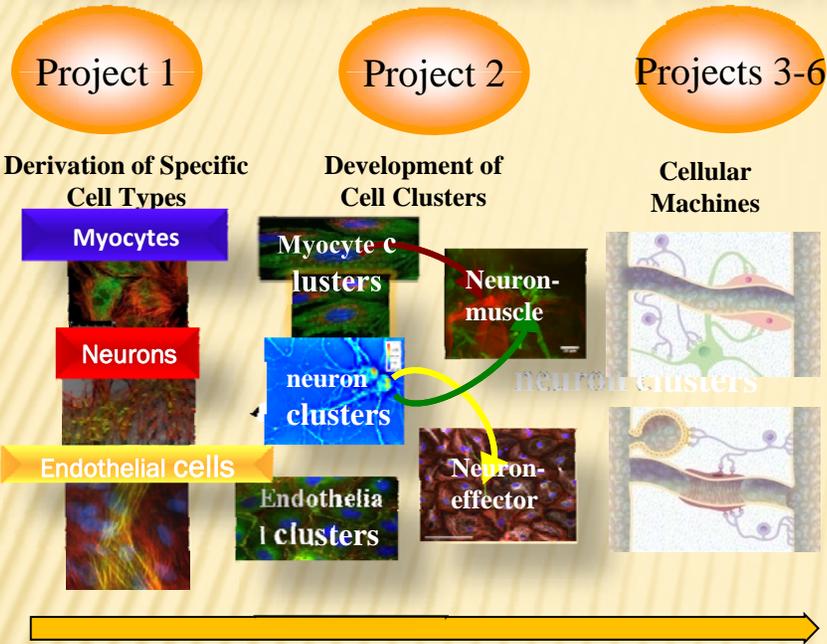
2009

2010

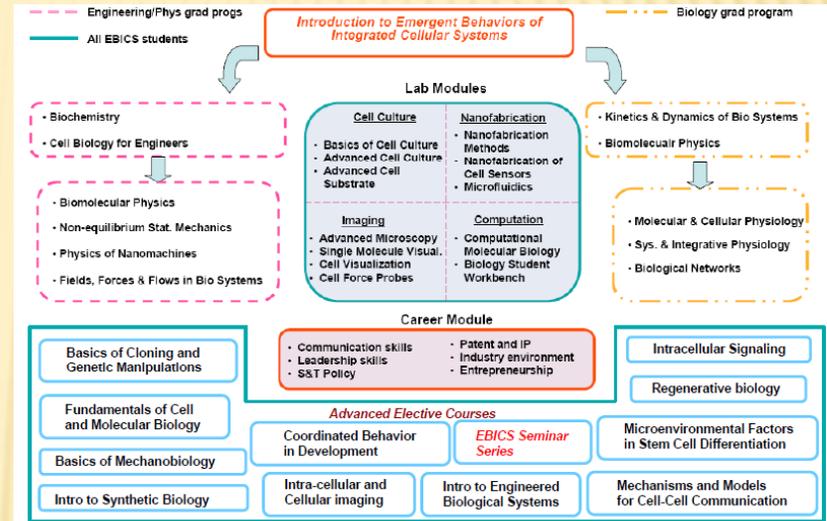
NSF-EFRI: A multi-faceted approach to modeling angiogenesis



# EMERGENT BEHAVIOR OF INTEGRATED BIOLOGICAL SYSTEMS



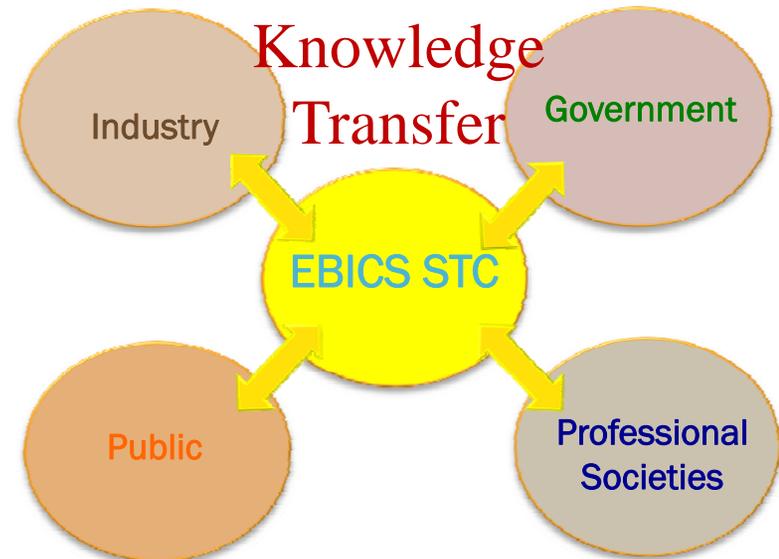
## Education



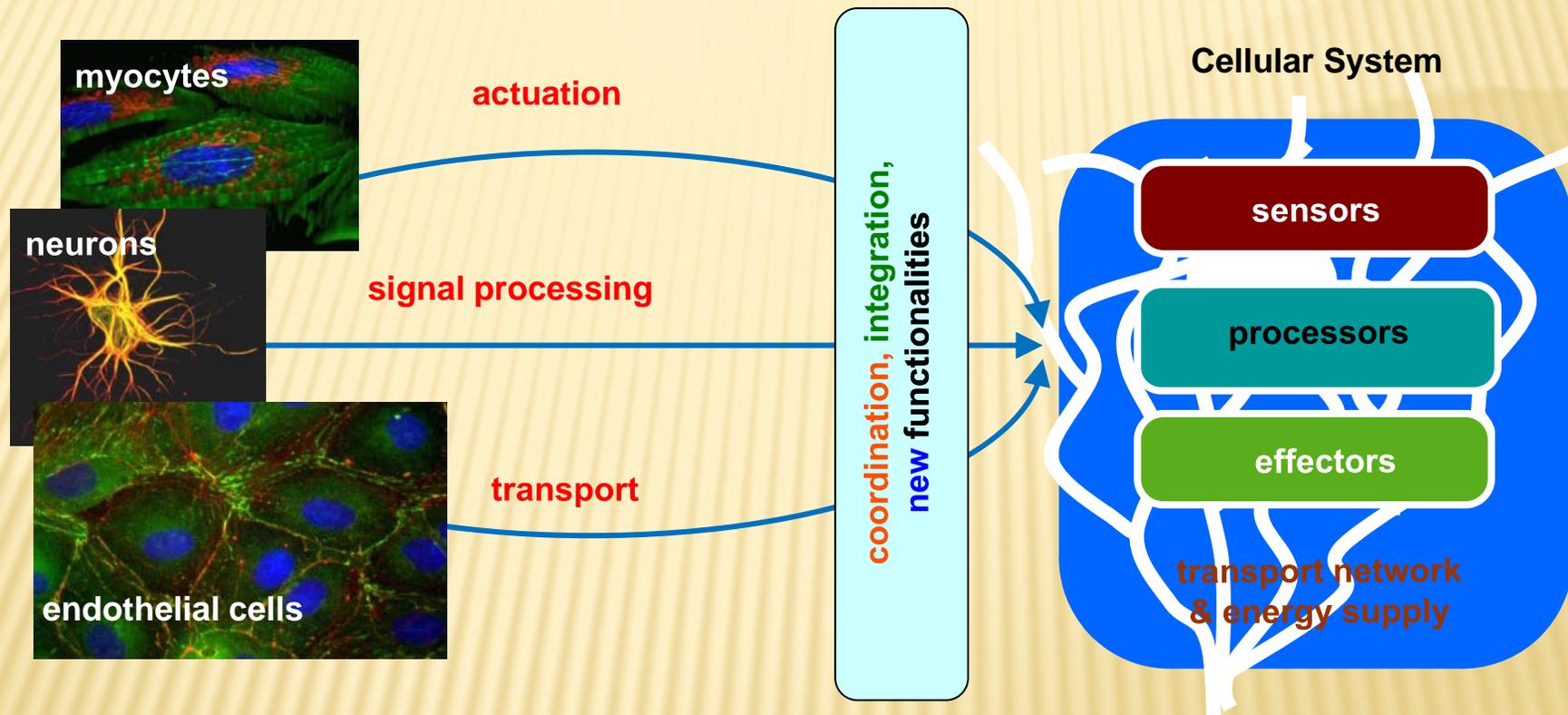
## Diversity



## Knowledge Transfer



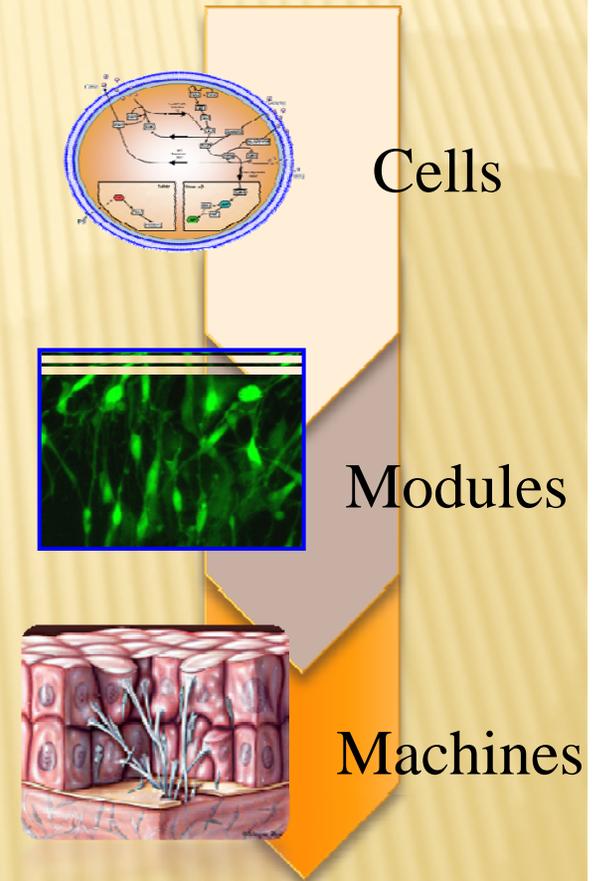
# INTEGRATED CELLULAR SYSTEMS: “BIOLOGICAL MACHINES”



# ACHIEVING OUR RESEARCH GOALS: A SERIES OF ESSENTIAL STEPS

We need to understand:

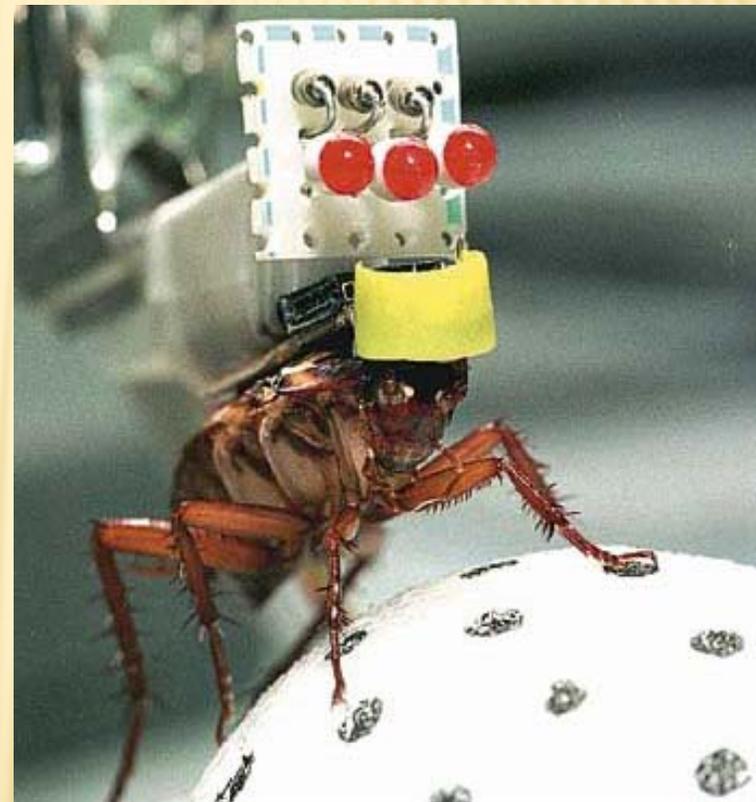
- how to **control cell differentiation** both in isolation and as part of a population of cells
- how cells **communicate** with their environment and neighboring cells to **develop coordinated behavior** (the **modules** of the machine)
- how to **assemble** the modules to produce functionality of the **machine**



# PUTTING IT ALL TOGETHER.....

## SOME EXEMPLARY BIOLOGICAL MACHINES

- ✘ Organ mimics for drug testing
- ✘ Biological robots
- ✘ Implantable systems for drug sensing, synthesis and release
- ✘ Self-replicating organisms for toxic waste clean-up



[www.biomachinations.com/?cat=17](http://www.biomachinations.com/?cat=17)

# EDUCATIONAL GOALS AND PLANS

- ✘ Educate the next generation of students in the “new biology”
- ✘ Develop the fundamental basis for a new discipline
- ✘ Some of the innovative components
  - + A new approach to graduate education at the engineering/biology interface (a new curriculum for a new discipline)
  - + Teaching consortium
  - + Summer schools (NSF GEM<sup>4</sup>)
- ✘ Leverage other, existing programs
  - + UIUC NIH Cancer Nanotechnology Training Center
  - + New UIUC and GT IGERTs
  - + MIT NIBIB Training Grant in BioSystems and Biomechanics
- ✘ Several educational models to promote wide dissemination
- ✘ Evaluation is essential

# BRINGING DIVERSITY TO EBICS

## **Our MSI partners:**

- Feeder programs
- Summer exchanges
- Active participation in EBICS research

## **At MIT:**

- CONVERGE
- MSRP
- BE REU program
- MITES

## **At UIUC:**

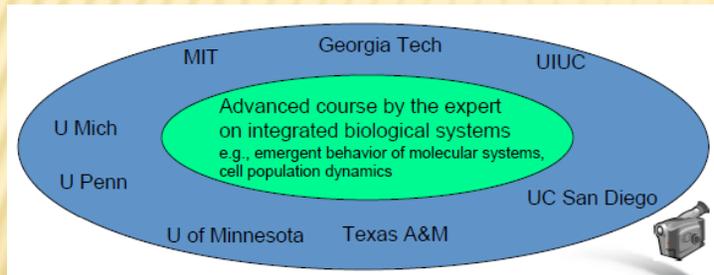
- MEP
- MERGE
- SURGE
- Inclusive Illinois

## **At Georgia Tech:**

- Women in Engineering
- FASET
- Building on an already successful URM recruiting program

# BROAD DISSEMINATION OF EBICS MESSAGE

**OPEN**COURSEWARE  
CONSORTIUM



Teaching consortium

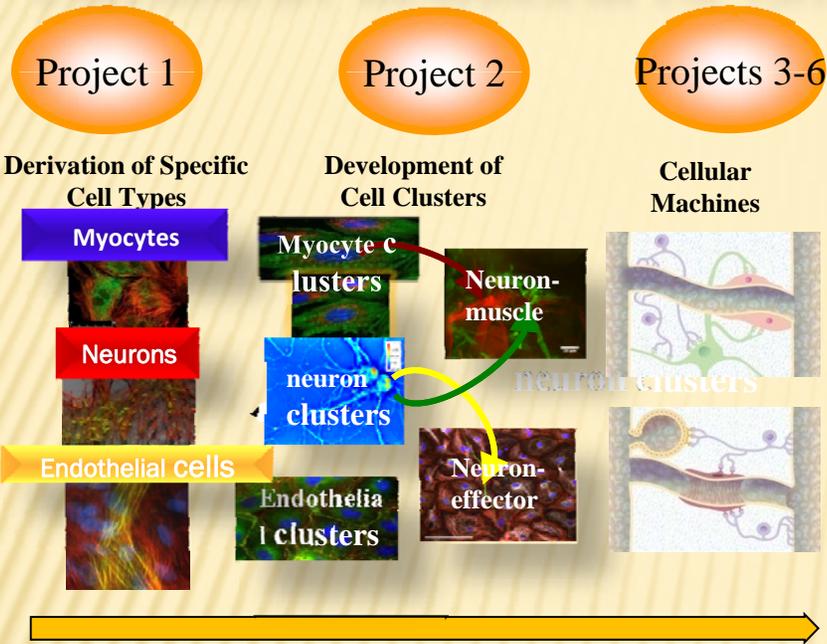
- Industrial ties
- Articles in the popular literature
- Children's book on Biological Machines



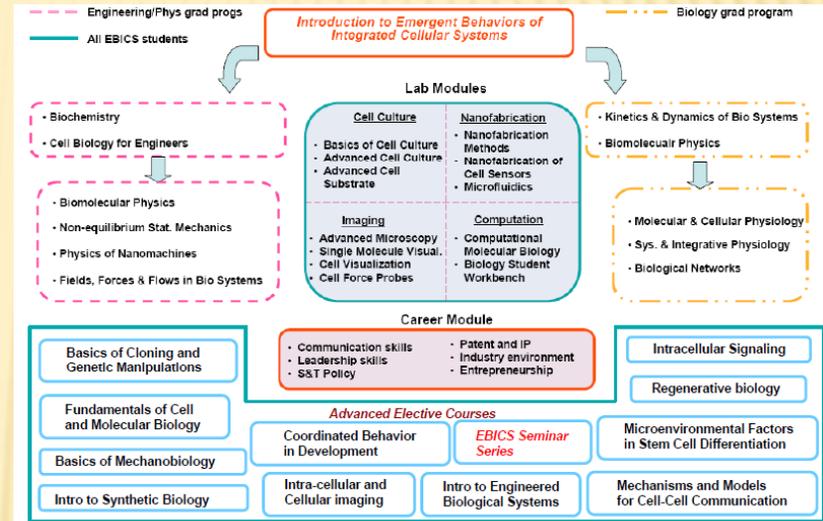
**The Cell as a Machine:**  
Mechano-, Controls, Systems Engineering  
Approach to Cell/Molecular Biology  
NSF Building, Arlington, Virginia  
December 20-21, 2007



# EMERGENT BEHAVIOR OF INTEGRATED BIOLOGICAL SYSTEMS



## Education



## Diversity



## Knowledge Transfer

