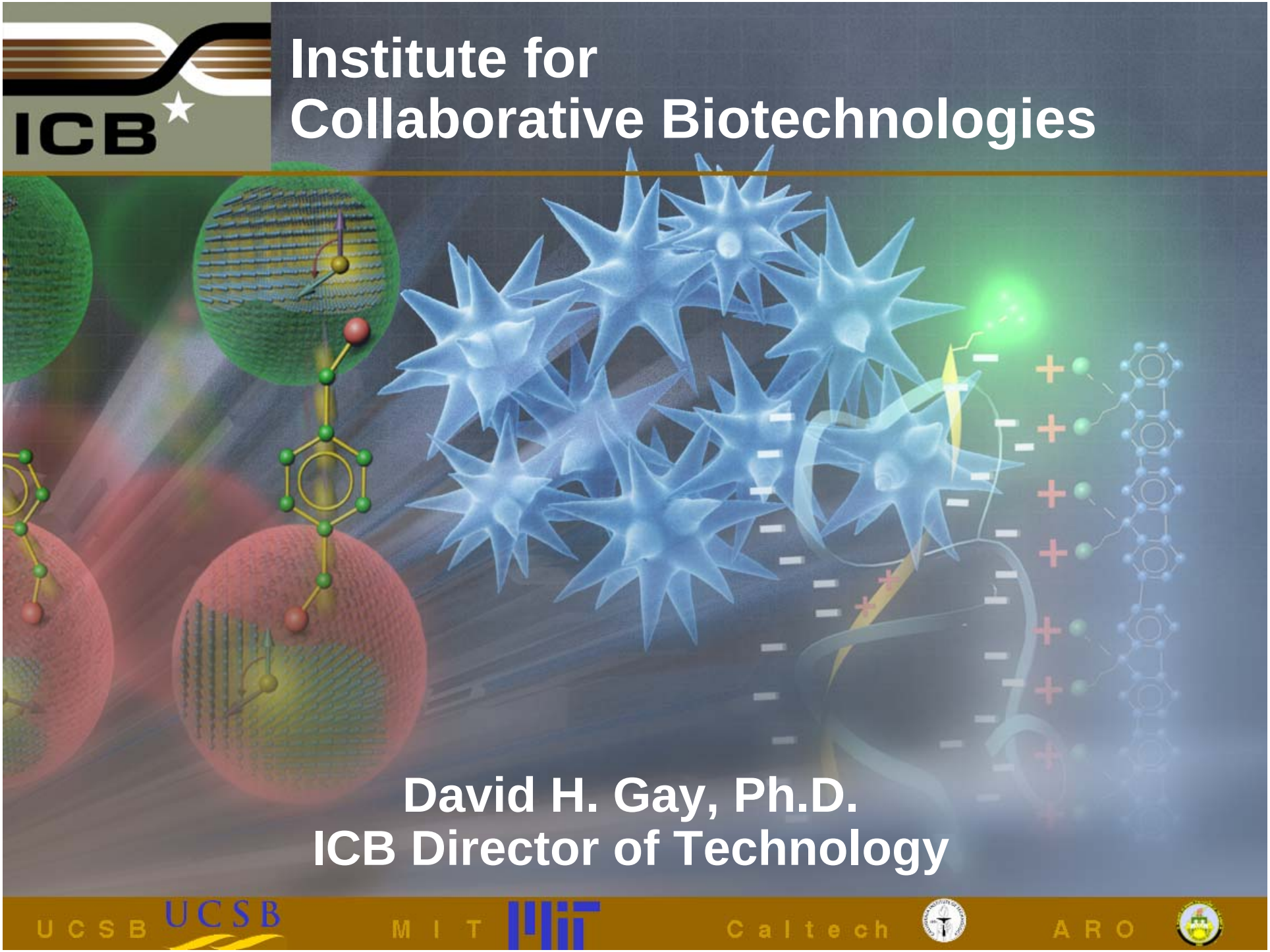

ICB
Institute for
Collaborative Biotechnologies
David H. Gay, Ph.D.
ICB Director of Technology
UCSB
UCSB
MIT
Caltech
ARO

INSTITUTE FOR COLLABORATIVE BIOTECHNOLOGIES

Mission: Enabling Network-Centric Technologies

- ***Led by UCSB with MIT and Caltech, with partners from Industry and Army labs***
- ***Uniquely interdisciplinary teams of molecular biologists, chemists, physicists and engineers***
- ***Harnessing biological mechanisms to develop advanced sensors, electronic, optical and magnetic materials, information processing and network control systems***

R&D at the interface between biotechnology and engineering

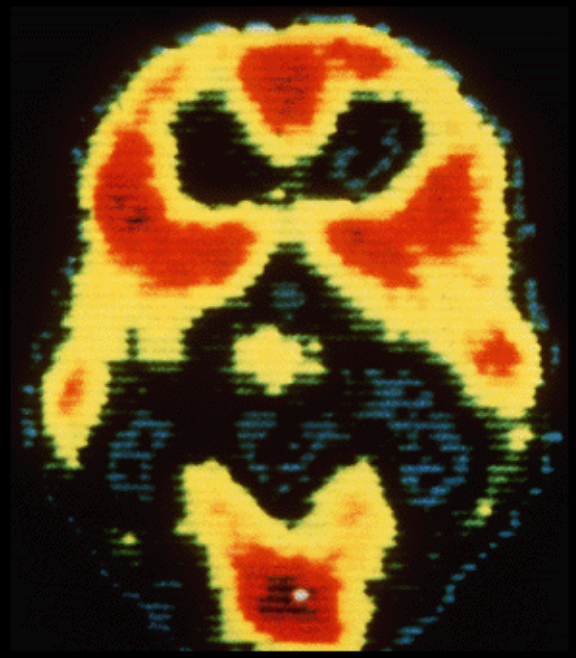
LEADERSHIP

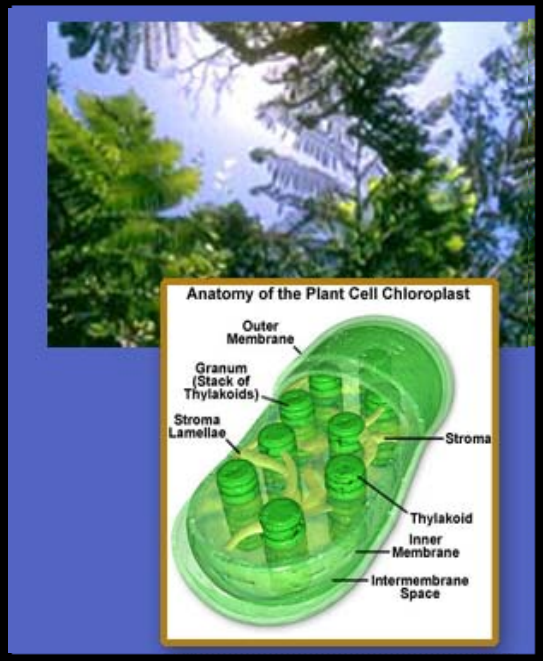
Dan Morse - Director
Biotechnology,
Biomolecular & Optoelectronic Materials

Frank Doyle - Associate Director
Systems Engineering,
Systems Biology, Network Science

Biology exhibits remarkably high performance unequaled by human engineering:

- ***The chemical sensors in the antennae of the moth detect single molecules***
- ***The human brain is a paragon of massive parallel information processing; it can heal around an injury, and learn, in ways our present electronics can't***
- ***Efficiency of photovoltaic energy transduction in green plants is virtually 100% - compared to the much lower efficiency in engineered devices***





Our Approach:

- ***Use biotechnology to dissect and identify fundamental mechanisms responsible for this uniquely high efficiency***
- ***Translate results to "hard" engineering, chemistry and physics.***

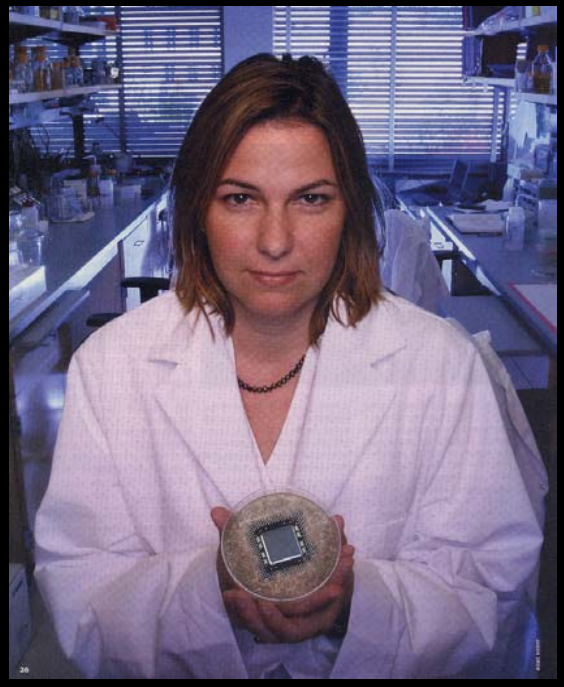
GRAND CHALLENGES

Translate the unequaled high-performance of biological systems into practical engineering to deliver revolutionary improvements in:

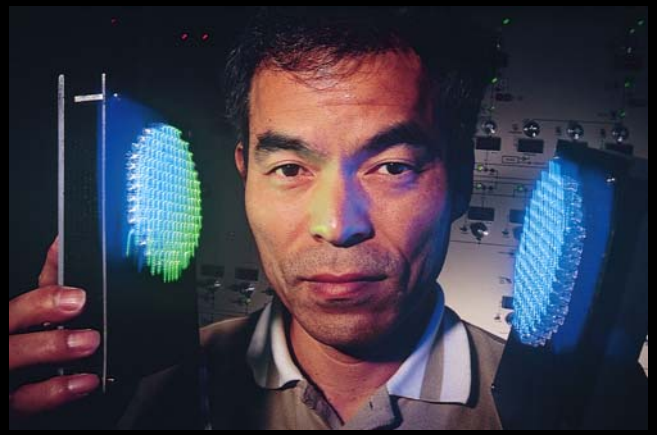
- ***Lightweight portable energy generation and storage***
- ***High-speed, high-density information sensing, processing and storage***
- ***Robust mobile networks for sensors, communications, command and control***

REVOLUTIONARY INTERDISCIPLINARY RESEARCH

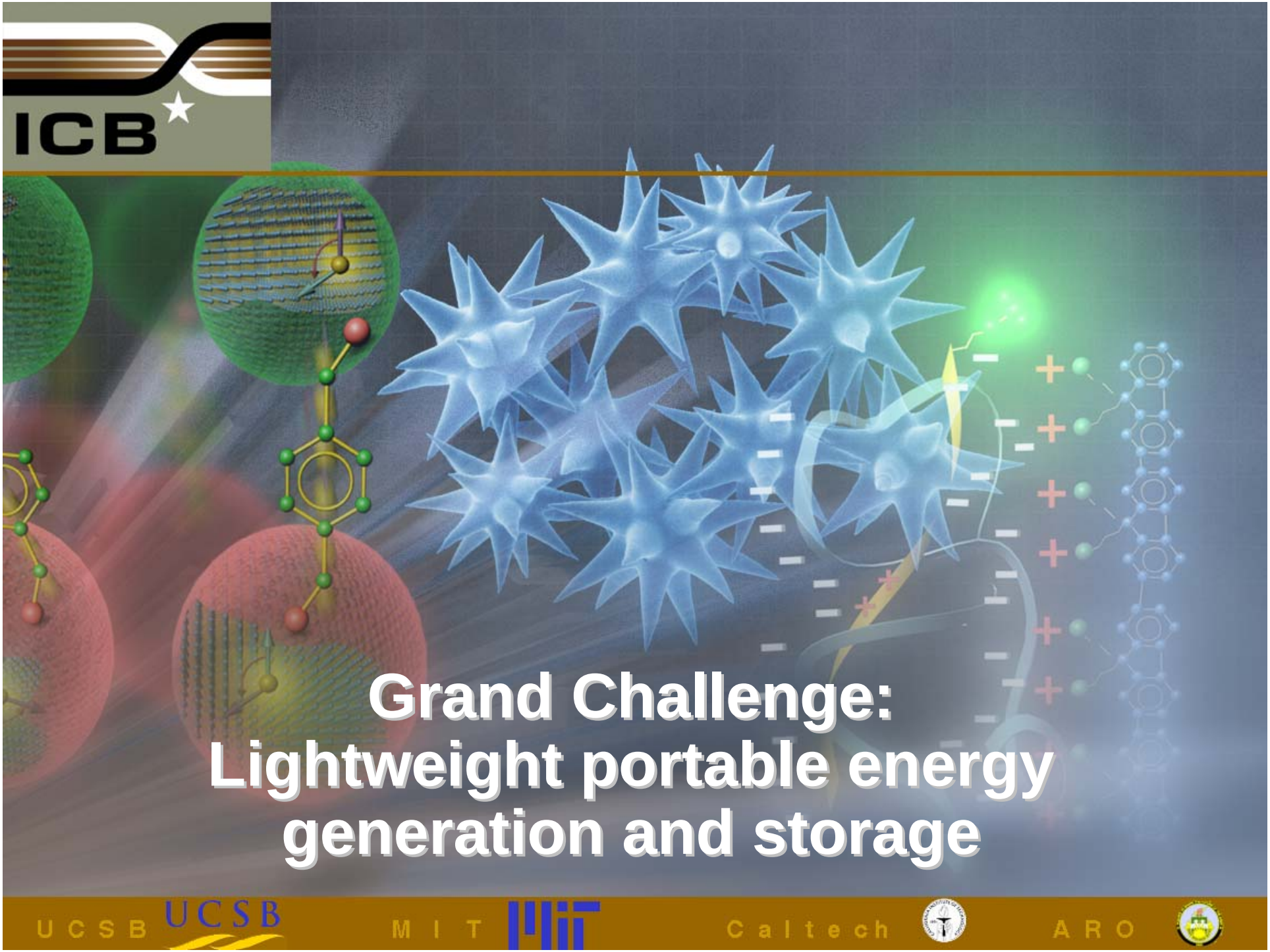
Alan Heeger - Nobel Laureate, 2000; His plastic wires and light sources enabled flexible displays



Angela Belcher, pioneer in bio-electronics and MIT Coordinator for ICB, won a MacArthur Award this year.

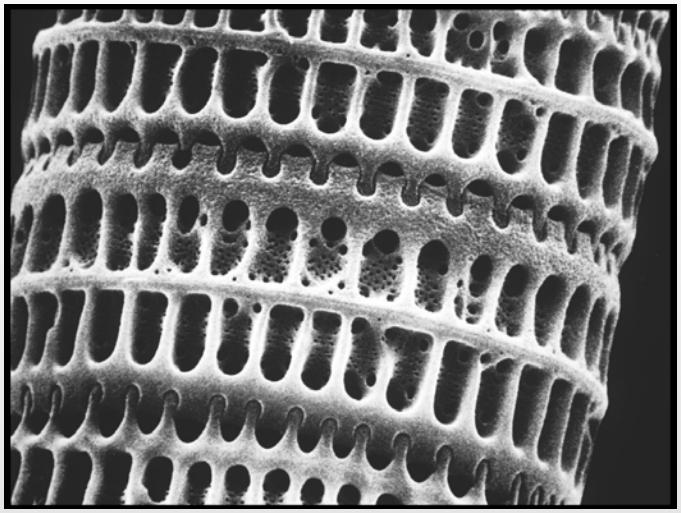


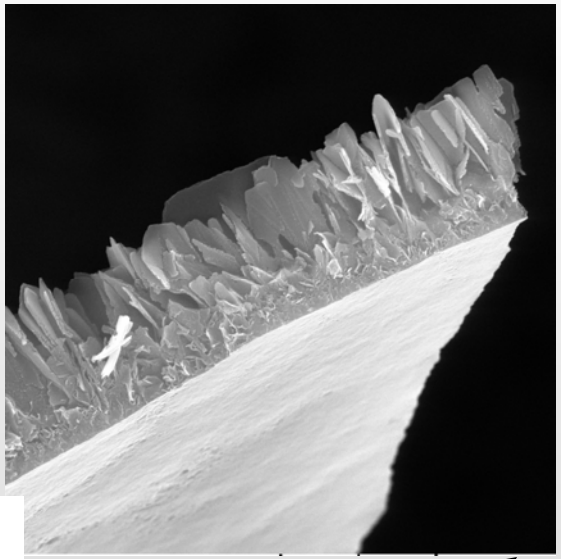
Shuji Nakamura, known as “the Thomas Edison of Japan” for his invention of the Gallium Nitride laser and LEDs

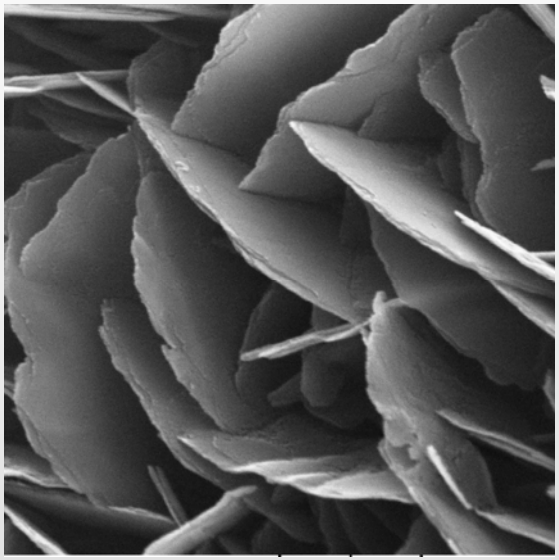

ICB
Grand Challenge:
Lightweight portable energy
generation and storage
UCSB
UCSB
MIT
Caltech
ARO

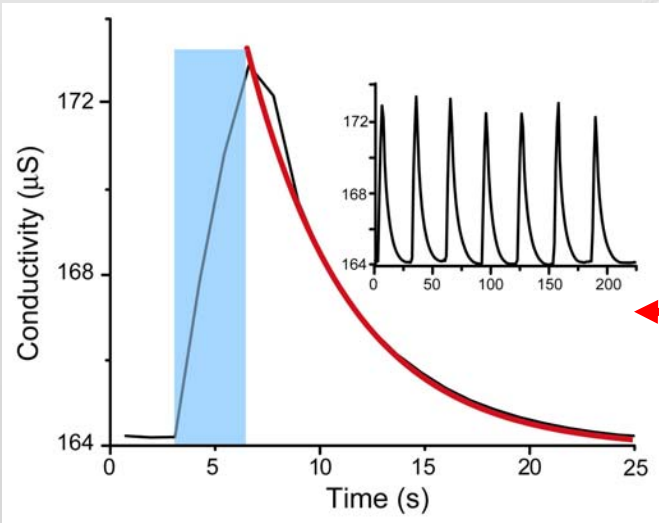
Breakthrough in Biomimetic Synthesis of Nanometer-Scale Photovoltaic and Light-weight Li-Battery Materials - with no biochemicals or organics!

ICB investigators discovered the molecular mechanism governing the biological nanofabrication of silica. They translated this to develop a radically new synthesis method for a wide-range of novel semiconductors:









Biomimetically Grown Photovoltaic $Co(OH)_2$ Plates Connected to Flat Conductive Backplane

Extremely long minority carrier lifetime, high dopant density, high surface area and unique single crystal morphology - all ideal for highly efficient photovoltaic energy transduction

This material cannot be made by conventional means!

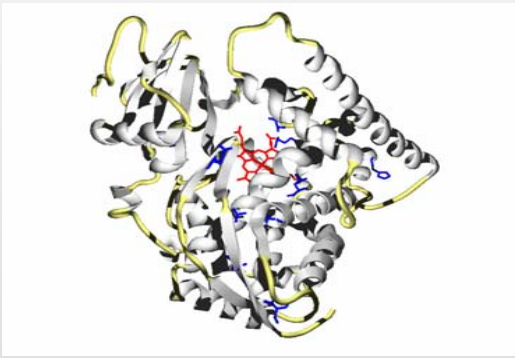
Low-cost Fuel & Fuel-Cell Feedstock

Frances Arnold (Caltech/ICB), one of the world's most creative genetic engineers, is "evolving" an enzyme to convert Methane to Methanol

Engineering bacteria to produce Methanol:

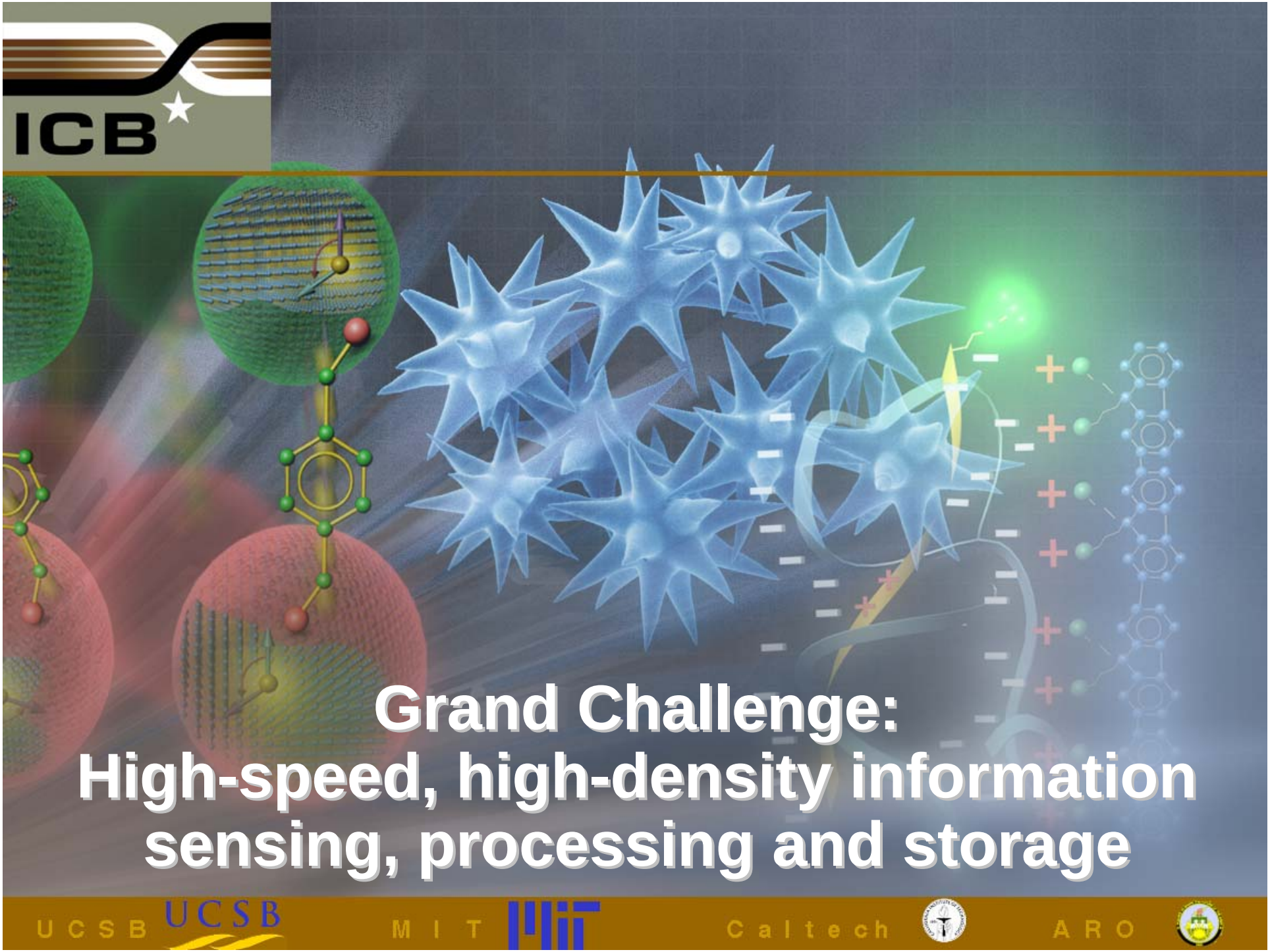
Methane + O_2 → Methanol + H_2O

She's already engineered Ethane-to-Ethanol conversion! (- never done before!)



Significance:

- *Convert **vast** methane resources to liquid fuel & fuel-cell feedstock*
- *Works at low temperature & pressure*
- *Can use small methane sources*


ICB
Grand Challenge:
High-speed, high-density information
sensing, processing and storage
UCSB
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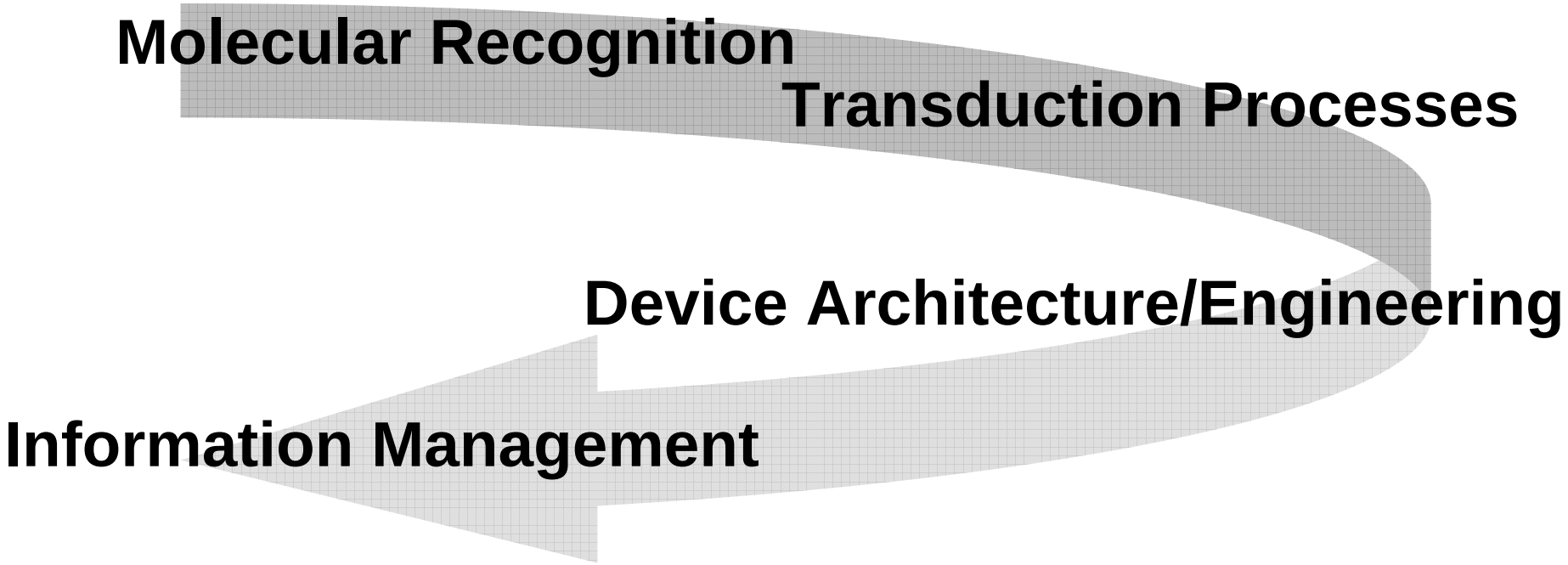
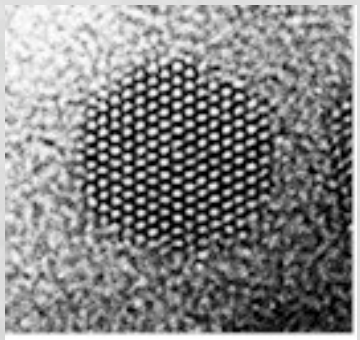
MIT
Caltech
ARO

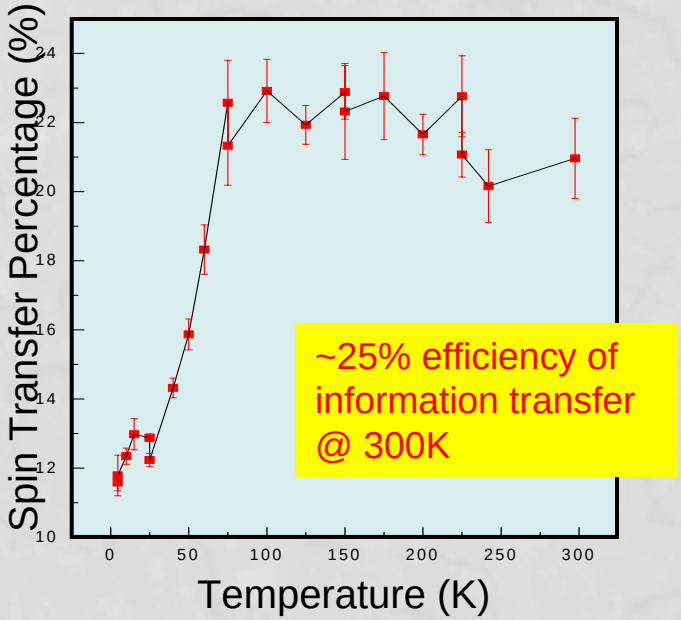
ICB Integrated Biosensor Efforts

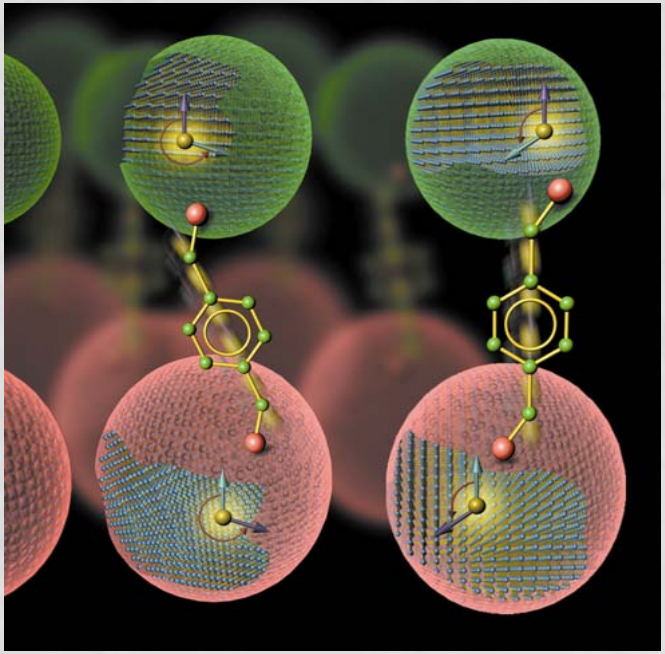


Bio-Molecular Spintronics - Enabler of Quantum Computing!

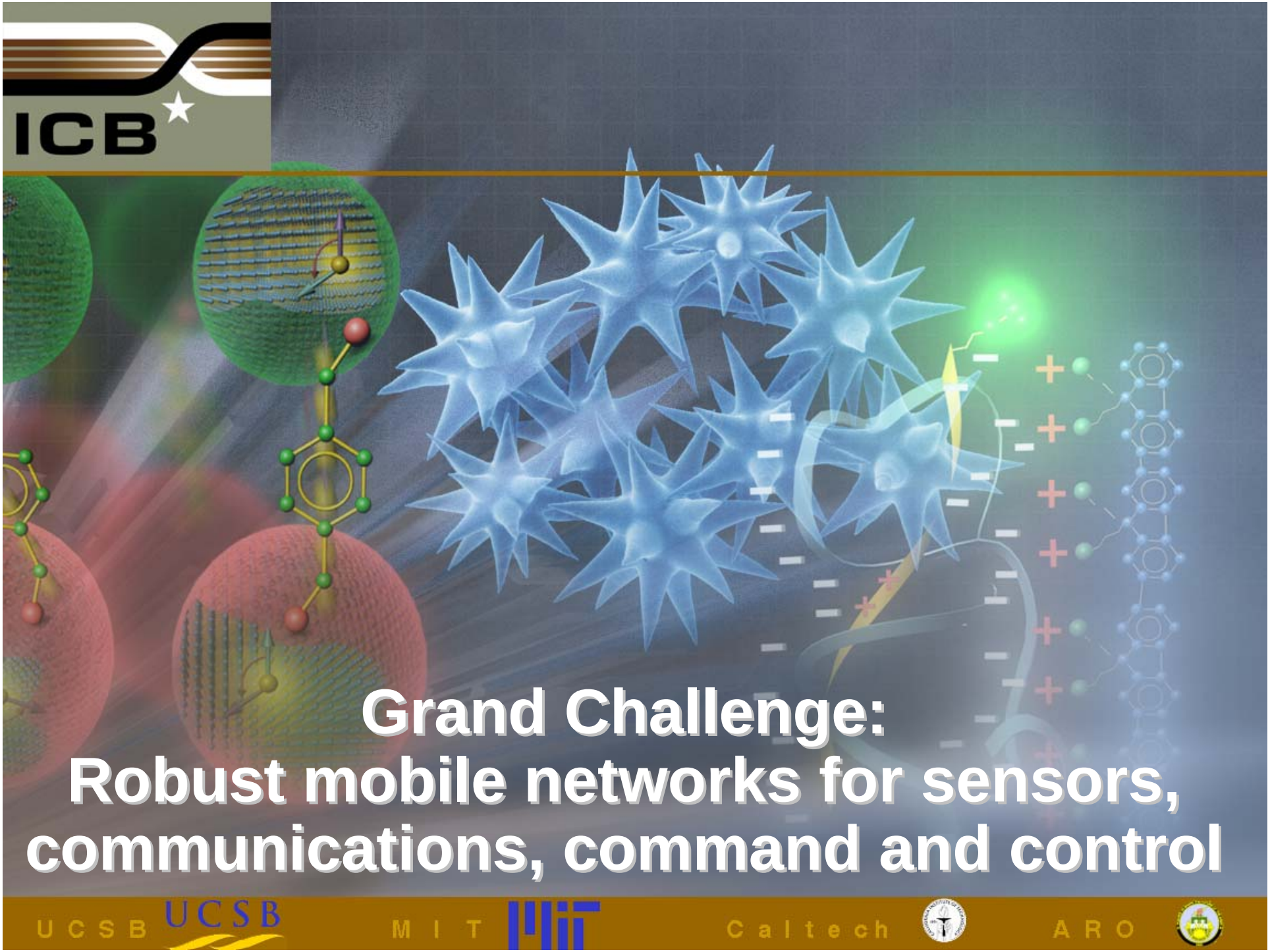
- ***Result:** Quantum information transfer achieved with high efficiency across biomolecular linkers at room temperature*
- ***Significance:** Bio-molecular spintronics! Major enabling step toward quantum computing, for extremely smaller and faster information storage and processing*







Semiconductor quantum dots linked by tailored bio-organic molecules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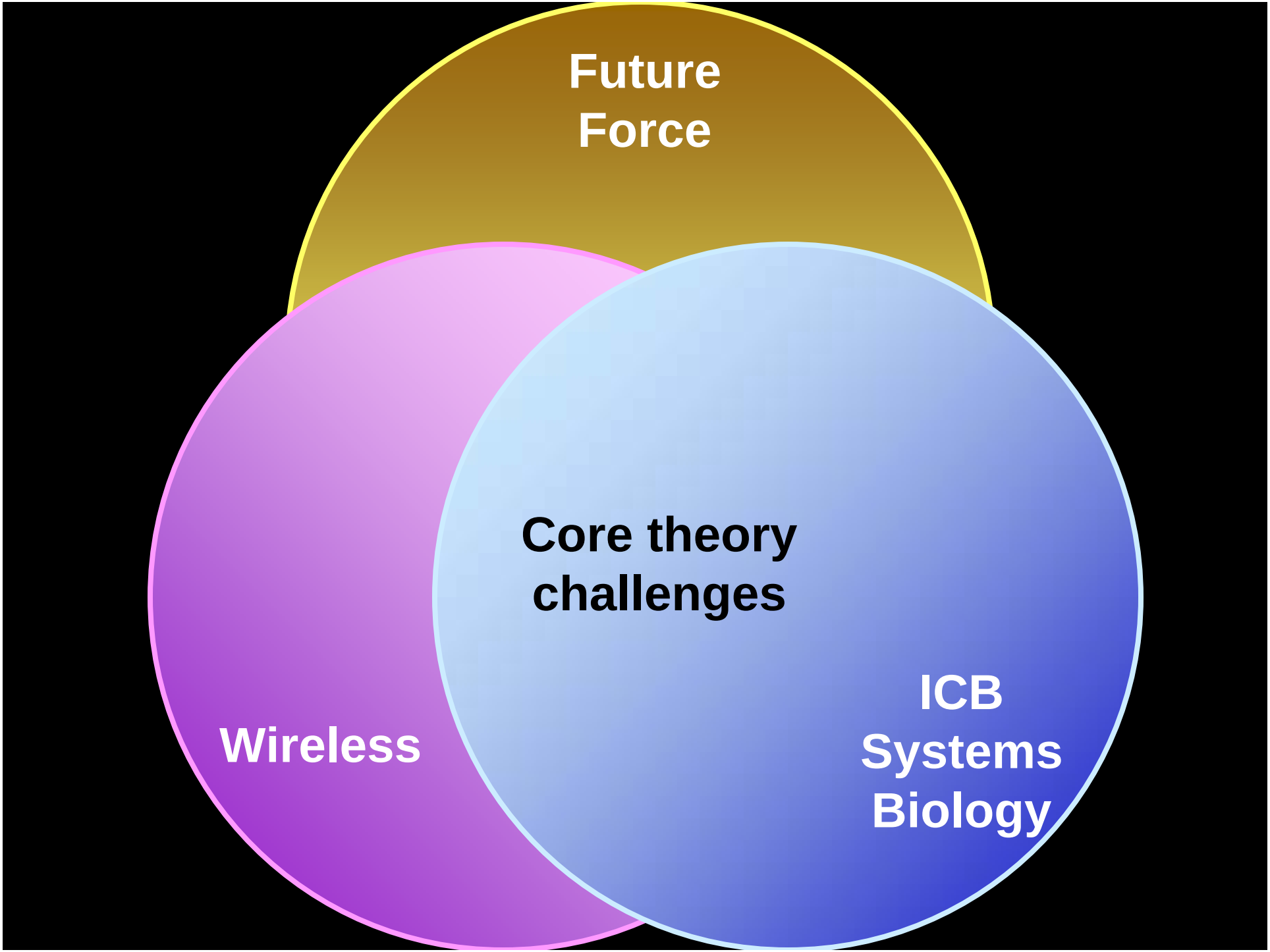
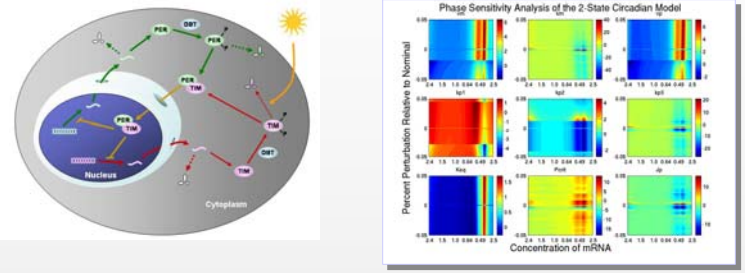

Future
Force
Core theory
challenges
Wireless
ICB
Systems
Biology

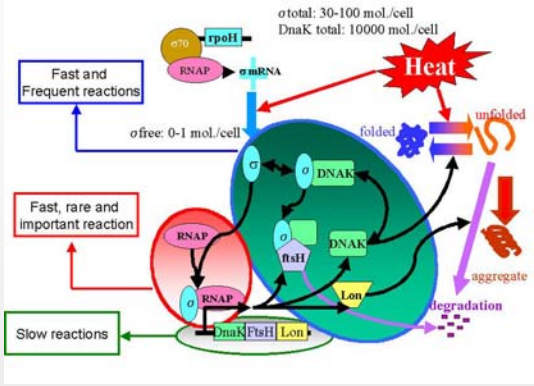
Improved Systems Analysis, Network Systems

Army Need: ability to simulate human performance fluctuations arising from metabolism and circadian rhythms



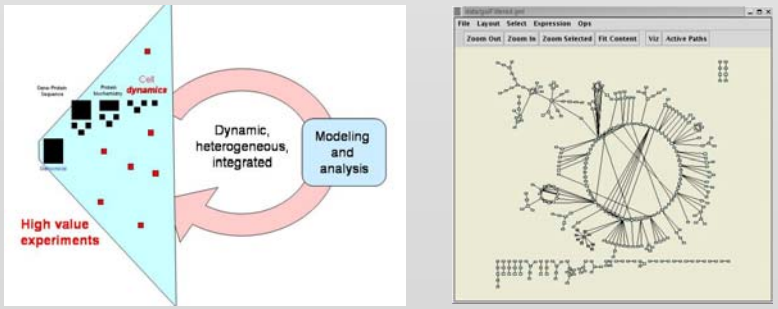
Stochastic model for gene regulation underlying circadian rhythm, demonstrating phase sensitivity

Army Need: tools for prediction of soldier response to biological agents

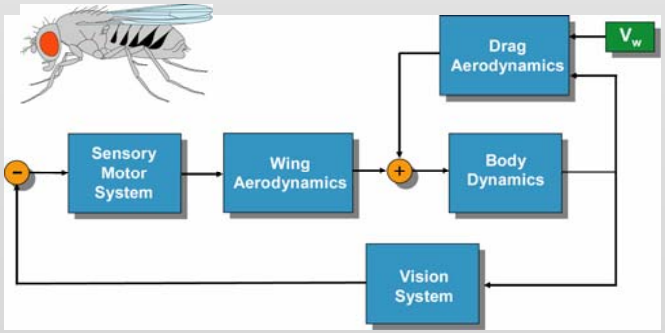


Stochastic model for bacterial heat shock response

Army Need: Systems biology approaches to integrating dynamics, heterogeneous measurements with modeling toolkit, and hypothesis generation



Army Need: biologically inspired devices for small scale unmanned aerial vehicles



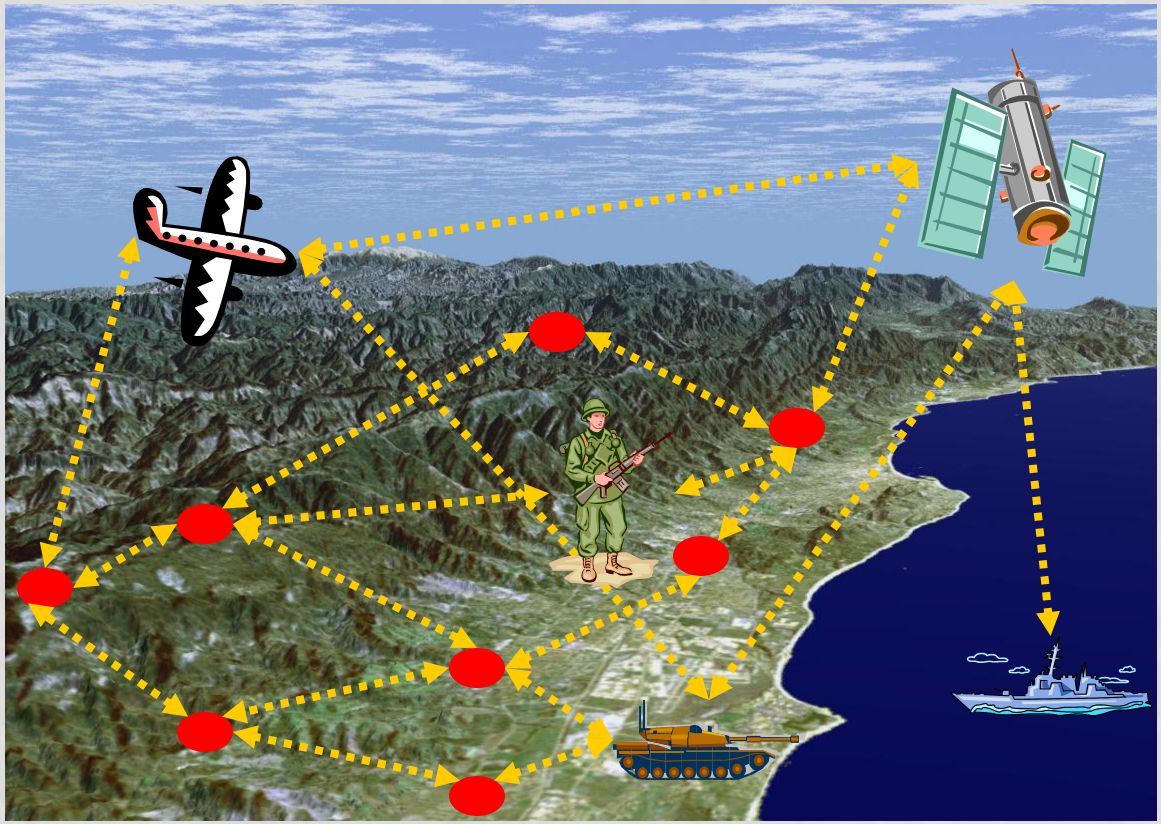
Vision & sensory motor processing in fly capable of generating complex behaviors that achieve desired response

Plan for the Coming Year

Network Science:

Robust Mobile Ad Hoc Networks for FCS

- *Communications, Command & Control*
- *Integrated sense-and-respond architecture*
- *Devices that sense, compute, and communicate*
- *Decentralized information processing*



TECHNOLOGY TRANSITIONING STRATEGY

***Build strong working partnerships with the Army and with Industry*, to keep current and future needs in focus, and to accelerate the transition from discovery to prototype development, commercial production and acquisition by the Army.**

ARMY PARTNERS

Collaborations, 6.2 projects or CRADAs:

- ***ARL***
  - ***SEDD***
  - ***CISD***
  - ***WMRD***
  - ***HRED***
- ***NSC***
- ***NVSED***
- ***ECBC***
- ***MRMC***
  - ***WRAIR***
  - ***USAMRIID***
  - ***USARIEM***
  - ***USACEHR***

INDUSTRIAL MEMBERS & ASSOCIATES

A company or other organization which supports the educational and research missions of the ICB and which wishes to benefit from interactions and collaborations with ICB faculty members and researchers, thus extending its own biotechnological research and development capabilities.

INDUSTRIAL MEMBERS & ASSOCIATES

Genencor International
Diversa
Intelligent Optical Systems
Innovative Micro Technology
Cambrios Technologies
Calhoun Vision
Sirigen
Nanex
MITRE

APPLIED (6.2) RESEARCH PROJECTS

Sirigen – ECBC - UCSB

Meeting Threat Detection Needs for the Army

IMT – NSC – MIT

Development and Validation of Microdevices for Food Safety Diagnostics

Nanex – ARL/SEDD - UCSB

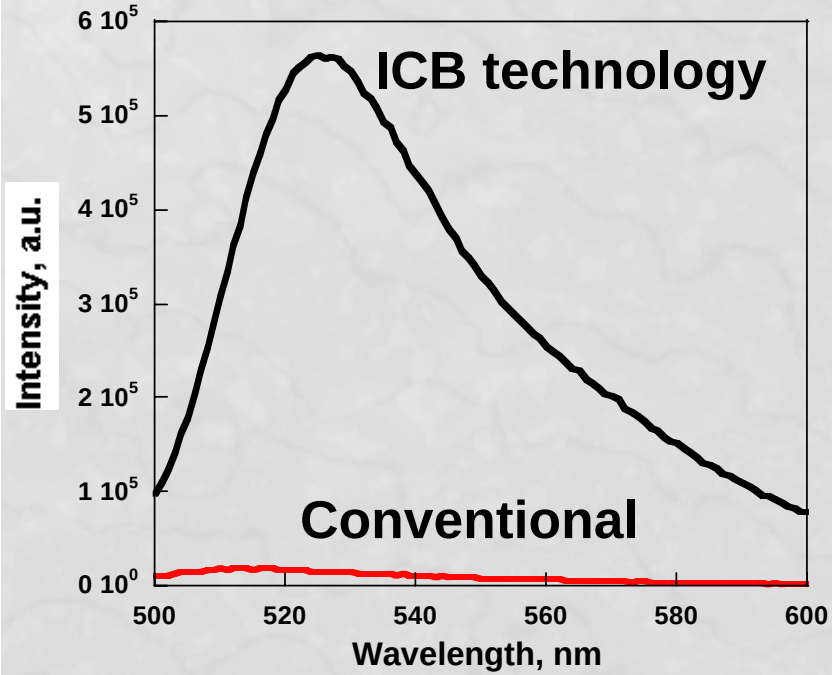
Development of a Portable DNA Sensor System

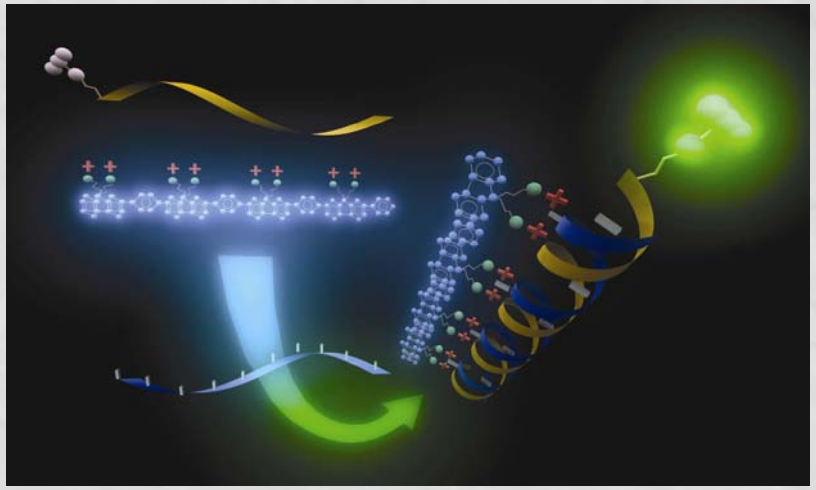
Cambrios – NSC - UCSB/MIT

Large Scale Phage Amplification for Electronic Materials

Revolutionary Advance in Sensors ICB-ECBC-SiriGen, Inc. (6.2)

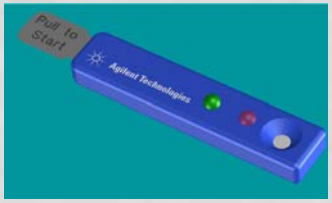
Quantum Jump in Sensitivity (Detection of Viral Pathogen)

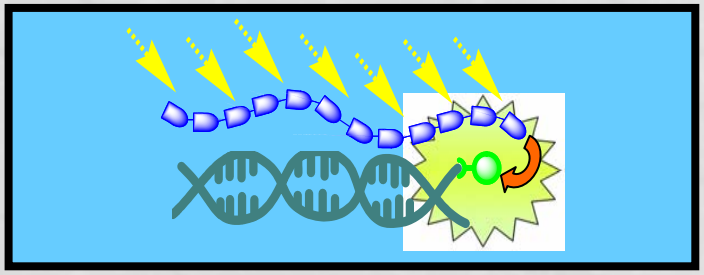




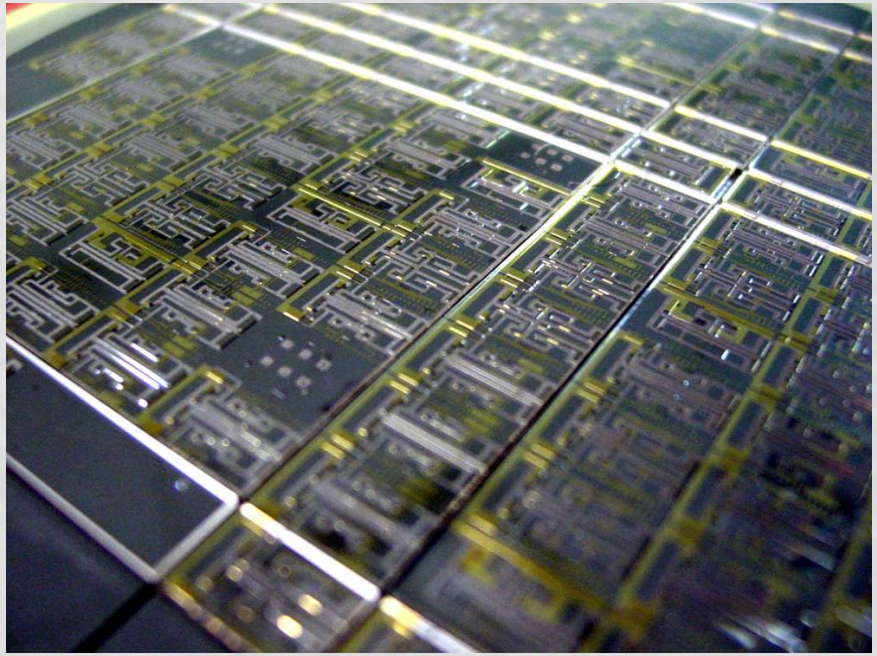
100x amplification!

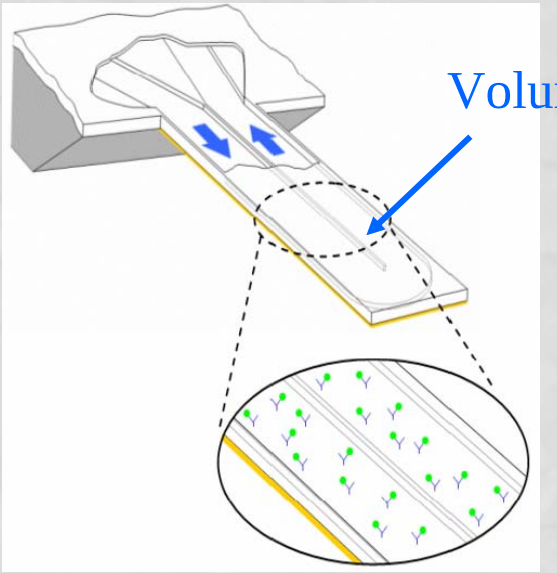
Deployable Sensors



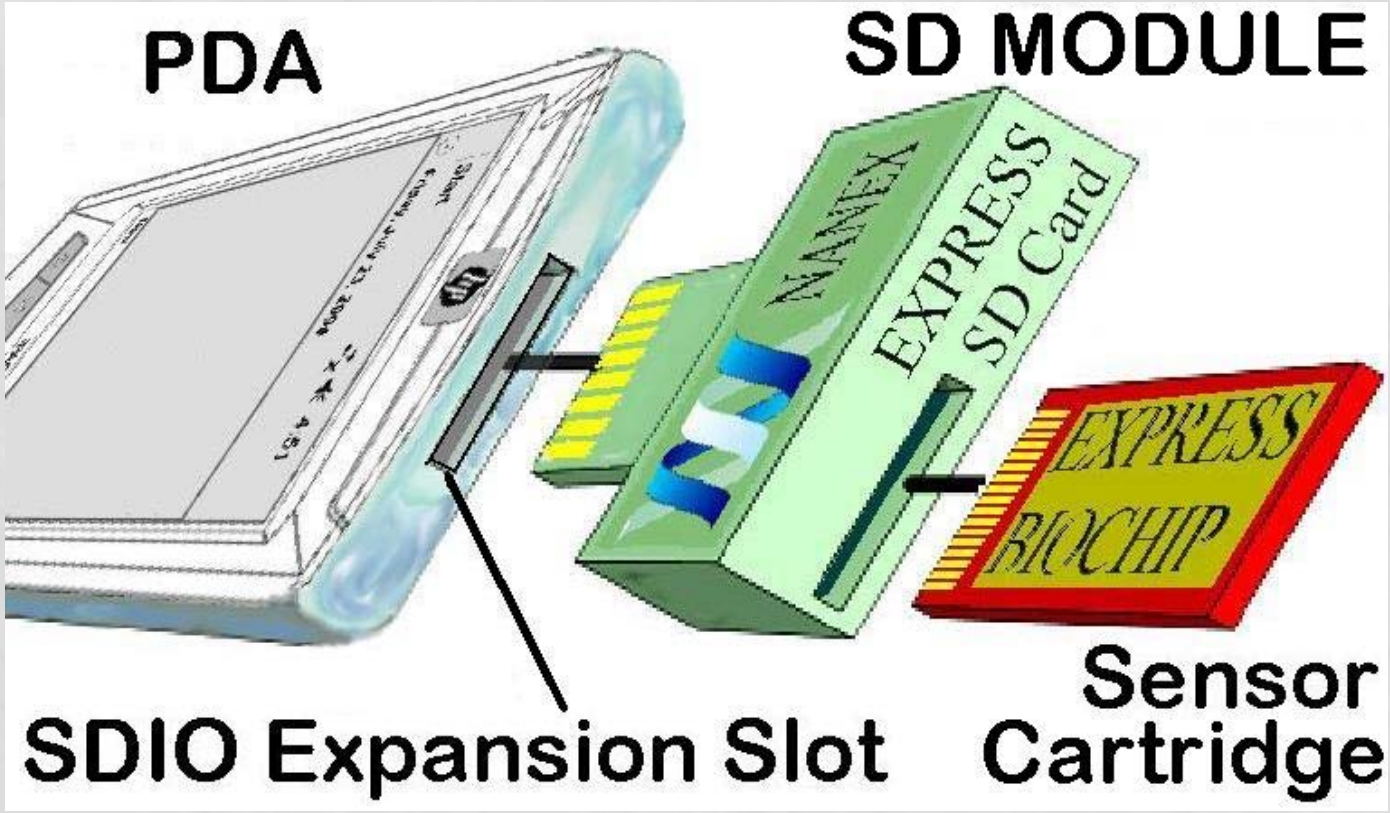


Food Safety Diagnostics
ICB-NSC-IMT-Zyomyx (6.2)

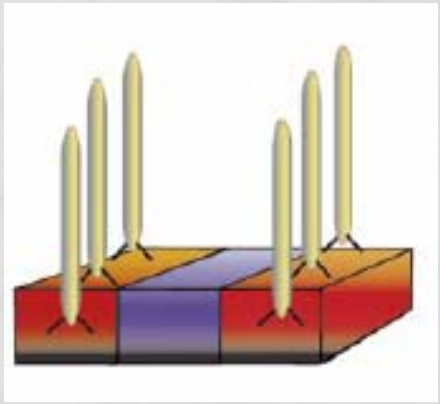


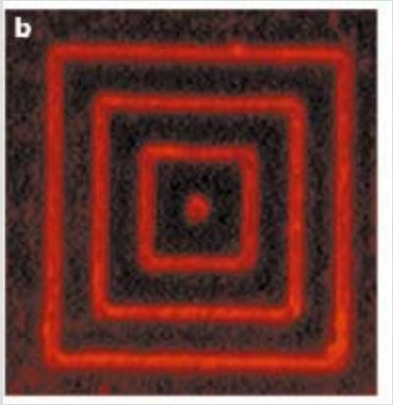


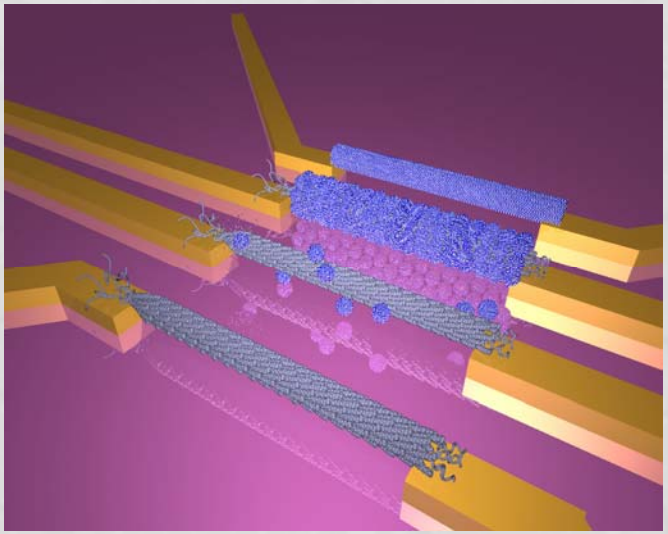
Electronic Detection of DNA
ICB-ARL-Nanex (6.2)

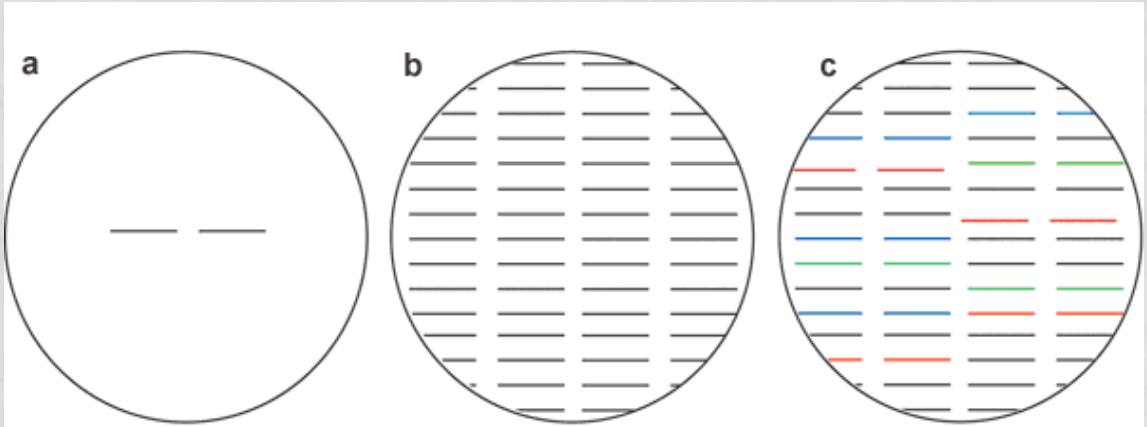


BioFabrication of Electronics
ICB-NSC-Cambrios (6.2)









a: Basic wire antenna

b-c: Large scale arrays of antennas will only be achieved by researching the commercial scale amplification of biological templates (b: arrays of one material forming one type of antenna; c:arrays of multiple materials forming multiple types of antennas.

OPPORTUNITIES FOR COLLABORATION

Joint projects funded through UARC

FY06 ICB 6.2 Program from ARO/ARL

Technology Transitioning via the Army Applied Biotechnology Center