Nano-Bio-Micro Interfaces

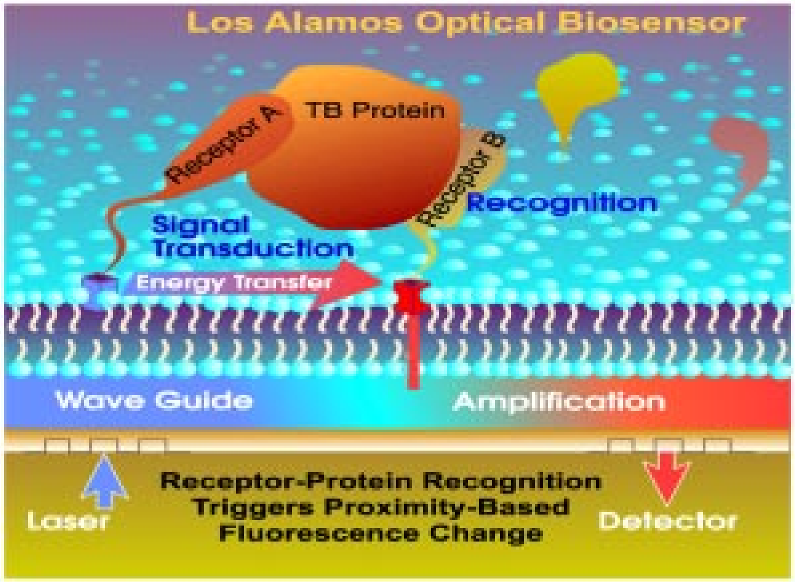
- Explore the *physical interface* between biomolecular systems and nanoscale synthetic materials

- Explore the multiple *length-scale interface* that bridges nanoscale functional assemblies to the micro (and larger) world of devices and applications

- Explore the *conceptual interface* of how biological systems can inspire the creation of new materials with new functions

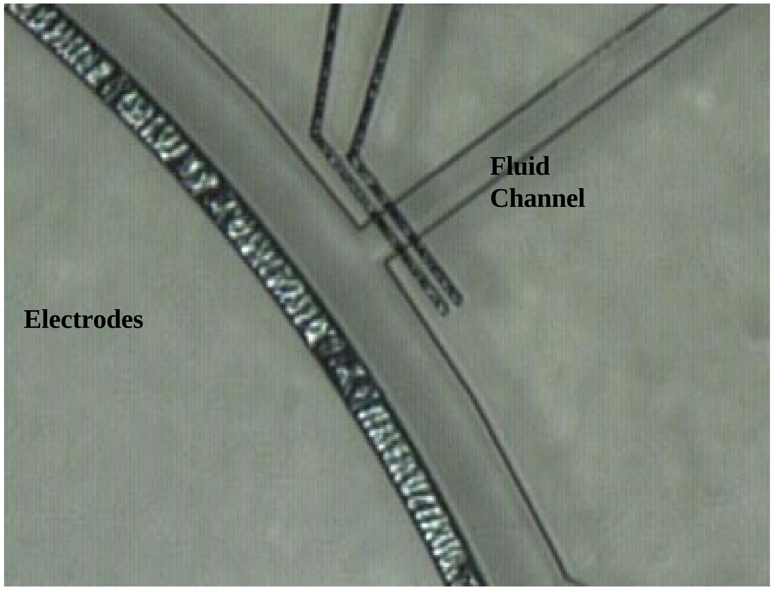
Examples

physical interface



Kelly, *et al* (LANL and U. of Arizona) "Integrated optical biosensor for detection of multivalent proteins" *Optics Lett.* 24 (1999) 1723.

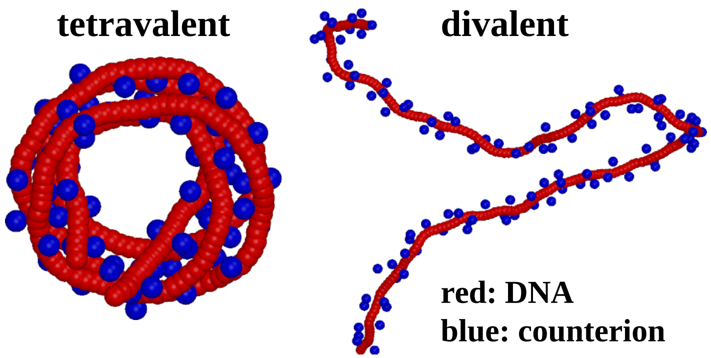
length-scale interface



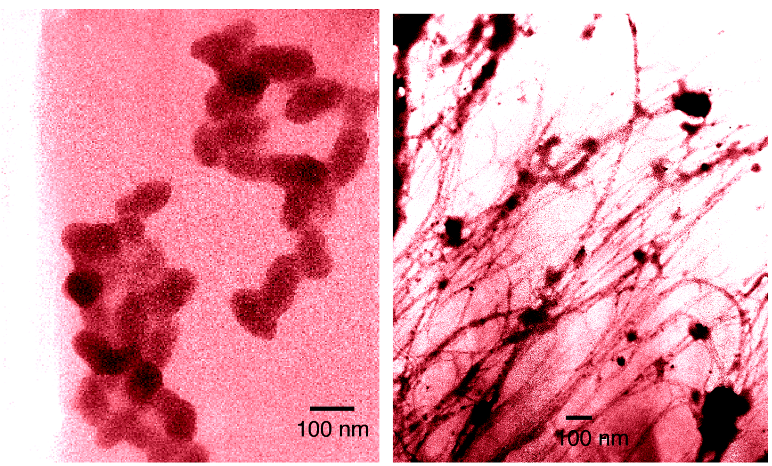
Microfluidic device fabrication (SNL)

Examples

conceptual interface

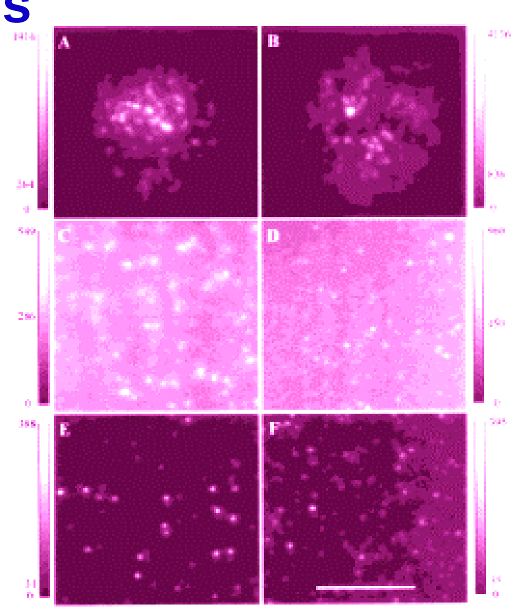


Stevens *et al* (SNL), "Simple simulations on DNA condensation" Biophys. J. 80 (2001) 130.



Wang *et al* (LANL), "Controlled synthesis of functional conducting polymer nanocomposites using polyelectrolyte templates" (2001).

advanced characterization tools

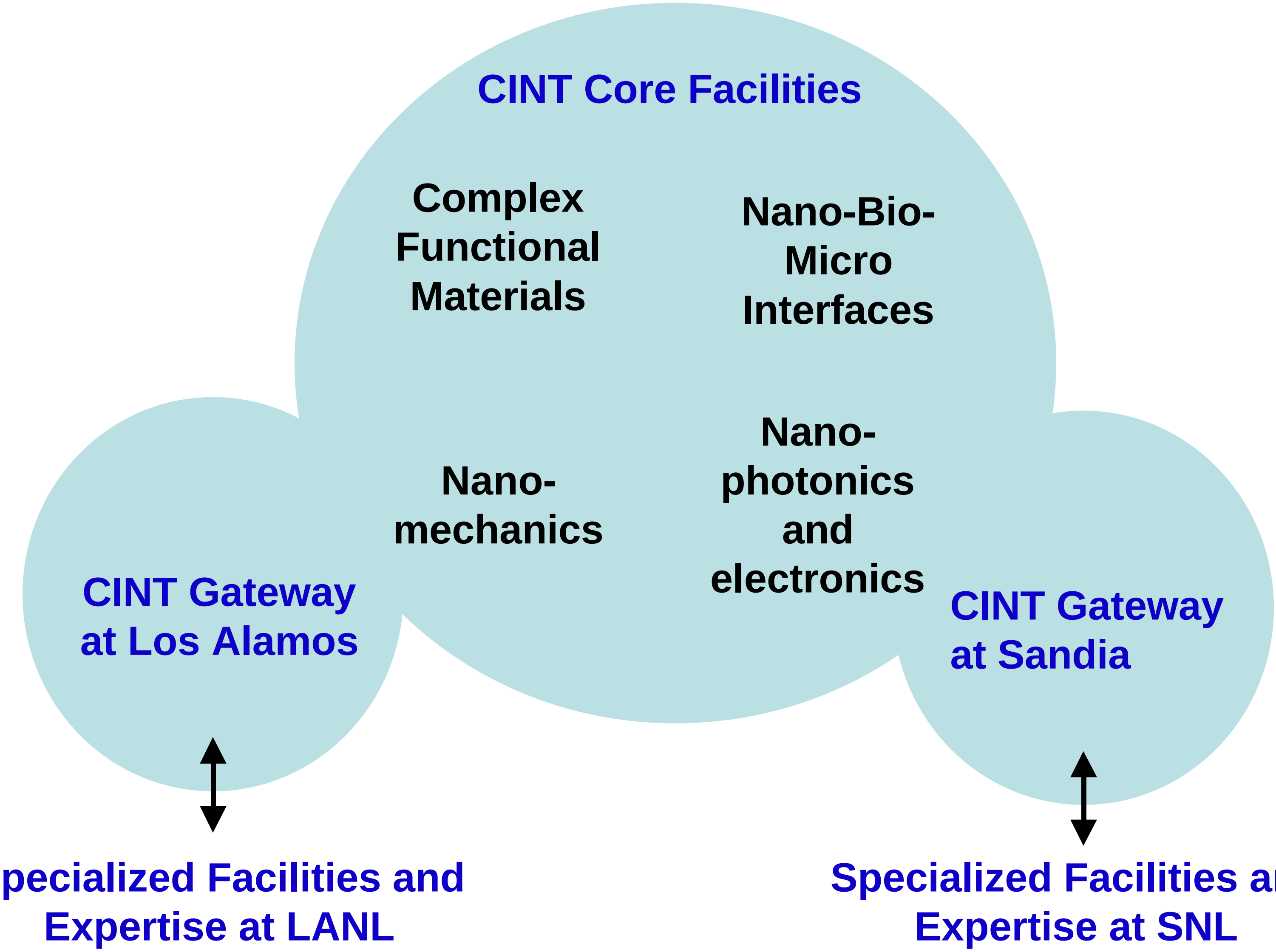


Ambrose, Goodwin, *et al* (LANL) "Single molecule detection with total internal reflection excitation …" *Cytometry* 36 (1999) 224.

How will CINT increase opportunities in Nano-Bio-Micro Interfaces?

- Collaborative, multi-disciplinary teams
  - ➢ Expertise in chemistry, physics, theory, biology and engineering
  - ➢ Connections between fundamental science (at CINT) and applications
- Access to capabilities at CINT and, through gateways, at Los Alamos and Sandia
  - ➢ Experimental probes (scanning probe microscopies, optical imaging and single molecule techniques, time-resolved spectroscopies, …)
  - ➢ Synthetic capabilities
  - ➢ Molecular and cell biology
  - ➢ Theory and high-performance computation
- Collaborators able to participate in and guide new capability development at CINT

Interaction of Collaborative User with CINT



Collaborators entering CINT have access to central capabilities, thrust capabilities, gateways, and non-CINT facilities at LANL, SNL.

CINT Staff Supporting Nano-Bio Interface Activities (partial listing)

Nano-Bio Interfaces

LANL	SNL
Andy Shreve	George Bachand
Peter Goodwin	Darryl Sasaki
Hsing-Lin Wang	Paul Ghorley
Woody Woodruff	John Shelnutt
Richard Keller	Alan Burns

LANL Gateway (Biomaterials)
Basil Swanson

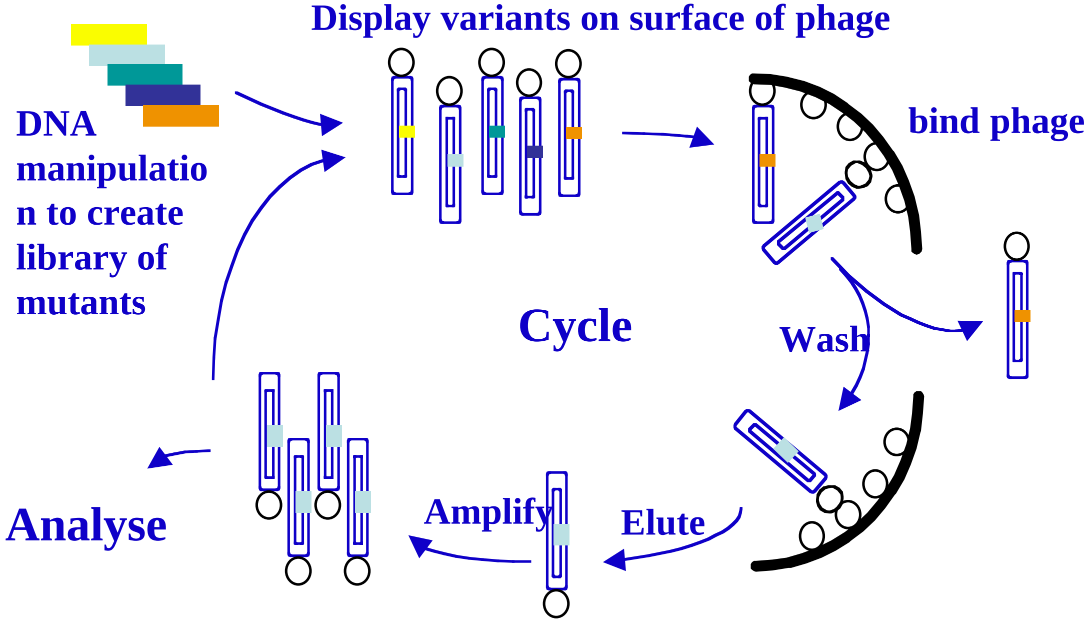
SNL Gateway (Characterization)
Jack Houston (IFM)

LANL Expertise (Biosciences)
Andrew Bradbury

SNL Expertise (Microelectronics)
Joel Wendt (e-beam Lithography)

Gateways Provide Nano-Bio-Micro Interfaces Thrust Area with Access to Critical National Lab Resources

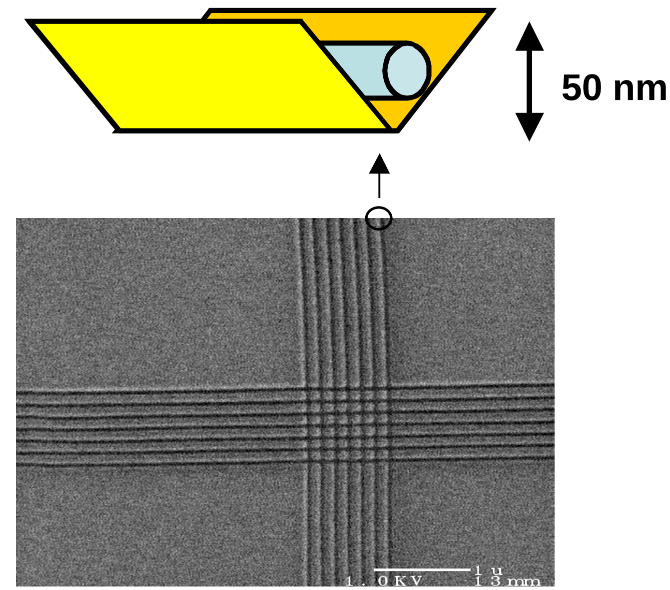
LANL Gateway (Biochemical Expertise)



Phage Display Methods (A. Bradbury *et al*, LANL, *Nature Biotech.* 18 (2000) 75; *J. Immunol. Methods* 253 (2001) 233.)

SNL Gateway Fabrication Capabilities

Microtubule confined in nanochannel

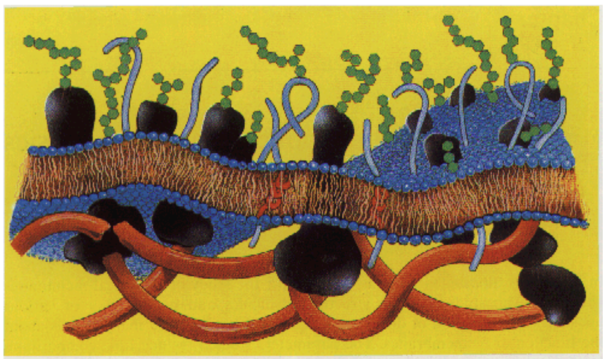


E-beam lithography (J. Wendt, SNL)

CINT collaborators can access LANL, SNL resources and expertise that are more specialized than those found in the CINT facility.

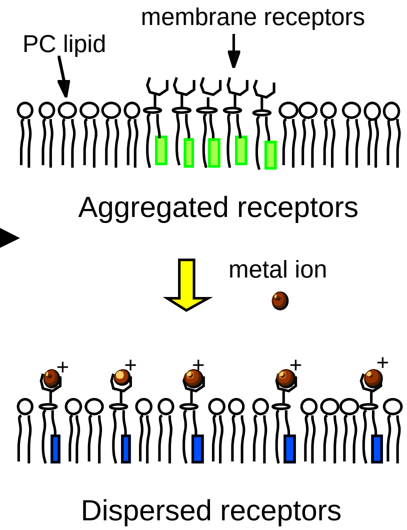
Scientific Challenges: (Physical Interface)
Integration of Functional Lipid Membranes into Complex Materials

Cell Membranes

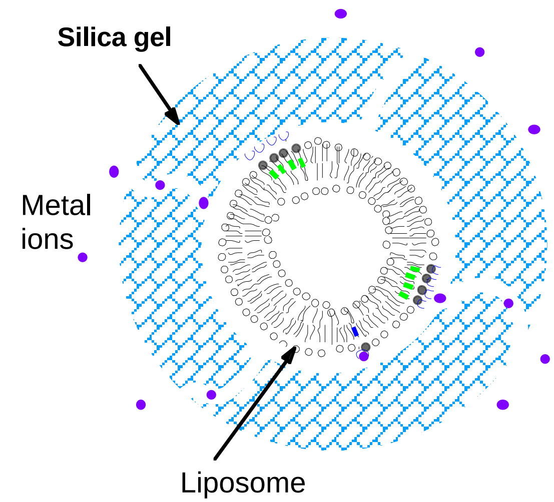


from "Liposomes: from physics to applications" D. D. Lasic, Ed.; Elsevier, 1993.

Functional Interfaces



3D-composites



***Nano-Bio-Micro Interfaces*:**
investigate and model membrane structures and functions

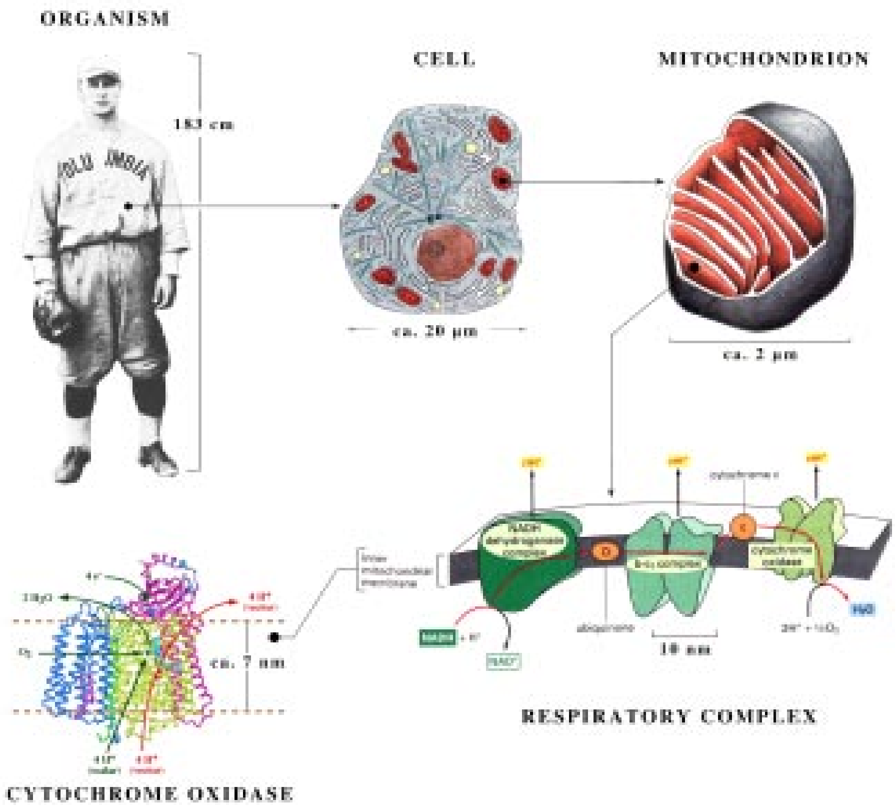
***Complex Functional Materials*:**
self-assembly of composites, investigations of composite functions

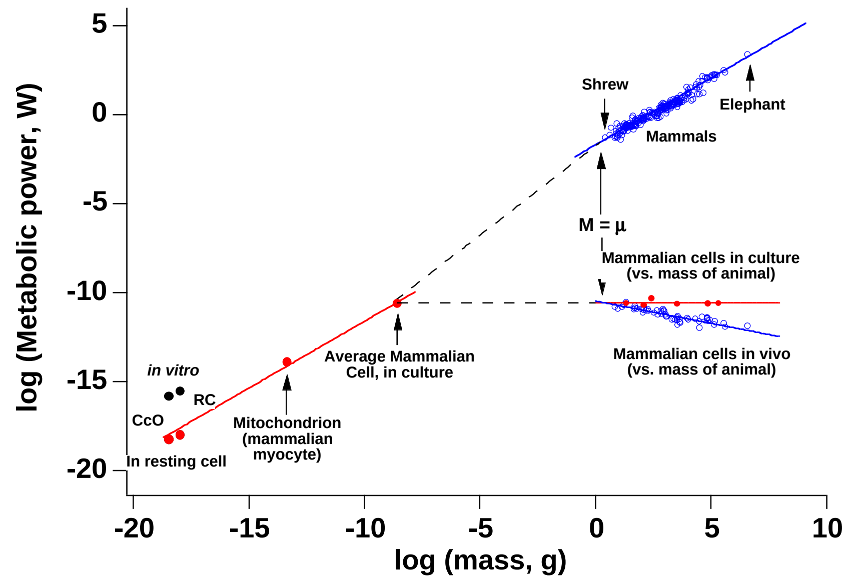
***Nanomechanics*:**
interrogate interfacial interactions and transport

***Nanophotonics/Electronics*:**
address active components and detect functional responses

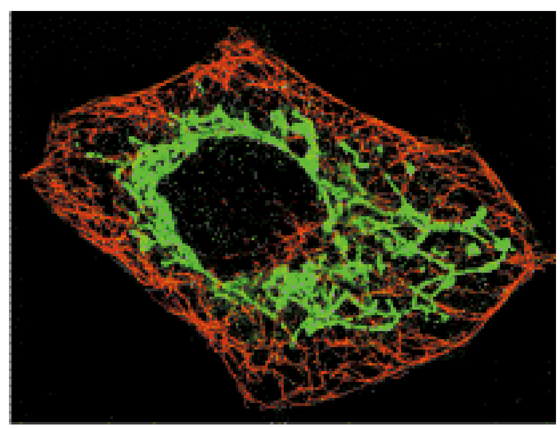
Scientific Challenges:
Bridging from Nano to Micro – What does biology teach us?
(Length scale and conceptual interfaces)

Multiple length scales and hierarchical organization in bioenergetics





West *et al*, "The origin of universal scaling laws in biology" ***Physica A*** **263** (1999) 104; "A general model for the origin of allometric scaling laws in biology" ***Science*** **276** (1997) 122; ***Proc Natl. Acad. Sci.***, submitted (2001).

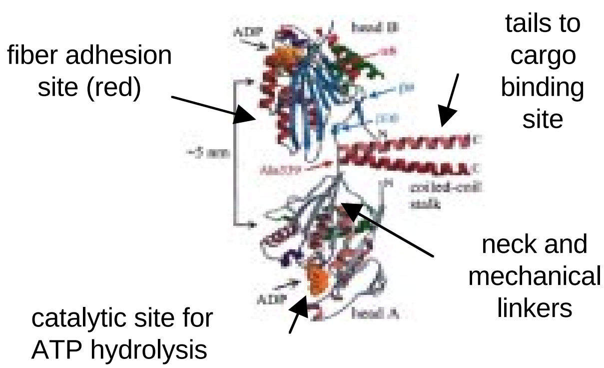


Time-averaged fluorescence image of mitochondria (green) and microtubules (red) in living cell; From M.P. Yaffe, *Science* 283 (1999) 1493.

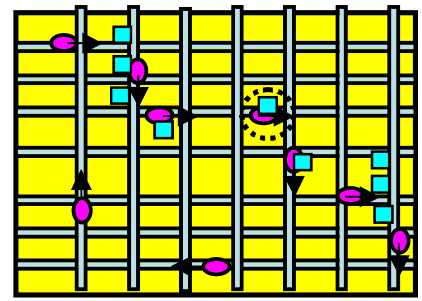
Can we control and optimize transport networks using lessons from biology?

How can motor proteins and interfaces be modified to provide transport that can be controlled and maintained in man-made systems?

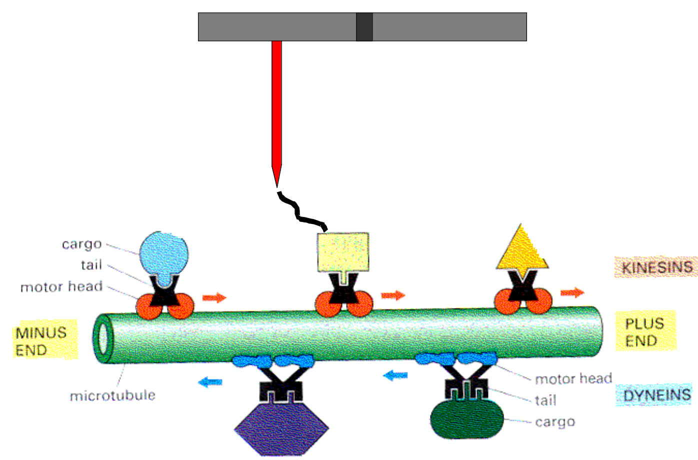
Modify Proteins



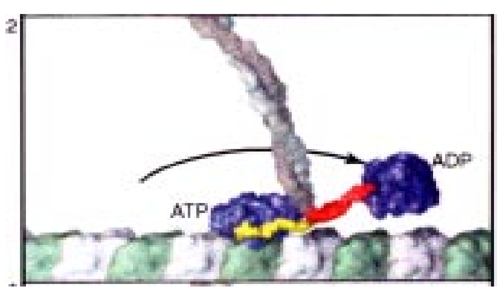
Assemble Fiber Networks



Monitor Protein Function



Activate Proteins

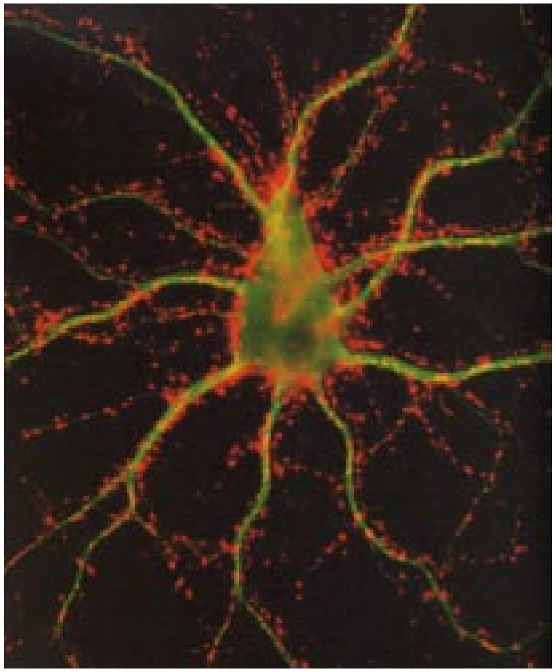


Scientific Challenge: Develop Materials Based on Attributes of Biological Systems by Control of Nano-Bio-Micro Interfaces

Hierarchical assembly, disassembly, replication
(length scale and conceptual interfaces)

Sensing and communication
(physical interface)

Response to stimuli
(physical interface)



Rat nerve cell
(Essential Cell Biology (1998))

Non-equilibrium systems
(conceptual interface)

Energy conversion
(length scale and conceptual interfaces)

Directed evolution
(conceptual interface)