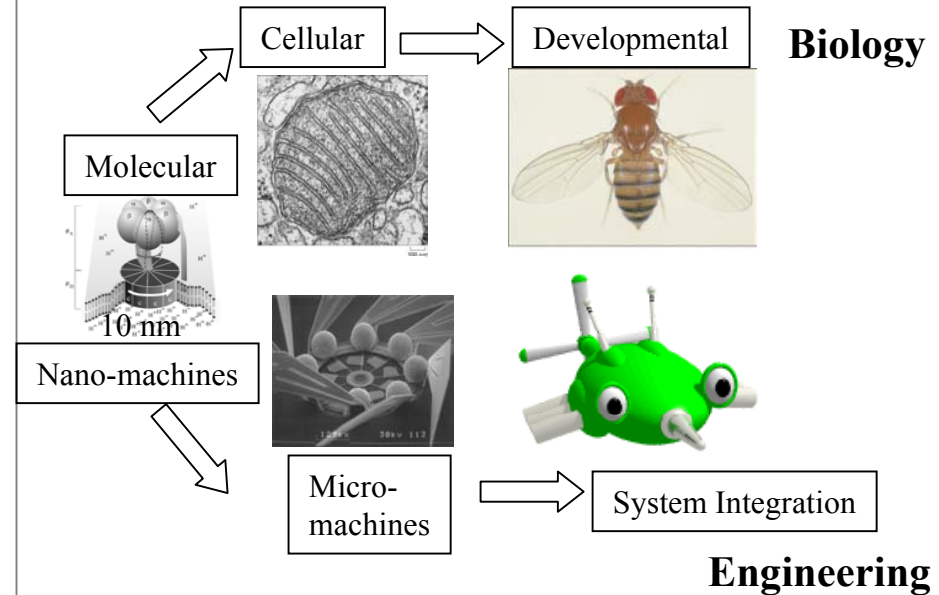


Goals and Potential Impact if Successful

Integrate nano-machines, e.g. proteins or their synthetic counterparts, with micro-machines and microelectronic, microwave and photonic devices for novel microsystems having the following potential impacts:

- molecular shuttles for BioMEMS with high-selectivity and high-speed reaction and detection.
- novel sensors and actuators using or emulating biological functions.
- *in vivo* energy sources for *in vivo* medical devices
- alternative energy sources based on sugar, fatty acid or other natural foods.



Approach

- Identify applications for protein-based, integrated nano/micro-systems.
- Develop packaging and interconnect schemes to integrate nano-machines into micro/nano sub-systems.
- Develop packaging and interconnect schemes to integrate the micro/nano subsystems with other micro-machines to form novel microsystems for the applications identified.

Accomplishments

- Developed a course for engineering and MCDB students.
- Modified optical and RF MEMS technologies, e.g. atomic layer deposition (ALD)-based self-assembled monolayer, for the self-assembly of nano-machines.
- Developed a feasible concept for a proton engine.

Bottlenecks and Open Research Questions

- Reliable nano-machines. Most of proteins and their synthetic counterparts are not reliable.
- Reliable micro-machines. Reliable MEMS devices are limited to those without contacts or with point contacts.
- Revised packaging and interconnect hierarchy and corresponding technologies for this new area.
- Surface science studies for reliable self-assembly. There is a need to address assembly yield and reliability.
- Energy conversion from proton gradients into electricity. Bridges connecting nano-machines to micro-machines are needed. One of them is to convert proton gradients generated by nano-machines into electricity to power micro-machines.