Nano/Bio Interface Center

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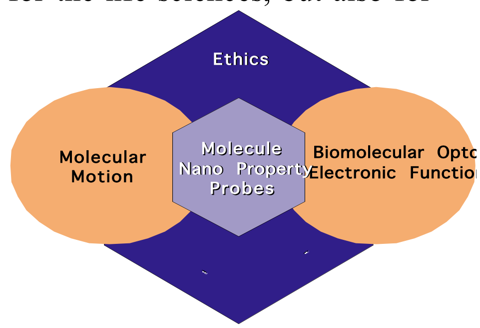
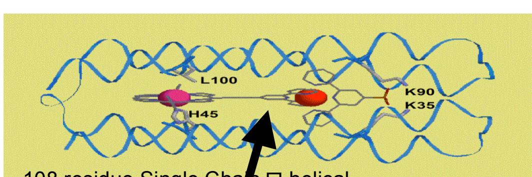
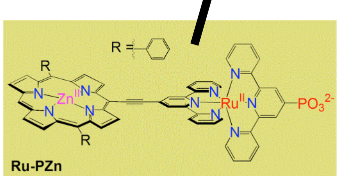
The ***Nano/Bio Interface Center*** **(NBIC)** at the University of Pennsylvania exploits Penn's strengths in design of molecular function and quantification of individual molecules to elucidate molecular interactions at the interface of physical and biological systems. The Center unites investigators from twelve departments in five schools (School of Engineering and Applied Science, School of Medicine, School of Arts and Sciences, Graduate School of Education and Wharton Business School) to provide, not only new directions for the life sciences, but also for engineering, in a two-way flow essential to fully realizing the benefits of the intersection of biology with nanotechnology.



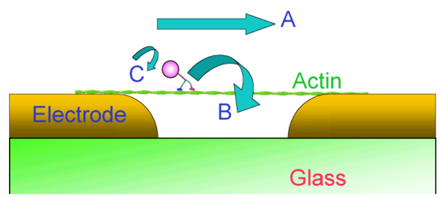
The fundamental research themes are: designed optoelectronic function in synthetic biomolecules and mechanical motion of molecules from physiological systems. Research Team 1 uses theoretical and experimental techniques to design and synthesize compounds that test fundamental bases of properties, determines mechanisms of functionality and assembles complex nanostructures that exploit the functionality to demonstrate opto-electronic device-like behavior. Research Team 2 develops methods of positioning biological macromolecules and controlling the thermal/chemical/mechanical environment, and determines the mechanisms associated with protein motion. Cross Cutting Initiative 1 develops the tools necessary to accomplish these goals, specifically by combining near field optical probes with mechanical and electronic probes at the single molecule level. Cross Cutting Initiative 2 engages internal and public discourse on ethical issues in nanotechnology using a platform of risk assessment to frame the activities. The ***NBIC*** houses an experimental facility that is a technical incubator of new probes of single molecule behavior (The Nano/Bio Probe Innovation Facility).

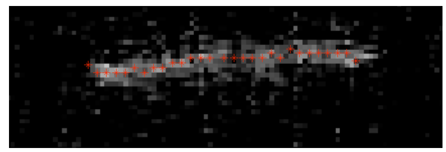




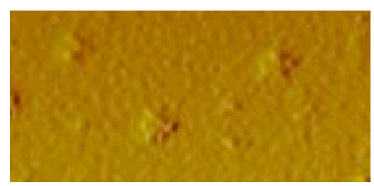
In Research Team -1 biomolecular optoelectronic function is produced by combining a new class of chromophores with synthetic polypeptides. Computational design (*Saven, DeGrado*) of four-helix bundles that bind and orient nonbiological metalloporphyirn cofactors has been extended towards chromophores which exhibit potent electrooptic properties (*Therien*), such as RuPZn. A single chain four-helix bundle was designed from first principles to bind uniquely RuPZn**.** The PZn unit is coordinated to the peptide through the single histidine residue (H45; a leucine residue, L100, is positioned on the distal side of nthe zinc porphyrin moiety). Additional electrostatic support is offered from two lysine residues (K35, K90) positioned towards the phosphate functional group of the terpyridyl ligand. This peptide has been made via protein expression strategies. Johnson and Bonnell have developed strategies for single molecule measurement; *in situ* nano electrode formation and simultaneous transport measurement in TEM and scanning probe based frequency dependent transport. Ferroelectric Nanolithography is being used to integrate the optically active synthetic peptides into pre designed multi component devices such as switches and sensors.

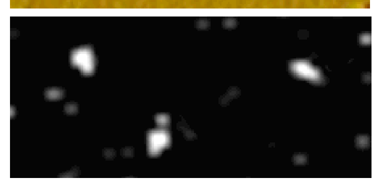
In Research Team -2 the mechanical molecular motion of individual ribosomes and motor proteins is systematically studied in order to determine mechanisms of transduction and translocation, processes that are critical to both cellular function and to engineering molecular motors. Most motility experiments are carried out with filaments immobilized to a surface. This arrangement hinders the filament's motion and prevents the motor from twisting around the filament. Thus, the geometry for observing motor activity in laboratory experiments is far from a representation of *in vivo* conditions. *Bau, Goldman*, and Sellars (NIH) patterned a pair of electrodes on glass substrates, etched a groove in the gap between the electrodes, and used dielectrophoretic nano-positioning to place actin filaments across the electrodes. The motion of the filaments was imaged optically, digitized, and their modes of vibrations analyzed. Microfluidic hydrodynamic mixing chambers have been designed (Bau and Hu) to control chemical environments with mixing rates sufficiently fast to quantify reaction dynamics and Composto has designed block copolymer templates with nm scale morphology to position actin filaments. A physical theory of dynamics of particles tethered by long nucleic acids was constructed.





Cross Cutting Initiative-1 is developing new approaches to probe and manipulate molecular/nanostructural function to exploit address challenges specific to molecular function at interfaces. Recent advances include the first simultaneous fluorescence and AFM imaging of a single ribosome (Discher) and 3-D tomography of sub wavelength features with near field optical probes (Schotland). Single molecule fluorescence and AFM have separately emerged as two of the most critical tools for biophysics. Discher and Goldman are combining the two methods to better understand ribosomes, which are the cell's complex protein synthesis 'factories'. Dual modality nano-imaging presents problems in coupling such as optical or mechanical interference, but these problems are solvable as illustrated by simultaneous imaging of individual ribosomes.





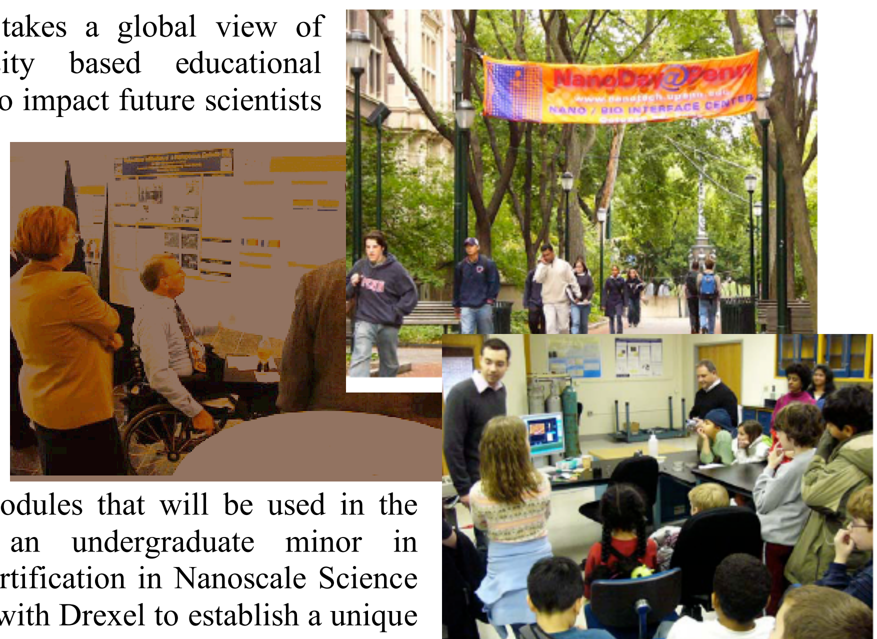
The focus on probe development results in a unique set of shared facilities that are also a platform for interaction with industry. The combined fluorescence/AFM is done within the context of a Veeco beta site for the BioScope, which resulted in substantial several shop notes and redesign of the microscope. The Nano/Bio Probe Facility benefits from support by several metrology companies.

Cross Cutting Initiative -2 is integrating consideration of ethics in all NBIC activities, through workshops for students and faculty, discussions and tutorials in educational outreach initiatives, content to formal courses, and public engagement. A pilot study on risk perception is being used to drive a national study on this critical topic.

The International Nano/Bio Probe Network

With the development of an industry that supplies instrumentation for local probes and the increasing relevance of these length scales in research and manufacturing , the use of these techniques has expanded widely across a range of disciplines. At the same time, scientific issues at the cutting edge of next generation techniques are increasing in complexity. This evolution has resulted in a lack of venue for synergistic exchange between scientists and engineers advancing the field. On Jan. 16/17, 2006 Penn hosted a workshop of a subset of international leaders in the field with industry and government representatives to address this issue. Attendees from Europe, Asia and the US discussed future goals and challenges and proposed the International Network. The NBIC developed the electronic infrastructure that facilitates discussion, collaboration and open source technology development.

The ***Nano/Bio Interface Center*** takes a global view of education, linking the university based educational initiatives with outreach activities to impact future scientists and engineers at all stages of development. With the City of Philadelphia School District we have developed a program that engages high school students in science activities, virtually all of whom are from underrepresented groups and more than half of whom are female. A multi component professional development program produces modules that will be used in the classroom. Penn established an undergraduate minor in Nanotechnology and a graduate certification in Nanoscale Science and Technology and has partnered with Drexel to establish a unique model of graduate education based on a Two University/One Campus concept.



References (10 point font)

[1] For further information about this project link to **<www.nanotech.upenn.edu>** or email **<Bonnell@lrsm.upenn.edu>**