

Prof. Chad A. Mirkin

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(<http://chemgroups.northwestern.edu/mirkingroup/>)



Dr. Chad A. Mirkin is the Director of the International Institute for Nanotechnology and the George B. Rathmann Professor of Chemistry, Professor of Chemical and Biological Engineering, Professor of Biomedical Engineering, Professor of Materials Science and Engineering, and Professor of Medicine.

Professor Mirkin is a chemist and a world renowned nanoscience expert, known for his development of nanoparticle-based biodetection schemes, the invention of Dip-Pen Nanolithography, and contributions to supramolecular chemistry, nanoelectronics, and nanooptics. He has authored over 400 manuscripts and 360 patents and applications, and has founded three companies, (Nanosphere, Nanoink, Aurasense) to commercialize nanotechnology in life science and semiconductor industries.

Dr. Mirkin has been recognized for his accomplishments with over 60 national and international awards. These include the \$500,000 Lemelson-MIT Prize, Havinga Medal, Gustavus John Esselen Award, Biomedical Engineering Society's Distinguished Achievement Award, Pittsburgh Analytical Chemistry Award, ACS Inorganic Nanoscience Award, iCON Innovator of the Year Award, NIH Director's Pioneer Award, Collegiate Inventors Award, National Inventors Hall of Fame (2002, 2004), ACS Nobel Laureate Signature Award for Graduate Education in Chemistry, Feynman Prize in Nanotechnology, I-Street Magazine's Top 5 List for Leading Academics in Technology, MRS Young Investigator Award, ACS Award in Pure Chemistry, PLU Fresenius Award, Harvard University E. Bright Wilson Prize, BF Goodrich Collegiate Inventors Award, Camille Dreyfus Teacher-Scholar Award, Alfred P. Sloan Foundation Award, DuPont Young Professor Award, NSF Young Investigator Award, Naval Young Investigator Award, Beckman Young Investigator Award, Dreyfus Foundation New Faculty Award and numerous others.

At present, he is a member of President Obama's Council of Advisors for Science and Technology, a member of the National Academy of Engineering and a Fellow of the American Association for the Advancement of Science. Dr. Mirkin has served on Editorial Advisory Boards of over twenty scholarly journals including *Journal of American Chemical Society*, *Angewandte Chemie (International Edition)*, *Accounts of Chemical Research*, *Advanced Materials*, *BioMacromolecules*, *Macromolecular Bioscience*, *SENSORS*, *Encyclopedia of Nanoscience and Nanotechnology*, *Chemistry-A European Journal*, *Chemistry & Biology*, *Nanotechnology Law & Business*, *The Scientist*, *Journal of Materials Chemistry*, and *Journal of Cluster Science*, *Plasmonics*. He is the founding editor of the journal *Small*, and he has co-edited two bestselling books on nanobiotechnology.

Dr. Mirkin holds a B.S. degree from Dickinson College (1986, elected into Phi Beta Kappa) and a Ph.D. degree in chemistry from the Pennsylvania State University (1989). He was an NSF Postdoctoral Fellow at the Massachusetts Institute of Technology prior to becoming a chemistry professor at Northwestern University in 1991.

Abstracts:

Research Lecture

The Polyvalent Gold Nanoparticle Conjugate: Materials Synthesis, Biodiagnostics, and Intracellular Gene Regulation

Tuesday, October 5, 2010. 4:00 p.m.

Lecture Theatre - Science B 103 (SB 103)

Over the past decade, we have developed methods for modifying nanoparticles with oligonucleotides and explored how they can be used as designer constructs for preparing highly ordered, highly functional materials. Some of these structures are crystalline and have lattice parameters which are tailorable by virtue of nanoparticle and DNA synthon. Over the course of these studies, we have discovered many unusual fundamental properties that make these materials particularly useful in biodiagnostics and intracellular gene regulation. This seminar will focus on the rules that govern the use of these conjugates and sequence specific crystallization, high selectivity and sensitivity nucleic acid and protein detection, and "antisense" therapy. Specifically, we will introduce the concept of the "antisense particle", as well as similarly functionalized siRNA particles, which exhibit a range of unique properties that make them very well-suited for gene regulation. In particular, the particles are highly resistant to nuclease digestion, have high and tailorable binding constants for target mRNA, and

exhibit high entry efficiency into multiple cell types. Further, we can tailor the chemistry on the nanoparticle surface, and thus control the particles' binding strength to complementary target sequences, ultimately demonstrating that changing the binding strength or surface chemistries offers a means to control the degree of protein expression.

Public Lecture

Molecular Printing: A Chemist's Approach to a Desk Top Fab

Wednesday, October 6, 2010. 7:00 p.m.

Lecture Theatre – ICT 102

Microfabrication and printing techniques have revolutionized the world, as they are the backbone of the microelectronics industry and the microarrays used in the life sciences. Over the past decade, there have been major advances in the development of nanoscale molecular printing tools, techniques that allow one to chemically control a surface with sub-100 nm resolution. A number of lithography techniques appropriate to fabricating nanoscale integrated circuits include multi-photon induced photoresist polymerization, zone-plate array lithography, and phase-shift photolithography. Though these methods are highly parallel, they rely on non-standard optical instrumentation and light sources not readily available to most researchers or preclude arbitrary nanoscale pattern formation. Established methods such as electron-beam lithography and focused ion beam (FIB) lithography have been employed for generating complex nanoscale patterns, but such approaches are low throughput and restricted to scan areas several hundred microns in length. Furthermore, the aforementioned nanolithography techniques are not amenable to the direct deposition of soft materials (e.g. DNA, proteins, lipids) because of harsh conditions used during patterning. Traditional approaches for making DNA or protein microarrays include photolithography and inkjet printing, but these methods do not allow one to generate nanoscale patterns relevant to making dense biosensor arrays or artificial environments that mimic the extracellular matrix.

Recently, massively parallel scanning-probe based methods have been used to address such challenges and mark a step towards the realization of a "desktop fab." Such a tool should enable simple, flexible, high-throughput, and low-cost nano- and microscale patterning and allow chemists, biologists, and engineers to rapidly synthesize and study systems pertaining to nanoparticle catalysis, single particle electronic devices, and biochemical processes at the cell surface. Specifically, polymer pen lithography (PPL) is a scanning probe-based molecular printing method, which uses arrays of elastomeric tips to transfer chemically reactive materials (e.g. alkanethiols, proteins, polymers) in a direct-write manner onto a variety of surfaces. PPL enables one to print patterns of nanometer and micrometer-sized features over large areas with high registry and at low cost. Features generated by PPL depend on tip-substrate contact time in addition to the amount of force applied to the tips. We have studied the force dependency in detail and were able to derive a quantitative model relating feature edge length and applied force that matches experimental results. The science and development of PPL has enabled researchers to systematically investigate phenomena in chemistry, biology, and materials science. As a start, we have explored the use of PPL for patterning multiple bioactive proteins at the same time and synthesizing sub-10 nm crystalline nanoparticles on a surface, opening up the possibility for studying catalysis and a wide variety of single particle devices.

Research Lecture

Allosteric Supramolecular Catalysts and Enzyme Mimics

Thursday, October 7, 2010. 11:00 a.m.

Lecture Theatre- MacEwan Conference and Student Centre (MSC) Room: Cassio A & B

Through the use of enzymes and related structures, Nature takes a complex, integrated approach to regulating cellular activities via signal cascades, molecular transport, and catalysis. These critical functions are performed using information storage and retrieval processes that make use of molecular recognition. Our efforts aim to develop a supramolecular toolbox for the preparation of abiotic enzymatic systems that effectively mimic the reactivity and properties inherent in allosteric biological systems. To this end, synthetic organic and inorganic chemistries are employed in parallel with macromolecular modeling in order to create molecular machines based on stimuli-responsive metal-organic supramolecular structures. Although these supramolecular entities have little or nothing in common with basic elements of the biological toolbox (proteins, RNA, DNA, lipids, etc.), they exhibit a full range of bio-inspired functions including selective guest substrate recognition and binding, cooperativity, regulated shape change, and unique catalytic properties. This presentation will address synthetic methods and challenges in developing a general methodology for the construction of abiotic supramolecular assemblies and highlight the most recent advances and discoveries pertaining to applications of allosterically induced recognition, catalysis, and self-amplification.