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California Institute of Technology  
Tuesday, October 24, 2017; 8:10 AM

Frances Arnold is the Dickinson Professor of Chemical Engineering, Biochemistry, and Bioengineering at the California Institute of Technology, where her work focuses on protein engineering by directed evolution, with applications in energy, chemicals, and medicine. Her laboratory pioneered enzyme evolution methods widely used in academic and industrial laboratories to create new protein catalysts. The recent focus is on creating new enzymes for abiological chemistry and expanding the catalytic repertoire of the biological world.

Dr. Arnold's contributions have been recognized by the Raymond and Beverly Sackler Prize in Convergence Research (2017), the Millennium Technology Prize (2016), the Eni Prize in Renewable and Nonconventional Energy (2013), and the Charles Stark Draper Prize of the US National Academy of Engineering (2011). She was awarded the National Medal of Technology and Innovation in 2011 and was inducted into the National Inventors Hall of Fame in 2014. She has also been elected to membership in all three US National Academies of Science, Medicine, and Engineering and the American Academy of Arts and Sciences. Prof. Arnold has honorary doctorates from Stockholm University, the ETH Zurich, and the University of Chicago.

Dr. Arnold chairs the Advisory Panel of the David and Lucile Packard Foundation Fellowships in Science and Engineering program and serves as a judge for the Queen Elizabeth Prize in Engineering. She holds more than 50 US patents and is active in technology transfer. Dr. Arnold received her BS in Mechanical and Aerospace Engineering from Princeton University and a PhD in Chemical Engineering from UC Berkeley.

### **Abstract: Biocatalysts for Abiological Chemistry: Bringing New Chemistry to Life**

We create enzymes that catalyze reactions not known in living systems. Our approach to expanding nature's catalytic repertoire is inspired by how nature innovates: new enzymes appear when the 'promiscuous' activities of existing proteins become useful for meeting new challenges or exploiting new opportunities. Mimicking this, we start with existing proteins (in my refrigerator or in databases) and identify catalytic activities that may be known to synthetic chemistry but that nature has not (yet) discovered. Proteins with even very low levels of activity can become new enzymes as we accumulate beneficial mutations in sequential rounds of mutation and screening (directed evolution).

We have found that heme proteins are a wonderful source of new biochemistry: engineered cytochrome P450s and other heme proteins catalyze a wide range of synthetically useful carbene and nitrene transfer reactions, from alkene cyclopropanation to Si-C bond formation to direct amination of C-H bonds. It's fascinating to observe how members of nature's vast catalog of proteins can be evolved—with only a few mutations—to catalyze these reactions with high efficiency and selectivities, even selectively forming chemical bonds that are unknown in biology. These results demonstrate the ease with which evolution can innovate. In the future these fully genetically-encoded catalysts may access vast areas of chemical space that life has not explored.

"Directed Evolution of Cytochrome c for Carbon-Silicon Bond Formation: Bringing Silicon to Life," S.B. J. Kan, R. D. Lewis, K. Chen, F. H. Arnold. *Science* 354, 1048-1051 (2016).

"Highly Stereoselective Biocatalytic Synthesis of Key Cyclopropane Intermediate to Ticagrelor," K. E. Hernandez et al. *ACS Catalysis* 6, 7810-7813 (2016).

"Enzyme-Controlled Nitrogen-Atom Transfer Enables Regiodivergent C-H Amination" T. K. Hyster et al., *J. Am. Chem. Soc.* 136, 15505-15508 (2014).



## Charles M. Lieber

Harvard University

Tuesday, October 24, 2017; 9:00 AM

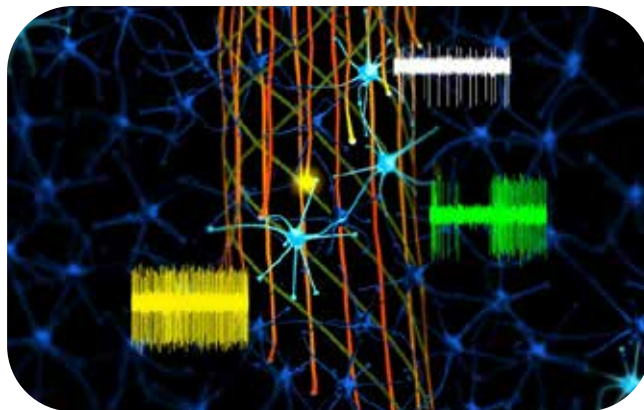
Charles M. Lieber received his undergraduate degree from Franklin and Marshall College and carried out his doctoral studies at Stanford University, followed by postdoctoral research at the California Institute of Technology. He was an Assistant Professor at Columbia University, and now holds appointments in the Department of Chemistry and Chemical Biology, as the Mark Hyman Professor of Chemistry, and in the John A. Paulson School of Engineering and Applied Sciences at Harvard University. He also serves as the Chair of the Department of Chemistry and Chemical Biology. Lieber has pioneered the synthesis of a broad range of nanowire materials, the characterization of the fundamental properties of these materials,

the development of methods of hierarchical assembly of nanowires, and applications of these materials in nanoelectronics, nanophotonics, and nanocomputing. He has pioneered the field of nano- bioelectronics with seminal contributions to sensing, the development of novel nanoelectronic cell probes, and cyborg tissues.

Lieber's work has been recognized with many awards, including the MRS Von Hippel Award (2016), Remsen Award (2016), IEEE Nanotechnology Pioneer Award (2013), Willard Gibbs Medal (2013), and Wolf Prize in Chemistry (2012). Lieber is an elected member of the National Academy of Sciences and the American Academy of Arts and Sciences. He is Co-Editor of *Nano Letters*, and has published over 380 papers and is the principal inventor on more than 40 patents.

### **Abstract: Nanoelectronic Tools for Brain Science**

Nanoscale materials enable unique opportunities at the interface between the physical and life sciences, for example, by integrating nanoelectronic devices with cells and/or tissue to make possible communication at the length scales relevant to biological function. In this presentation, I will overview a new paradigm for seamlessly merging nanoelectronic arrays and circuits with the brain in three-dimensions (3D), syringe-injectable mesh electronics. First, the design and properties of the mesh electronics with micrometer feature sizes and effective bending stiffness values similar to neurons and neural tissue will be described. Second, I will describe quantitative time-dependent histology studies demonstrating the absence of a tissue immune response on at least a year time-scale, as well as interpenetration of neurons and neurofilaments through the open mesh electronics structures. Third, I will report electrophysiology data demonstrating the capability to track and stably record from the same single neurons and neural circuits for more than a year. Fourth, I will describe several 'applications' of the unique mesh electronics capabilities that provide new insight into fundamental brain science problems, including aging and vision. Finally, the prospects for future advances of these nanoelectronic tools for overcoming complex challenges in neuroscience through the development of precision electronic therapeutics and brain-machine interfaces will be discussed.



Syringe-Injectable Mesh Electronics



## Joseph M. DeSimone

University of North Carolina at Chapel Hill  
Tuesday, October 24, 2017; 10:05 AM

Dr. Joseph M. DeSimone is the CEO/Co-founder of Carbon, Inc. located in Silicon Valley. Prior to this, DeSimone was the Chancellor's Eminent Professor of Chemistry at the University of North Carolina at Chapel Hill, and William R. Kenan, Jr. Distinguished Professor of Chemical Engineering at North Carolina State University and of Chemistry at UNC. DeSimone has published over 300 scientific articles and has over 150 issued patents in his name with over 200 patents pending. In June, 2016 DeSimone was recognized by President Barack Obama with the National Medal of Technology and Innovation.

DeSimone is one of less than twenty individuals who have been elected to all three branches of the U.S. National Academies: National Academy of Medicine (2014), National Academy of Sciences (2012) and the National Academy of Engineering (2005). He is also a member of the American Academy of Arts and Sciences (2005). DeSimone has received over 50 major awards and recognitions including the inaugural \$250,000 Kabiller Prize in Nanoscience and Nanomedicine; 2015 Dickson Prize from Carnegie Mellon University; 2014 Industrial Research Institute Medal; 2014 Kathryn C. Hach Award for Entrepreneurial Success; 2012 Walston Chubb Award for Innovation by Sigma Xi; 2010 AAAS Mentor Award in recognition of his efforts to advance diversity in the chemistry PhD workforce; 2009 NIH Director's Pioneer Award; 2009 North Carolina Award; 2008 \$500,000 Lemelson-MIT Prize for Invention and Innovation; 2002 John Scott Award presented by the City Trusts, Philadelphia, given to "the most deserving" men and women whose inventions have contributed in some outstanding way to the "comfort, welfare and happiness" of mankind; and 2002 Engineering Excellence Award by DuPont.

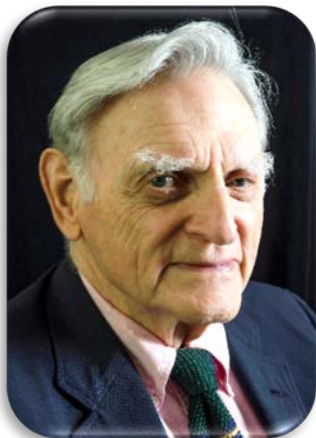
DeSimone is the co-founder of several companies including Micell Technologies, Bioabsorbable Vascular Solutions, Liquidia Technologies and Carbon. DeSimone received his B.S. in Chemistry in 1986 from Ursinus College in Collegeville, PA and his Ph.D. in Chemistry in 1990 from Virginia Tech. He currently resides in Monte Sereno, California with his wife of 30 years, Suzanne.

### **Abstract: Future Fabricated with Light: Continuous Liquid Interface Production to Drive Additive Manufacturing**

Despite the increasing popularity of 3D printing, also known as additive manufacturing (AM), the technique has not developed beyond the realm of rapid prototyping. This confinement of the field can be attributed to the inherent flaws of layer-by-layer printing, and in particular, anisotropic mechanical properties that depend on print direction, visible by the stair-casing surface finish effect. Indeed "3D printing" is a misnomer: it is actually 2D printing over and over again. This lecture will describe a new advance in additive manufacturing that is rapid, continuous and no longer layer-by-layer that promises to advance industry beyond basic prototyping to 3D manufacturing. The new Continuous Liquid Interface Production technology (CLIP) harnesses light and oxygen to continuously grow objects from a pool of resin instead of printing them layer-by-layer. CLIP capitalizes on the fundamental principle of oxygen inhibited photopolymerization to generate a continual liquid-interface of uncured resin between the growing part and the exposure window. This interface eliminates the necessity of an iterative layer-by-layer process allowing for continuous production. CLIP technology raises the state-of-the-art in additive manufacturing in three ways:

- GAME-CHANGING SPEED: 25-100 times faster than conventional 3D printing
- COMMERCIAL QUALITY: produces objects with consistent mechanical properties
- MATERIAL CHOICE: enables a broad range of polymeric materials

Moreover, continuous production enables advantages including the fabrication of large overhangs without the use of supports, reduction of the stair-casing effect without compromising print time, and isotropic mechanical properties. Combined, these advantages result in multiple indicators of layerless and monolithic fabrication using CLIP technology.



## John B. Goodenough

The University of Texas at Austin  
Tuesday, October 24, 2017; 10:55 AM

John B. Goodenough is a Professor of Materials Engineering at The University of Texas at Austin. After returning from World War II, he received a Ph.D. in Physics from the University of Chicago in 1952, was a Group Leader of The MIT Lincoln Laboratory from 1952-1976 where he helped to develop the magnetic memory element of the first RAM of the digital computer and engaged in fundamental studies of transition-metal oxides. From 1976-1986, he was Professor and Head of the Inorganic Chemistry Laboratory of the University of Oxford, England, where he developed the cathodes that have enabled the Li-ion battery, and since 1986 he has held the Virginia H. Cockrell Centennial Chair of Engineering at The University

of Texas at Austin where he has continued development of the rechargeable battery, catalytic electrodes for the solid oxide fuel cell, and the use of high pressure to study the transition from localized to itinerant *d* electrons in transition-metal oxides.

### **Abstract: Rechargeable Batteries: Evolution and Promise**

In 1967, invention at the Ford Motor Company of the lithium-sulfur rechargeable battery consisting of liquid electrodes and a ceramic electrolyte stimulated interest in new battery strategies. In the early 1970's, the first energy crisis awakened some to the vulnerability of modern society to its dependence on fossil fuels, particularly oil. In the late 1960's, studies in France and Germany of the chemistry of lithium intercalation into the layered sulfides led, in the 1970's, to exploration of the Li/TiS<sub>2</sub> battery cell, an effort that was abruptly abandoned because during charge of a lithium anode from a flammable liquid electrolyte anode dendrites grow across the electrolyte to create an internal short-circuit with incendiary consequences. This problem led to exploration of extraction of lithium from layered oxides since a rechargeable-battery cell can be fabricated in a discharged state and the oxides offer a cell of higher voltage. In Japan, lithium intercalated into graphite offered a dendrite-free anode, which made graphitic carbon a low-cost discharged anode. The SONY Corp. of Japan used the carbon/LiCoO<sub>2</sub> Li-ion battery to launch the wireless revolution. However, this application does not compete with the energy stored in a fossil fuel, and the flammable liquid electrolyte has prevented development of the Li-ion battery to where it can power an all-electric road vehicle competitive in cost with a vehicle powered by an internal combustion engine. Realization of how to plate a lithium anode without dendrites and the development of a glass electrolyte with a Li<sup>+</sup> conductivity approaching that of the flammable liquid electrolyte is providing new concepts of battery-cell design that offer promise of an energy economy that can reduce our dependence on fossil fuels and the emissions of polluting gases from our highways.



## Stephan Link

Rice University

Tuesday, October 24, 2017; 1:00 PM

Stephan Link is Associate Professor of Chemistry and of Electrical and Computer Engineering at Rice University in Houston. He received his Ph.D. in chemistry in 2000 from the Georgia Institute of Technology where he worked for Professor Mostafa A. El-Sayed. In 2006, he joined the Rice Chemistry Department after postdoctoral positions at Georgia Tech and the University of Texas at Austin, where he worked for Professor Paul F. Barbara. Link is a leader in the field of plasmonics and nanophotonics. His group applies single-molecule and single-particle spectroscopy techniques to help decipher the physical rules that explain how plasmonic nanoparticles interact with one another and with their environment. His goal is to

better understand how to use plasmons to probe materials and initiate chemical reactions.

Link is the 2015 recipient of the Welch Foundation's Norman Hackerman Award in Chemical Research. Other awards during his independent career include the inaugural Outstanding Young Scientist Award from the NANOSMAT Society, the Elsevier Lectureship Award of the Japanese Photochemistry Association, the 3M Nontenured Faculty Award, and the National Science Foundation's CAREER Award. For outstanding achievements during his PhD, Link was honored with the International Union of Pure and Applied Chemistry's Prize for Young Chemists given to the top five dissertations worldwide. Link is also an outstanding teacher, having received several teaching awards at Rice University, including the Graduate Student Association Faculty Teaching/Mentoring Award and the Charles Duncan Award for Outstanding Academic Achievement, which is awarded for excellence in both scholarship and teaching.



## Catherine J. Murphy

University of Illinois at Urbana-Champaign  
Tuesday, October 24, 2017; 1:10 PM

Catherine Murphy is the Peter C. and Gretchen Miller Markunas Professor of Chemistry at the University of Illinois at Urbana-Champaign (UIUC). She earned two B.S. degrees from UIUC in 1986, one in chemistry and one in biochemistry, while conducting undergraduate research with T. B. Rauchfuss. She obtained her Ph.D. in 1990 at the University of Wisconsin, Madison, under the direction of A. B. Ellis. From 1990-1993 she was an NSF and then an NIH postdoctoral fellow in the laboratory of J. K. Barton at the California Institute of Technology. Professor Murphy started her independent career at the University of South Carolina's Department of Chemistry and Biochemistry in 1993, and rose through the ranks

there, ultimately becoming the Guy F. Lipscomb Professor of Chemistry in 2002. In 2009 she returned to UIUC in her present position. Her research interests include the synthesis, surface chemistry, optical properties, biological applications and environmental implications of colloidal metal nanocrystals, especially gold. She is the winner of the 2011 Inorganic Nanoscience Award from the American Chemical Society's Division of Inorganic Chemistry, was named a 2011 Fellow of the American Chemical Society, a 2014 Fellow of the Royal Society of Chemistry, and a 2017 Fellow of the Materials Research Society. She won the Carol Tyler Award from the International Precious Metals Institute in 2013, and the Transformational Research and Excellence in Education (TREE) Award from the Research Corporation for Scientific Advancement in 2015. In 2015 she was elected to the U.S. National Academy of Sciences. In addition to her research, she is well-known to the chemistry community as the Deputy Editor of the *Journal of Physical Chemistry C* (2011-present) and as a co-author of the best-selling general chemistry textbook *Chemistry: the Central Science*, from the 10<sup>th</sup> to the current 14<sup>th</sup> editions.

### **Abstract: Growth, Form and Reactivity of Anisotropic Gold Nanostructures**

It has been known for centuries that "finely-divided" metals do not look like bulk metals. Gold nanocrystals in colloidal suspension can appear red, green, blue, purple or brown depending on their shapes and state of aggregation. The visible colors of these metal nanocrystal suspensions are due to the coherent oscillation of conduction-band electrons upon resonant illumination with light, a phenomenon now termed "the plasmon." A seed-mediated growth approach to growing gold nanorods has been developed over the last two decades in our laboratory, leading to nanoscale control of crystal growth and therefore controllable plasmon bands throughout the visible and near-infrared portions of the electromagnetic spectrum. The seed-mediated growth method, performed in aqueous solution at room temperature, relies on the presence of various structure-directing agents to produce the nanorods in high yield. A recent factorial design-of-experiment approach has revealed molecular-level insights into the growth process. The interface of these colloidally stable nanocrystals with other solvents, polymers, biomolecules, and materials is an active area of research that spans the physics of metamaterials to photothermal destruction of pathogenic cells. Recent results from the laboratory along two lines of inquiry – performing spatially selective chemistry on colloidal nanoscale objects, and the effects these virus-size objects have on living cells – will be presented.



## Thomas E. Mallouk

Pennsylvania State University

Tuesday, October 24, 2017; 2:15 PM

Tom Mallouk is Evan Pugh University Professor of Chemistry, Biochemistry and Molecular Biology, and Physics and Head of the Department of Chemistry at Penn State University. He was an undergraduate at Brown University, where he worked with Aaron Wold, was a graduate student with Neil Bartlett at the University of California, Berkeley, and did postdoctoral research with Mark Wrighton at MIT. He began his independent career at the University of Texas at Austin before moving to Penn State in 1993. His research is focused on problems in materials chemistry, including photoelectrochemistry, electrochemical energy conversion, low-dimensional physical phenomena, and motion on the nanoscale. He

is a member of the National Academy of Sciences and of the American Academy of Arts and Sciences, a Fellow of the American Chemical Society and of AAAS, and has received numerous awards for teaching and research.

### **Abstract: Assembly and Disassembly of Layered Solids**

Layered solids – which have strong bonds in two dimensions and weaker links in the third - are interesting building blocks for composite materials and devices because they potentially offer control over structure at the molecular level. Our research in this area began with the question of whether such compounds could be built up one layer at a time in controlled sequences on surfaces. This was possible by using either molecular precursors, in the case of metal phosphonates, or exfoliated sheets derived from lamellar microcrystals. Many layered oxides consist of negatively charged sheets interleaved by exchangeable cations. These oxides are particularly amenable to exfoliation (and to other topochemical reactions) by simple ion-exchange and acid-base reactions. Recently we have found that van der Waals solids such as graphite, hexagonal BN, and MoS<sub>2</sub> can also be intercalated and exfoliated without incurring damage to the sheets by means of acid-base and redox reactions.

An interesting consequence of the layer-by-layer assembly processes is the overcompensation of the surface charge of nanosheets. This effect can be exploited to invert the layer charge of nanosheets (which is typically negative for sheets derived from early transition metal oxides) and enable the intercalation of negatively charged molecules and nanoparticles. While studying these reactions, we observed surprisingly strong bonding between late transition metal oxide nanoparticles and early transition metal oxide nanosheets. Calorimetric measurements and electronic structure calculations suggest that d-acid/base interactions – originally proposed by Leo Brewer to explain the anomalous stability of early-late transition metal alloys – contribute to the strength of nanoparticle/nanosheet covalent bonding. This finding helps us understand the strong metal support interaction (SMSI) in catalysis and provides a prescription for stabilizing catalytically active late transition metal nanoparticles.





## Mounji Bawendi

Massachusetts Institute of Technology  
Tuesday, October 24, 2017; 3:05 PM

Professor Mounji Bawendi received his A.B. in 1982 from Harvard University and his Ph.D. in chemistry in 1988 from The University of Chicago. This was followed by two years of postdoctoral research at Bell Laboratories, working with Dr. Louis Brus, where he began his studies on nanomaterials. Bawendi joined the faculty at MIT in 1990, becoming Associate Professor in 1995 and Professor in 1996.

Professor Bawendi has followed an interdisciplinary research program that aims at probing the science and developing the technology of chemically synthesized nanocrystals and other nanostructures. This work has included the development of novel methods for synthesizing, characterizing, and processing quantum dots, magnetic nanoparticles, and tubular J-aggregates as novel materials building blocks, studying fundamental optical and magnetic properties of nanocrystals using a variety of spectroscopic methods, including the development of optical tools to study single nanocrystals, and combining quantum dots and magnetic particles with various optical and electronic device structures to study their device properties. His work has also included developing applications of quantum dots in biological and biomedical imaging and sensing, in light emitting devices, photodetection, and solar energy conversion. Professor Bawendi has also pursued translating knowledge gained in his lab to the clinic.

**Abstract: Quantum Dots: From Curiosity Based Science to Applications in Displays, Bio-imaging and Energy Harvesting**

No abstract available.







5555 San Felipe, Suite 1900 Houston, Texas 77056 713.961.9884