Advances in Synthetic and Biological Chemistry

61st Conference on Chemical Research
Peter B. Dervan, Program Chair

October 23-24, 2017
Houston, Texas
The Welch Foundation is a legacy to the world from Robert Alonzo Welch, a self-made man with a strong sense of responsibility to humankind, an enthusiastic respect for chemistry and a deep love for his adopted state of Texas. Mr. Welch came to Houston as a youth and later made his fortune in oil and minerals. Over the course of his career and life he became convinced of the importance of chemistry for the betterment of the world. He had a belief in science and the role it would play in the future. In his will, Mr. Welch stated, “I have long been impressed with the great possibilities for the betterment of Mankind that lay in the field of research in the domain of chemistry.” Mr. Welch left a generous portion of his estate to his employees and their families. The balance began what is now The Welch Foundation.

The Welch Foundation, based in Houston, Texas, is one of the United States’ oldest and largest private funding sources for basic chemical research. Since its founding in 1954, the organization has contributed to the advancement of chemistry through research grants, departmental programs, endowed chairs, and other special projects at educational institutions in Texas. The Foundation presents the Welch Award in Chemistry for chemical research contributions which have had a significant positive influence on mankind. The Foundation also bestows the Norman Hackerman Award in Chemical Research, an award that recognizes the work of young researchers in Texas.

Each year since 1957, The Robert A. Welch Foundation hosts a conference which draws leading scientists from around the world to explore state-of-the-art research in various areas of chemistry. The Foundation sponsors these annual conferences in order to support increased fundamental research in chemistry.

This year’s two-day conference will be held on October 23-24, 2017, at the Hilton Houston North Hotel in Houston. The title of the 61st annual Welch Conference in Chemical Research is: Advances in Synthetic and Biological Chemistry. Presiding over the conference will be a member of the Welch Scientific Advisory Board, Dr. Peter B. Dervan, Bren Professor of Chemistry, California Institute of Technology.
ADVANCES IN SYNTHETIC AND BIOLOGICAL CHEMISTRY

The 2017 Welch Conference on Chemical Research will provide advances in chemistry with applications in biology, medicine and materials. The goal of synthetic chemistry is the discovery or invention of new properties. The late Nelson Leonard described this as “syntheses with a purpose.”

In a session on chemical biology, renowned scientists will describe small molecules that control stem cell self-renewal and differentiation, the use of alpha/beta peptide unnatural oligomers in biology, base editing technology that enables programmable correction of point mutations in human genomes, redox chemistry at a distance mediated by DNA through long range signaling and coordination of DNA repair, synthesis of increasingly complex architectures for medicine, and new approaches to glycosylation-targeted cancer therapy.

In a session on new materials, pathfinding researchers will spotlight the evolution of enzymes that catalyze reactions not known in living systems, invent nanoscale materials at the interface between the physical and life sciences, reimagine 3D manufacturing based on continuous liquid interface production technology, innovate selective chemistry on colloidal nanoscale objects, assemble nanosheets for catalytically active late-transition metal nanoparticles, and apply quantum dots to bioimaging and energy harvesting. In addition to the 12 all-star Speakers, 4 distinguished scientists will act as Session Leaders and guide discussion after the talks.
PROGRAM
“ADVANCES IN SYNTHETIC AND BIOLOGICAL CHEMISTRY”
Monday, October 23, 2017

8:30   CHARLES W. TATE, Chair of the Board of Directors
8:35   PETER B. DERVAN, California Institute of Technology, Program Chairman

SESSION I – FROM MOLECULES TO MEDICINE

8:40   TADHG P. BEGLEY, Texas A&M University, Discussion Leader
8:50   PETER G. SCHULTZ, The Scripps Research Institute
        “Playing with the Molecules of Life”
9:30   Discussion
9:40   SAMUEL H. GELLMAN, University of Wisconsin-Madison
        “Impact of Backbone Modifications on Informational Properties of Polypeptides”
10:20  Discussion
10:30  Break
10:45  DAVID R. LIU, Harvard University
        “Base Editing: Programmable Editing of Single Base Pairs in Living Systems Without
        Double-Stranded DNA Cleavage”
11:25  Discussion
11:35  LUNCH

SESSION II – FROM MOLECULES TO MEDICINE

1:00   BRENT IVERSON, The University of Texas at Austin, Discussion Leader
1:10   JACQUELINE K. BARTON, California Institute of Technology
        “DNA-Mediated Signaling”
1:50   Discussion
2:00   Break
2:15   K. C. NICOLAOU, Rice University
2:55   Discussion
3:05   CAROLYN R. BERTOZZI, Stanford University
        “Cancer Immune Therapies Targeting Glyco-immune Checkpoints”
3:45   Discussion
3:55   Adjourn
SESSION III – MAKING MOLECULES AND MATERIALS

8:00  **XIAOWEI ZHANG**, Harvard University, *Discussion Leader*

8:10  **FRANCES H. ARNOLD**, California Institute of Technology
      “Biocatalysts for Abiological Chemistry: Bringing New Chemistry to Life”

8:50  Discussion

9:00  **CHARLES M. LIEBER**, Harvard University
      “Nanoelectronic Tools for Brain Science”

9:40  Discussion

9:50  Break

10:05 **JOSEPH M. DESIMONE**, University of North Carolina
      “Future Fabricated with Light: Continuous Liquid Interface Production to Drive Additive Manufacturing”

10:45 Discussion

2017 Welch Awardee Lecture

10:55 **JOHN B. GOODENOUGH**, The University of Texas at Austin
      “Rechargeable Batteries: Evolution and Promise”

11:35 LUNCH

SESSION IV – MAKING MOLECULES AND MATERIALS

1:00  **STEPHAN LINK**, Rice University, *Discussion Leader*

1:10  **CATHERINE J. MURPHY**, University of Illinois at Urbana-Champaign
      “Growth, Form and Reactivity of Anisotropic Gold Nanostructures”

1:50  Discussion

2:00  Break

2:15  **THOMAS E. MALLOUK**, The Pennsylvania State University
      “Assembly and Dissassembly of Layered Solids”

2:55  Discussion

3:05  **MOUNGI BAWENDI**, Massachusetts Institute of Technology
      “Quantum Dots: From Curiosity Based Science to Applications in Displays, Bio-imaging and Energy Harvesting”

3:45  Discussion

3:55  Adjourn
Charles W. Tate is Chairman and Founder of CRG L.P., an investment firm targeting private credit in the healthcare industry. He has over 40 years’ experience in investment banking, merchant banking, and private equity. Prior to forming CRG, Tate was a Partner and Member of the Management Committee of Hicks, Muse, Tate & Furst Incorporated from 1991 until June 2002. After starting his career at Bank of America in New York, he worked at Morgan Stanley & Co. for 19 years mostly as a Managing Director in the Mergers and Acquisitions Department. Presently, Mr. Tate serves on The University Cancer Foundation Board of Visitors for M.D. Anderson Cancer Center and is a member of the Executive Committee and also serves on The University of Texas Development Board. In addition to The Welch Foundation, there are many other boards on which Mr. Tate has served in the past. He received his B.B.A. from The University of Texas at Austin in 1968 and his M.B.A from Columbia University Graduate School of Business in 1972. As well as being elected to The University of Texas at Austin McCombs School of Business Hall of Fame in 2003, he was also elected a Distinguished Alumnus of The University of Texas in 2007. Mr. Tate also received The University of Texas at Austin 2011-2012 Presidential Citation in recognition of his leadership, sustained commitment, and service to The University. Currently, he serves on the Board of Overseers of the Columbia University Graduate School of Business.
Peter B. Dervan is the Bren Professor of Chemistry at the California Institute of Technology. Dervan pioneered a field of chemistry with studies directed toward understanding the chemical principles for the sequence specific recognition of DNA. Dervan received his B.S. degree from Boston College, and Ph.D. at Yale. He was a postdoctoral fellow at Stanford University and began his association with Caltech as an assistant professor in 1973. Professor Dervan served as chair of Caltech’s division of chemistry and chemical engineering from 1994 to 1999. He is a member of the National Academy of Sciences, the National Academy of Medicine, the American Academy of Arts and Sciences, the American Philosophical Society, the French Academy of Sciences and the German National Academy of Sciences. Professor Dervan received the 2006 National Medal of Science from President Bush “for his fundamental research contributions at the interface of chemistry and biology and his influence in education and industrial innovation”. Other awards include the Harrison Howe Award (1988), Arthur C. Cope Award (1993), Willard Gibbs Medal (1993), Nichols Medal (1994), Maison de la Chimie Foundation Prize (1996), Remsen Award (1998), Kirkwood Medal (1998), Alfred Bader Award (1999), Max Tishler Prize (1999), Linus Pauling Medal (1999), William C. Tolman Medal (1999), Tetrahedron Prize (2000), Harvey Prize (Israel) (2002), Ronald Breslow Award (2005), Wilbur Cross Medal (2005), Frank H. Westheimer Medal (2009) and the Prelog Medal (2015). He has served on several Scientific Advisory Boards for the pharmaceutical and biotechnology industries. He is Chair of the Scientific Advisory Board of the Robert A. Welch Foundation. Dervan is an outstanding teacher, having received several teaching awards given by the undergraduate students at Caltech. Over 60 of Dervan's former graduate and postdoctoral coworkers hold academic research positions around the world, many of whom are leaders in chemistry, biology and medicine.

Introduction: Advances in Synthetic and Biological Chemistry

The 2017 Welch Conference on Chemical Research will provide advances in chemistry with applications in biology, medicine and materials. The goal of synthetic chemistry is the discovery or invention of new properties. The late Nelson Leonard described this as “syntheses with a purpose.”

In a session on chemical biology, renowned scientists will describe small molecules that control stem cell self-renewal and differentiation, the use of alpha/beta peptide unnatural oligomers in biology, base editing technology that enables programmable correction of point mutations in human genomes, redox chemistry at a distance mediated by DNA through long range signaling and coordination of DNA repair, synthesis of increasingly complex architectures for medicine, and new approaches to glycosylation-targeted cancer therapy.

In a session on new materials, pathfinding researchers will spotlight the evolution of enzymes that catalyze reactions not known in living systems, invent nanoscale materials at the interface between the physical and life sciences, reimagine 3D manufacturing based on continuous liquid interface production technology, innovate selective chemistry on colloidal nanoscale objects, assemble nanosheets for catalytically active late-transition metal nanoparticles, and apply quantum dots to bioimaging and energy harvesting. In addition to the 12 all-star Speakers, 4 distinguished scientists will act as Session Leaders and guide discussion after the talks.
Tadhg P. Begley obtained his B.Sc. degree from the National University of Ireland and his Ph.D. from Caltech working with Peter Dervan. He carried out postdoctoral studies with Wolfgang Oppolzer (Geneva) and with Chris Walsh (MIT) before beginning his independent career at Cornell in 1986. Tadhg moved to Texas A&M in 2009 where he is the D. H. R. Barton and Robert A. Welch Professor of Chemistry. His research interests center around the mechanistic enzymology of cofactor biosynthesis and catabolism. He has coauthored “The Organic Chemistry of Biological Pathways” with John McMurry and has edited The Wiley Encyclopedia of Chemical Biology and a volume of Comprehensive Natural Products Chemistry on cofactors. His research has been recognized by an honorary D.Sc. degree from the National University of Ireland, a MERIT award from NIH and the Repligen Award in the Chemistry of Biological Processes from the American Chemical Society.
Peter G. Schultz graduated summa cum laude from Caltech in 1979 and continued there for his doctoral degree (in 1984). He then spent a postdoctoral year at the Massachusetts Institute of Technology before moving to the University of California, Berkeley, and the Howard Hughes Medical Institute. He is currently President and the Scripps Professor of Chemistry at the Scripps Research Institute. Schultz has made a number of major contributions to science including the discovery of catalytic antibodies, methodology that for the first time expands the genetic codes of living organisms, and the development and application of combinatorial methods in chemistry and biology including the first generation of combinatorial materials libraries. Schultz has received numerous awards including the Alan T. Waterman Award, NSF (1988), the Wolf Prize in Chemistry (1994), the Paul Ehrlich Prize (2002), the Cope Award (2006), the Solvay Prize (2013) and Wieland Prize (2016). Professor Schultz is a member of the National Academy of Sciences, USA (1993) and the Institute of Medicine of the National Academy of Sciences (1998). He is active on many editorial and scientific advisory boards and co-founder of Affymax, Symyx Technologies, Syrrx, Kalypsys, Phenomix, Ambrx, Ilypsa, Wildcat Technologies and Ardelyx.

Abstract: Playing with the Molecules of Life

Our research program combines the tools and principles of chemistry with the molecules and processes of living cells to synthesize new molecules and molecular assemblies with novel physical, chemical and biological functions. By studying the structure and function of the resulting molecules, new insights can be gained into the mechanisms of complex biological and chemical systems. Examples of this synergistic chemical/biological approach to synthesis will be discussed including the addition of amino acids with novel biological, chemical and physical properties to the genetic codes of prokaryotic and eukaryotic organisms, and the identification of small molecules that control stem cell self-renewal and directed differentiation, as well as reprogramming of somatic cells.
Samuel H. Gellman
University of Wisconsin-Madison
Monday, October 23, 2017; 9:40 AM

Sam Gellman is the Ralph F. Hirschmann Professor of Chemistry at the University of Wisconsin - Madison. He earned his A.B. from Harvard University in 1981 and his Ph.D. from Columbia University, under Ronald Breslow, in 1986. After an NIH post-doctoral fellowship at the California Institute of Technology, with Peter Dervan, Gellman joined the faculty at the University of Wisconsin - Madison in 1987. He is currently the Ralph F. Hirschmann Professor of Chemistry. Major interests in Gellman's research program involve chemical biology, organic chemistry and biophysics. Specific topics include fundamental studies of non-covalent interactions, elucidation of the origins of peptide and protein folding preferences, development and application of unnatural oligomers that display protein-like conformational behavior ("foldamers"), creation of new amphiphiles for membrane protein manipulation, and development of new biologically active polymers.

Abstract: Impact of Backbone Modifications on Informational Properties of Polypeptides

Folded biopolymers perform diverse functions in biological systems. Most of these operations require the biopolymer chain to adopt a specific conformation. Over the past two decades there has been growing interest in the prospect that biopolymer functions might be recapitulated and perhaps even improved upon with unnatural oligomers that manifest discrete folding preferences. Such systems are referred to generically as "foldamers".

This lecture will focus on recent progress in the use of use of α/β-peptide foldamers (i.e., peptides containing both α- and β-amino acid residues) to mimic information-rich surfaces displayed by natural polypeptides. The resulting foldamers can inhibit specific protein-protein interactions, or they can augment signaling through polypeptide-activated receptors. Advantages of the α/β-peptides include resistance to proteolysis and the ability to transmit signals that differ in subtle ways from those of a prototype α-peptide.
David R. Liu
Harvard University
Monday, October 23, 2017; 10:45 AM

David R. Liu is Professor of Chemistry and Chemical Biology at Harvard University, Howard Hughes Medical Institute Investigator, and Core Institute Member and Vice-Chair of the Faculty of the Broad Institute of Harvard and MIT. Liu graduated first in his class at Harvard in 1994. He performed synthetic organic and bioorganic chemistry research on sterol biosynthesis under Professor E. J. Corey’s guidance as an undergraduate. During his Ph.D. research with Professor Peter Schultz at U. C. Berkeley, Liu initiated the first general effort to expand the genetic code in living cells. He earned his Ph.D. in 1999 and became Assistant Professor of Chemistry and Chemical Biology at Harvard University in the same year. He was promoted to Associate Professor in 2003 and to Full Professor in 2005. Liu became a Howard Hughes Medical Institute Investigator in 2005 and joined the JASONs, academic science advisors to the U.S. government, in 2009. Liu has earned several university-wide distinctions for teaching at Harvard, including the Joseph R. Levenson Memorial Teaching Prize, the Roslyn Abramson Award, and a Harvard College Professorship. He has published more than 135 papers and 47 issued patents. His research accomplishments have earned distinctions including the American Chemical Society Pure Chemistry Award, the Arthur C. Cope Young Scholar Award, and awards from the Sloan Foundation, Beckman Foundation, NSF CAREER Program, and Searle Scholars Program. In 2016 he was named one of the Top 20 Translational Researchers by Nature Biotechnology. Professor Liu’s research integrates chemistry and evolution to illuminate biology and enable next-generation therapeutics. His major research interests include (i) the evolution of proteins with novel therapeutic potential using phage-assisted continuous evolution (PACE); (ii) the engineering and delivery of genome-editing proteins to study and treat genetic diseases; and (iii) the discovery of bioactive synthetic small molecules and synthetic polymers through DNA-templated organic synthesis, an approach developed in his laboratory. He is the scientific founder or co-founder of several biotechnology and therapeutics companies including Ensemble Therapeutics, Permeon Biologics, and Editas Medicine.

Abstract: Base Editing: Genome Editing of Single Base Pairs in Living Systems Without Double-Stranded DNA Cleavage

In this lecture I will describe the development and early in vitro and in vivo applications of base editing, a new approach to genome editing that enables programmable correction of point mutations efficiently without requiring DNA backbone cleavage or donor DNA templates. Base editing has the potential to advance the scope and effectiveness of genome editing of point mutations, which represent the substantial majority of known human genetic variants associated with disease but are difficult to correct cleanly and efficiently using standard genome editing methods.
Professor Brent L. Iverson is the W.J. and V.M. Raymer Professor and a Distinguished Teaching Professor in the Department of Chemistry at the University of Texas at Austin. He attended Stanford University then received a Ph.D. from the California Institute of Technology in 1987, working in the laboratory of Professor Peter Dervan. After postdoctoral work at the Scripps Research Institute in La Jolla, he began teaching at UT in 1990. His research career has spanned the interface of chemistry and biology. On the chemical side, his laboratory created the first synthetic foldamer shown to adopt an abiotic higher order structure in water. Later work led to the development of threading polyintercalating molecules that bind specifically to long sequences of DNA, exhibiting high affinities and extremely slow off-rates. More recently, the laboratory has been exploiting advances in the understanding of factors influencing aromatic stacking geometries to create dynamic solid materials capable of dramatic color changes in response to various stimuli. On the molecular biology side, his laboratory has helped pioneer the use of fluorescence-activated cell sorting (FACS) technology to screen relatively large protein libraries for directed evolution applications. Earlier work helped in the development of an engineered antibody called Anthim, an FDA-approved cure for late stage anthrax that has now been added to the Strategic National Stockpile (SNS). More recent efforts have been geared toward creating better screening technologies for enzyme engineering. The latest such technology, called YESS, uses expression in the yeast endoplasmic reticulum combined with FACS sorting to enable the engineering and comprehensive analysis of proteases, kinases and sortases. In 2013, Brent became the second Dean of the School of Undergraduate Studies (UGS) at UT. UGS was created to deploy then manage a reimagined and innovative core curriculum along with other university-wide academic programs, while simultaneously providing an entry point for first-time students who do not yet know what major they would like to pursue.
Dr. Jacqueline K. Barton is the John G. Kirkwood and Arthur A. Noyes Professor of Chemistry and Norman Davidson Leadership Chair of the Division of Chemistry and Chemical Engineering at the California Institute of Technology. She is a native New Yorker. Barton was awarded the A.B. *summa cum laude* at Barnard College in 1974 and a Ph.D. in Inorganic Chemistry at Columbia University in 1978. After a postdoctoral fellowship at Bell Laboratories and Yale University, she became an assistant professor at Hunter College, City University of New York. In 1983, she returned to Columbia University. In the fall of 1989, she joined the faculty at Caltech. From 1997 to 2016 she held the Arthur and Marion Hanisch Memorial Professorship. In 2009, she began her term as Chair of the Division. Professor Barton has pioneered the application of transition metal complexes to probe recognition and reactions of double helical DNA. Through this research, Barton has trained more than 100 graduate students and postdoctoral students. She has received many awards. These include the NSF Alan T. Waterman Award, the ACS Award in Pure Chemistry, and a MacArthur Foundation Fellowship. She has been elected to the American Academy of Arts and Sciences, the American Philosophical Society, and the National Academy of Sciences, along with an honorary fellowship in the Royal Society of Chemistry. In 2011, Dr. Barton received the 2010 National Medal of Science from President Obama. In 2015, she received the ACS Priestley Medal.

**Abstract: DNA-mediated Signaling**

Many experiments have now shown that double helical DNA can serve as a conduit for efficient redox chemistry over long molecular distances. This chemistry is exquisitely sensitive to perturbations in the DNA base stack, such as arise with base mismatches, lesions, and protein binding. We have now been exploring how this chemistry may be used within the cell for long range signaling. Increasingly, 4Fe-4S clusters are being found in DNA-binding proteins involved in genome maintenance. These 4Fe-4S clusters, common redox cofactors, are associated not only with repair proteins but also DNA polymerases and primase. Studies are described to characterize DNA-mediated charge transport by these metalloproteins. Experiments indicate that this chemistry is important in the context of oxidative damage and also may provide a first step in how DNA repair proteins may localize in the vicinity of lesions. This redox chemistry at a distance, mediated by the DNA helix, offers a route for long range signaling and coordination of DNA repair and DNA-processing proteins across the genome.
K. C. Nicolaou
Rice University
Monday, October 23, 2017; 2:15 PM

K. C. Nicolaou is currently the Harry C. Olga K. Wiess Professor of Chemistry at Rice University. He previously served concurrently as the founding chairman of the Chemistry Department at the Scripps Research Institute and a distinguished Professor of Chemistry at the University of California, San Diego (1989-2013). His research activities focus on the discovery and development of new synthetic strategies and technologies, and their applications to the total synthesis of natural and designed molecules of biological and medical importance. He is a co-author of the Classics in Total Synthesis series (I, II, III) and Molecules that Changed the World.

Among his many awards and honors are the Award for Creative Work in Synthetic Organic Chemistry, American Chemical Society (1993), the Dr. Paul Janssen Prize for Creativity in Organic Synthesis, Janssen Research Foundation (1994), the William H. Nichols Medal, New York Section-American Chemical Society (1996), the Linus Pauling Medal, Oregon, Portland, Puget Sound Sections-American Chemical Society (1996), the Ernst Schering Prize, Ernst Schering Research Foundation (Germany, 2001), the Tetrahedron Prize for Creativity in Organic Chemistry (2002), the ACS Nobel Laureate Signature Award for Graduate Education in Chemistry (2003), the A.C. Cope Award, American Chemical Society (2005), the Chandler Medal, Columbia University (2008), the Benjamin Franklin Medal in Chemistry (2011), and the Wolf Prize (Israel, 2016).

He is a Fellow of the American Academy of Arts and Sciences (1993), Member of the National Academy of Sciences (USA, 1996), Foreign Member of the Academy of Athens (Greece, 2001), Honorary Fellow of the Indian Academy of Sciences (2007), Member of the German Academy of Sciences Leopoldina (2009), Member of the American Philosophical Society (2011), and Foreign Member of the Royal Society of London (2013). He holds 10 honorary degrees from universities around the world.


In this lecture, a brief historical overview of organic synthesis and its impact on biology and medicine will be followed by highlights of advances in total synthesis from the speaker’s laboratories. Specifically, the total synthesis of natural and designed molecules of biological and medical importance will be presented, including the anticancer agents Taxol®, calicheamicin γ1, uncialamycin, shishijimicin A, and antibiotic viridicatumtoxin B. The lecture will also touch upon the impact of total synthesis on the advent of antibody drug conjugates (ADCs) for targeted cancer therapies.

References:
Carolyn R. Bertozzi
Stanford University
Monday, October 23, 2017; 3:05 PM

Carolyn Bertozzi is the Anne T. and Robert M. Bass Professor of Chemistry and Professor of Chemical & Systems Biology and Radiology (by courtesy) at Stanford University, and an Investigator of the Howard Hughes Medical Institute. She completed her undergraduate degree in Chemistry from Harvard University in 1988 and her Ph.D. in Chemistry from UC Berkeley in 1993. After completing postdoctoral work at UCSF in the field of cellular immunology, she joined the UC Berkeley faculty in 1996. In June 2015, she joined the faculty at Stanford University coincident with the launch of Stanford's ChEM-H institute.

Prof. Bertozzi's research interests span the disciplines of chemistry and biology with an emphasis on glycoscience in human health and disease. She is known for launching the field of bioorthogonal chemistry, inventing reactions such as the Staudinger ligation, copper-free click chemistry and the Pictet-Spengler ligation, and applying these reactions to in vivo imaging and therapeutic protein engineering. Presently, her lab works on developing cancer immune therapies that target glyco-immune checkpoint receptors and their glycan ligands, on the development of point-of-care tuberculosis diagnostics that exploit carbohydrate metabolic pathways, and on the rare genetic disease NGly1 in which a defect in de-N-glycosylation leads to transcription factor dysregulation. She has been recognized with many honors and awards for her research accomplishments. She is an elected member of the Institute of Medicine, the National Academy of Sciences, the German Academy of Sciences Leopoldina, the National Academy of Inventors, the Inventors Hall of Fame, and the American Academy of Arts and Sciences. She has been awarded the National Academy of Sciences Award in the Chemical Sciences, the ACS Arthur C. Cope Award, the Lemelson-MIT Prize, the Heinrich Wieland Prize, and a MacArthur Foundation "Genius" Award, among many others. Her efforts in undergraduate education have earned her the UC Berkeley Distinguished Teaching Award and the Donald Sterling Noyce Prize for Excellence in Undergraduate Teaching.

Abstract: Cancer Immune Therapies Targeting Glyco-immune Checkpoints

Successful tumors are products on natural selection that survived the various mechanisms meant to prevent cancer in humans. Evading immune surveillance is a critical requirement for cancer progression, and likewise, tumor environments are often immune suppressive. Discovery of the specific receptor-ligand interactions that suppress immune cell reactivity against cancer cells has led to exciting new interventions such as the T cell checkpoint inhibitors. Studies of where these immune therapies succeed or fail hints at a much broader landscape of immune modulatory receptor-ligand interactions that have yet to be exploited for cancer therapy. We are studying tumor glycosylation as an axis of immune modulation that might be targetable for immune therapy. Altered glycosylation patterns have long been identified as hallmarks of cancer, but their functional significance with respect to immune suppression is just now coming into focus. For example, we discovered that overexpression of sialosides, a common cancer glycosylation phenotype, allows cancer cells to recruit immune suppressive Siglec receptors to the synapse with NK cells. Disruption of this interaction can be achieved using antibody-sialidase conjugates that selectively de-sialylate the cancer cell surface. Conversely, immune activating receptors that normally recognize microbial glycans can be redirected to respond to cancer cells using antibody-glycan conjugates. These and other new approaches to glycosylation-targeted cancer therapy will be discussed in this presentation.
Xiaowei Zhuang
Harvard University
Tuesday, October 24, 2017; 8:00 AM

Xiaowei Zhuang is the David B. Arnold Professor of Science and the director of Center for Advanced Imaging at Harvard University, and a Howard Hughes Medical Institute investigator. Her lab develops advanced optical imaging technologies, in particular single-molecule and super-resolution imaging methods, to study biological systems. She invented STORM, one of the first single-molecule-based super-resolution imaging methods, which allows imaging of biological structures with nanometer-scale resolution. She discovered novel cellular structures using STORM. She invented a single-cell transcriptome imaging method, MERFISH, and has applied this method to study cells and tissues at the systems level. Her lab has also developed and applied many other imaging approaches to investigate biomolecular systems.

Zhuang received her B.S. degree from the University of Science and Technology of China, her Ph.D. degree in physics the lab of Prof. Y. R. Shen at UC Berkeley, and her postdoctoral training in biophysics in the lab of Prof. Steven Chu at Stanford University. She joined the faculty of Harvard University in 2001 and joined the Howard Hughes Medical Institute as an investigator in 2005.

Zhuang is a member of the US National Academy of Sciences and the American Academy of Arts and Sciences, a foreign member of the Chinese Academy of Sciences and the European Molecular Biology Organization, a fellow of the American Association of the Advancement of Science and the American Physical Society, and an honorary fellow of the Royal Microscopical Society. She has received honorary doctorate degrees from the Stockholm University and the Delft University of Technology. Among her other awards are the MacArthur Fellowship, the Pure Chemistry Award from the American Chemical Society, the Max Delbrück Prize in Biological Physics from the American Physical Society, the Raymond and Beverly Sackler International Prize in Biophysics, and the National Academy of Sciences Award in Molecular Biology, etc.
Frances H. Arnold
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.

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.
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$_2$ 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$_2$ 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$^+$ 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 10th to the current 14th 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.
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$_2$ 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.
Professor Mounqi 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.