ANSER Mission Statement

The Argonne-Northwestern Solar Energy Research (ANSER) Center brings together scientists from many disciplines to explore the Sun’s enormous potential to supply energy for human needs. ANSER’s broad portfolio of cross-disciplinary basic research seeks innovative solutions to the challenging technical problems of putting solar energy to work.

www.ANSERCenter.org
ANSER@northwestern.edu

Initiative for Sustainability and Energy at Northwestern (ISEN) Mission Statement

ISEN’s mission is to create, advance and communicate new science, technology, and policy for sustainability and energy. Its particular focus is on sustainable energy supply, demand and use.

www.isen.northwestern.edu
isen@northwestern.edu
Harry B. Gray
Arnold O. Beckman Professor of Chemistry, CalTech, and Founding Director of The Beckman Institute

Harry Barkus Gray (Northwestern Univ PhD, 1960) is the Arnold O. Beckman Professor of Chemistry and the Founding Director of the Beckman Institute at the California Institute of Technology. His main research interests center on inorganic spectroscopy, photochemistry, and bioinorganic chemistry, with emphasis on understanding electron transfer in proteins. His contributions to chemistry include over 700 papers and 17 books. Major awards: the National Medal of Science from President Ronald Reagan (1986); the Linderstrom-Lang Prize (Denmark, 1991); the Gibbs Medal (1994); the Harvey Prize (Israel, 2000); the National Academy of Sciences Award in Chemical Sciences (2003); the Benjamin Franklin Medal in Chemistry (2004); the Wolf Prize in Chemistry (Israel, 2004); the City of Florence Prize in Molecular Sciences (Italy, 2006); six national awards from the American Chemical Society, including the Priestley Medal (1991); and 16 honorary doctorates. He is a member of the National Academy of Sciences; the American Academy of Arts and Sciences; the American Philosophical Society; a foreign member of the Royal Danish Academy of Sciences and Letters; the Royal Swedish Academy of Sciences; the Royal Society of Great Britain; and the Accademia Nazionale dei Lincei (Italy). He was California Scientist of the Year in 1988. He has served as a Member of the Board of Directors of the Arnold and Mabel Beckman Foundation since 1994.

KEYNOTE ADDRESS
Tuesday, May 5, 2009, Coon Auditorium, 6:30p.m.
Powering the Planet with Solar Fuel

AGENDA
Wednesday, May 6, 2009
McCormick Tribune Forum

8:30–8:45 a.m. Welcome
Michael Wasielewski, Northwestern University and Argonne National Laboratory

8:45–9:30 a.m. Biological, Hybrid and Bio-Inspired Systems for Efficient Energy Conversion
Thomas Moore, Arizona State University

9:30–10:15 a.m. Water Oxidation Chemistry of Photosystem II and Artificial Systems
Gary Brudvig, Yale University

10:15–10:45 a.m. BREAK

10:45–11:30 a.m. Biomimetic Models for the Hydrogenases
Thomas Rauchfuss, University of Illinois at Urbana-Champaign

11:30–12:15 p.m. The Role of Excited Charge Transfer States in Polymer Solar Cells
René Janssen, Eindhoven University of Technology

12:15–1:30 p.m. LUNCH – ON YOUR OWN

1:30–2:15 p.m. Interface Engineering for Better Photovoltaics
Tobin Marks, Northwestern University

2:15–3:00 p.m. Visualizing Excited State Electron and Atomic Movements in Photoactive Transition Metal Complexes During Solar Fuel Generation
Lin Chen, Argonne National Laboratory and Northwestern University

3:00–3:30 p.m. BREAK

3:30–4:15 p.m. Organic Photovoltaics: Some Issues, Some Approaches
Mark Ratner, Northwestern University

4:15–5:00 p.m. Three-Dimensional Synthesis for New Photoelectrode Architectures
Michael J. Pellin, Argonne National Laboratory and Northwestern University
Solar energy is unique among carbon-neutral energy sources for its enormous potential to satisfy the expected doubling of US energy requirements over the next 50 years. The ANSER Center was established in July of 2007 and joins established strengths at Northwestern U. (NU) and Argonne National Laboratory (ANL) with those of senior personnel at Yale U. (Yale), the U. of Illinois at Urbana-Champaign (UIUC), and the U. of Chicago (UC) in molecular and nanostructured assemblies, materials, catalysts, and phenomena integral to solar energy conversion and storage. Together, these institutions offer a critical mass of world-class researchers, and unique capabilities/facilities in synthesis, characterization, and theory to advance the broad frontier of solar energy science to produce environmentally benign renewable energy. The nature and complexity of these problems requires an integrated systems approach that comes only from focused, team-oriented interdisciplinary research with close communication and coordination among team members. A strong multi-disciplinary team approach to solving scientific problems has traditionally been part of NU and ANL scientific culture.

ANSER Center Vision

The long-term vision of the ANSER Center is to develop the fundamental understanding, materials and methods necessary to create dramatically more efficient technologies for solar fuels and electricity production. The ANSER Center’s goals are to achieve this vision by understanding and characterizing the basic phenomena of solar energy conversion dynamics, by designing and synthesizing new nanoscale architectures with extraordinary functionality, and by linking basic solar energy conversion phenomena across time and space to create emergent energy conversion systems operating with exceptional performance. At the same time, the ANSER Center seeks to create and mentor a technically excellent workforce capable of solving energy-related problems far into the future.

ANSER Center Objectives

The purpose of multi-disciplinary research carried out by the ANSER Center is to develop a fundamental understanding of:

- the interaction of light and charge with molecules and materials;
- the energy levels and electronic structures of molecules and materials;
- the dynamics of photoinduced charge generation, separation, and transport with unparalleled temporal and spatial resolution;
- the interfaces at which charge generation, separation, transport, and selective chemical reactions occur;
- the properties of unique materials, from self-assembling, bio-inspired materials for hydrogen fuel production from water to transparent conductors and nanostructured hard and soft materials for solar electricity generation.

ANSER Center Research

The ANSER Center is organized around four basic research thrusts, each dealing with a solar energy conversion chain culminating in a specific end use. These thrusts are:

- Bio-inspired Systems for Solar Fuels Production
- Interface Science for Organic Photovoltaics
- Nanostructured Architectures for Hybrid Organic-Inorganic Solar Cells
- Advanced Thermoelectric Materials for Solar Thermal Power Conversion

Please visit our web site www.ANSERCenter.org

Contact us at: ANSER@northwestern.edu
She has established a facility for laser pump, x-ray probe dynamic structural studies at the Advanced Photon Source at Argonne. She has been awarded the distinguished performance medal 2002 from the University of Chicago who governs Argonne National Laboratory under a contract with the US Department of Energy.

Lin Chen, Argonne/Northwestern University

**Visualizing Excited State Electron and Atomic Movements in Photoactive Transition Metal Complexes During Solar Fuel Generation**

Lin X. Chen received her B. Sc. in chemistry from Peking University, and her Ph.D. in physical chemistry from the University of Chicago under Graham R. Fleming on ultrafast protein dynamics using laser spectroscopy and molecular dynamics simulation. After her postdoctoral research with Herbert L. Strauss and Robert G. Snyder at the University of California at Berkeley on molecular dynamics of long chain molecules studied by Raman and FTIR spectroscopy as well as normal mode analysis, she joined the Chemistry Division at Argonne National Laboratory where she is currently a senior scientist. Since 2007, she holds a joint appointment with Department of Chemistry, Northwestern University as a Professor of Chemistry. Her research interests are mainly on fundamental interactions between molecules and lights (from IR to X-rays) and the consequences of these interactions in solar energy conversion, energy and electron flow in photosynthetic reaction centers, organic materials such as conjugated oligomers and polymers, metal complexes and aggregates, as well as hybrid nanoscale materials. She uses ultrafast lasers to probe molecular dynamics and energetics, and uses steady-state and ultrafast X-rays to probe static and dynamic structures of above mentioned systems in solutions and films during light induced processes. Meanwhile, she collaborates with theoreticians on modeling the excited state structures and molecular dynamics that can be used to elucidate the experimental data. She has pioneered the laser initiated time-resolved X-ray absorption spectroscopy (LITR-XAS) to detect transient oxidation state, coordination and nuclear geometry of metal complexes in photochemical reactions relevant to solar fuel generation and photocatalysis. Her other research area is fundamental electronic processes in organic materials in photovoltaic and molecular device applications from conjugated oligomers and polymers to covalently linked electron donor and acceptor arrays in solutions and films. Her research goal is being able to understand and control electron and energy flow in materials and during chemical reaction mechanisms with light. She has established a facility for laser pump, x-ray probe dynamic structural studies at the Advanced Photon Source at Argonne. She has been awarded the distinguished performance medal 2002 from the University of Chicago who governs Argonne National Laboratory under a contract with the US Department of Energy.
flow in artificial systems, the use of molecular heterojunctions inspired by photosynthesis in OPV devices, the focus on the design and assembly of biomimetic systems that illustrate the control of excitation energy cascade overpotentials (or activation energies) using Earth-abundant elements. Their premise is that key features of biological systems have evolved energy transduction mechanisms that operate at high efficiency, e.g., very low overpotentials (or activation energies) using Earth-abundant elements. Their premise is that key features of biological photochemistry, catalysis, and control can be incorporated into artificial or hybrid systems to increase the efficiency of energy production and use for technological needs. Specifically, their recent research of biological photochemistry, catalysis, and control can be incorporated into artificial or hybrid systems to increase the efficiency of energy production and use for technological needs. Specifically, their recent research of biological photochemistry, catalysis, and control can be incorporated into artificial or hybrid systems to increase the efficiency of energy production and use for technological needs. Specifically, their recent research of biological photochemistry, catalysis, and control can be incorporated into artificial or hybrid systems to increase the efficiency of energy production and use for technological needs. Specifically, their recent research of biological photochemistry, catalysis, and control can be incorporated into artificial or hybrid systems to increase the efficiency of energy production and use for technological needs.

A second thrust of the program is in materials synthesis using Atomic Layer Deposition (ALD). We are currently exploring Atomic Layer Deposition as a facile synthesis method for functionalizing nanoporous and nanostructured materials. This work has driven new synthetic routes for synthesizing active materials ranging from nonadiabatic intramolecular behavior to aspects of molecular devices, including photovoltaics, conductive polymers, molecular transport junctions and molecular switches.

His professional history involves undergraduate work at Harvard, graduate work at Northwestern, post-doctoral work at Aarhus and Munich, and faculty positions at New York University and Northwestern. He is now Dumas University Professor at NU and Co-Director of the Initiative for Sustainability and Energy at Northwestern (ISEN). He has very active international collaborations, particularly in Denmark, Israel and the Netherlands. He has been awarded the Feynman Prize, the Langmuir Award of the American Chemical Society, and is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the International Academy of Quantum Molecular Sciences, the Royal Danish Academy of Sciences and an annual canoe trip which puts all things back into perspective.

A major interest for our group is environmentally-motivated organometallic chemistry. We are interested in fundamental studies leading to clean fuels. One aspect of this research is the elucidation of nature's methods for producing H₂. A long term interest is in catalysts for removing sulfur from fossil fuels, focusing on mechanisms of C—S bond cleavage.

Presenters

Thomas Moore, Arizona State University

Biological, Hybrid & Bio-Inspired Systems for Efficient Energy Conversion

Thomas Moore is a Professor of Chemistry and Biochemistry at Arizona State University and Director of the Center for Bioenergy and Photosynthesis. Professor Moore has a Ph.D. in Chemistry from Texas Tech University. He has served as President of the American Society for Photobiology in 2004 and received the Senior Research Award from the Society in 2001. For the period 2005-2007 he was awarded a Chaire Internationale de Recherche Blaise Pascal, Région d’Ile de France, where he lectured and collaborated on research in bioenergetics, energy and sustainability at the Université de Paris Sud, Orsay, and CEA Saclay. Professor Moore and his long-time colleagues, Professors Ana Moore and Devens Gust, work on artificial photosynthesis. Their work is based on the observation that biological systems have evolved energy transduction mechanisms that operate at high efficiency, e.g., very low overpotentials (or activation energies) using Earth-abundant elements. Their premise is that key features of biological photochemistry, catalysis, and control can be incorporated into artificial or hybrid systems to increase the efficiency of energy production and use for technological needs. Specifically, their recent research focuses on the design and assembly of biomimetic systems that illustrate the control of excitation energy flow in artificial systems, the use of molecular heterojunctions inspired by photosynthesis in OPV devices, the interface of biological catalysts to electromotive force, and solar-driven water oxidation.

Michael J. Pellin, Argonne/Northwestern University

Three-Dimensional Synthesis for New Photoelectrode Architectures

Dr. Michael J. Pellin is the Materials Science Division Director (Acting) responsible for the Materials Science Division at Argonne National Laboratory. Mike is also the Argonne lead for the Argonne Northwestern Solar Energy (ANSER) Center. He is author of over 200 peer reviewed publications. He directs a world class research effort in understanding the surface chemistry of materials that includes operation of the world’s most sensitive trace analysis facility. Studies include basic research into the mechanisms of directed energy interactions with surfaces such as sputtering and laser desorption. His trace analysis instruments are used in the analysis of presolar grains providing insights into stellar nucleosynthesis and in the study of Genesis flight coupons allowing the most accurate determinations to date of the abundance of the elements in the solar system.

A second thrust of the program is in materials synthesis using Atomic Layer Deposition (ALD). We are currently exploring Atomic Layer Deposition as a facile synthesis method for functionalizing nanoporous and nanostructured materials. This work has driven new synthetic routes for synthesizing active materials such as transparent conducting oxides, oxidative dehydrogenation (ODH) catalysts, activated nanoporous membranes, superconducting rf cavities, and ISOLDE target fabrication. Stabilized sub-nanometer transition metal catalysts have been synthesized with high ODH activity which depending on the formulation activates alkane C-H bonds (for propene formation) specifically or C=C bonds specifically (for epoxidation). It has also lead to ZnO nanotube photovoltaic cells with the highest reported photovoltage. Further photovoltaic synthesis studies have lead to facile synthesis methods for two completely new photovoltaic cell architectures. These architectures provide new insights into the electron transport properties in wide band gap semiconductor mesoscopic structures.

ANSER Solar Energy Symposium 2009

Mark Ratner, Northwestern University

Organic Photovoltaics: Some Issues, Some Approaches

Mark Ratner is a materials chemist, whose work focuses on the interplay between molecular structure and molecular properties. This includes such aspects as molecular electronics, molecular optoelectronics, molecular systems design and biomolecular behavior, as well quantum and classical methodologies for understanding and predicting molecular structure and response. The major focus of his research for the last three decades has been the understanding of charge transfer and charge transport processes based on molecular structures, ranging from nonadiabatic intramolecular behavior to aspects of molecular devices, including photovoltaics, conductive polymers, molecular transport junctions and molecular switches.

His professional history involves undergraduate work at Harvard, graduate work at Northwestern, post-doctoral work at Aarhus and Munich, and faculty positions at New York University and Northwestern. He is now Dumas University Professor at NU and Co-Director of the Initiative for Sustainability and Energy at Northwestern (ISEN). He has very active international collaborations, particularly in Denmark, Israel and the Netherlands. He has been awarded the Feynman Prize, the Langmuir Award of the American Chemical Society, and is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the International Academy of Quantum Molecular Sciences, the Royal Danish Academy of Sciences and an annual canoe trip which puts all things back into perspective.

Biological, Hybrid & Bio-Inspired Systems for Efficient Energy Conversion

Biomimetic Models for the Hydrogenases

Thomas Rauchfuss, University of Illinois, Urbana-Champaign

Biomimetic Models for the Hydrogenases

Thomas B. Rauchfuss is Lycan Professor of Chemical Sciences at the University of Illinois at Urbana-Champaign. Degrees include a B. S. (1971) at University of Puget Sound (1971) and a PhD at Washington State (1975). He was a research fellow at the Australian National University until 1978, and has been at Illinois since then. Rauchfuss has published one book and over 250 papers. Awards include fellowships from the Sloan, Dreyfus Fellowships, Guggenheim, and Humboldt Foundations. He received the ACS Award in Inorganic Chemistry in 2002. He was the director of the School of Chemical Sciences from 1999 until 2007.

A major interest for our group is environmentally-motivated organometallic chemistry. We are interested in fundamental studies leading to clean fuels. One aspect of this research is the elucidation of nature’s methods for producing H₂. A long term interest is in catalysts for removing sulfur from fossil fuels, focusing on mechanisms of C—S bond cleavage.
**Presenters**

Michael Wasielewski, Northwestern University/Argonne, Director ANSER

Prof. Michael R. Wasielewski received his Bachelor of Science (1971) and Ph.D. (1975) degrees from the University of Chicago. Following his graduate work, he was a postdoctoral fellow at Columbia University. He then moved to the Argonne National Laboratory, where he rose through the ranks to become Senior Scientist and Group Leader of the Molecular Photonics Group. In 1994, he joined the faculty of Northwestern University, where he is currently Professor of Chemistry. He served as Chair of the Chemistry Department at Northwestern from 2001-2004. He is currently the Director of the Argonne-Northwestern Solar Energy Research Center, and also holds an appointment as Senior Scientist in the Center for Nanoscale Materials at Argonne. Prof. Wasielewski’s research centers on light-driven charge transfer and transport in molecules and materials, photosynthesis, nanoscale materials for solar energy conversion, spin dynamics of multi-spin molecules, molecular materials for optoelectronics and spintronics, and time-resolved optical and electron paramagnetic resonance spectroscopy. His research has resulted in over 330 publications. Prof. Wasielewski was elected a Fellow of the American Association for the Advancement of Science in 1995, and has held numerous distinguished lectureships and fellowships. Among Prof. Wasielewski’s recent awards are the 2008 Porter Medal for Photochemistry, the 2006 James Flack Norris Award in Physical Organic Chemistry of the American Chemical Society, and the 2004 Photochemistry Research Award of the Inter-American Photochemical Society.

**We are so pleased you could join us for the 2nd Annual ANSER Solar Energy Symposium.**

ANSER and ISEN would like to thank the following individuals who have helped make this event a success:

Christina Maki – Good Luck with your Graduate Studies in Kansas!

Hotel Orrington

Ivan Meyer, Director Tech Instruction/AV Tech, Medill

Jane Wuellner, ISEN Program Coordinator

Jay Walsh, VP Research, Northwestern University

Quince at the Homestead

**Join us again next year**

Be sure to register your name with the ISEN staff so you are notified early of next year’s Symposium details.

**Suggestions for Lunch on May 6th**

Norris University Center (Easy Walk – 5 minutes)

Self-Serve Food Court

East of the McCormick Tribune Building

Downtown Evanston (Approximate 20 minute walk)

Some suggestions:

Blu Sushi, 1700 Orrington Avenue

Burger King, 1740 Orrington Avenue

Flat Top Grill, 707 Church Street

GIO Restaurant, 1631 Chicago Avenue

Lou Malnati’s Pizza, 1850 Sherman Avenue

Mt. Everest Restaurant, 630 Church Street

Sashimi Sashimi, 640 Church Street

See an ISEN Staff Member for Map of Evanston and Directions