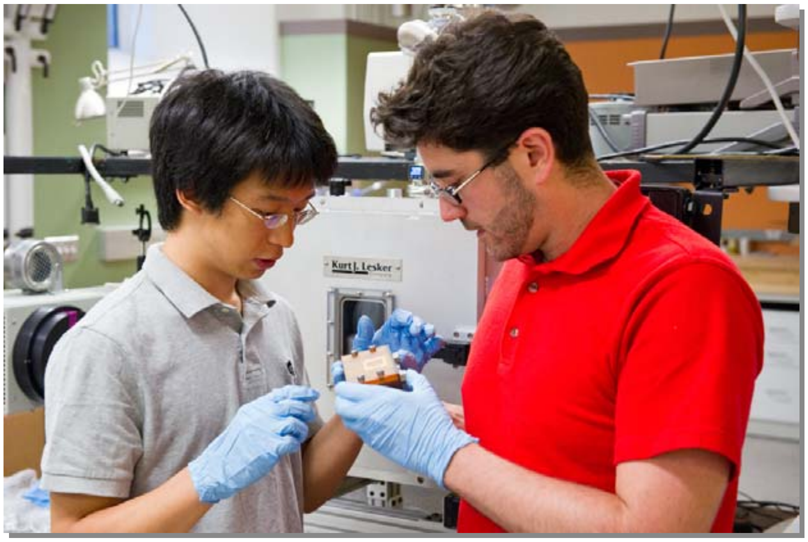
2011 MITEI Summer UROPs

Student Project Descriptions



Funding for MITEI UROPs in summer 2011 is provided by individual donors and by members of the MIT Energy Initiative, including inaugural Founding Member BP, Founding Member Shell, and individual Affiliate Members with a particular interest in supporting undergraduate research.
(http://web.mit.edu/mitei/about/members.html)

MITEI works with the MIT ***Undergraduate Research Opportunities Program*** (UROP) to support the participation of undergraduates in energy research and to encourage undergraduate interest in the energy field. MITEI UROPs can be conducted in any academic department or interdisciplinary laboratory.

The ***MIT Energy Initiative*** (MITEI) was formally launched by President Susan Hockfield in November 2006 to mobilize the capabilities and experience of the Institute to "foster new research in science and technology to increase energy supplies ... bringing scientists, engineers and social scientists together to envision the best energy policies for the future." MITEI is now a broad, Institute-wide initiative designed both to transform the global energy system to meet the needs of the future and to help build a bridge to that future by improving today's energy systems.

In 2011, ***MITEI has grown*** to:

- 65 private and public members
- More than $300M in research and education support
- 89 novel or early stage research projects

The undergraduate ***Energy Studies Minor,*** MIT's first interdisciplinary minor, was launched in September 2009.

In May 2010, MIT and its electric utility NSTAR announced a first of its kind collaboration to ***reduce MIT's electricity consumption*** by 15%, or 34M KWH.

Website: http://mit.edu/mitei/education/urop.html

Cover photos: Justin Knight

MITEI is pleased to present brief descriptions for 29 student research projects supported by MITEI members and private donors during summer 2011. The selection process was quite competitive, with many proposals received from both students and faculty. This summer's cohort of energy UROPs hails from 11 departments and is 52% female.

Student: **Arumina Balan** '14	Chemistry
Faculty: Mircea Dincă	Chemistry
Sponsor: BP	
Project: Synthesis of phthalocyanine frameworks for microporous electrode materials	

One limiting factor in the performance of lithium-ion batteries is the cathode. It suffers from challenges including poor ionic conductivity and a lack of reversibility. The Dincă group is addressing these issues through the use of porous covalent organic frameworks and metal-organic frameworks. We will synthesize, starting from common chemicals, and characterize a conductive framework of phthalocyanine, using a variety of potential linkers and metal centers. We will then examine the effect iodine doping has upon the framework. We will be able to determine the structure and pore characteristics using modeling, powder x-ray diffraction, and porosity measurements. Using techniques including cyclic voltammetry, conductivity at different temperatures, and thermoelectric measurements we will then understand the band structure of the material. Conductive phthalocyanine frameworks, with high internal volumes and surface areas, could prove to be an essential part of future energy storage devices.

Student: **Emily Chen** '14	Brain & Cognitive Sciences
Faculty: Jean-François Hamel	Chemical Engineering, Research Engineer
Sponsor: Shell	
Project: Producing biofuels from sorghum: a starchy plant	

This summer I have been granted sponsored funding to begin research in the Hamel Laboratory that focuses on the enzymatic hydrolysis of a starchy plant and the production of ethanol by fermentation. Under the direct supervision of Dr. Jean-François Hamel, I am working on this Biofuels project with a team of two other undergraduates. The goal of this project is to gain more insight into sorghum and its ability as a fuel substrate. It has drawn interest recently due to its resistant nature and its property of production with limited water. I will be performing the enzymatic hydrolysis of sorghum using alpha-amylase and glucoamylase. Here the project aims to optimize the two enzymes for the liquefaction and saccharification of Milo sorghum with respect to temperature, enzyme concentration, pH, and time. I will further analyze the effectiveness of the hydrolyzate by performing yeast fermentation for ethanol production.

Student: Jared Darby '12	Mechanical Engineering
Faculty: Ruben Juanes	Mechanical Engineering
Sponsor: Gravitas	
Project: Simple experiments to study the physics of CO2 migration and trapping in saline aquifers	

This summer, I will work with the Juanes Research Group to help with their ongoing theoretical and experimental research related to geological carbon dioxide (CO2) sequestration, which is a promising option for reducing global atmospheric CO2 emissions. I will assist with the design and execution of simple fluid-mechanics experiments to study the physics of subsurface CO2 injection, migration, and trapping. The goal of this experimental work is to help with the development of models for this process that are as simple as possible, while still capturing the important aspects of the physics. These models are useful for understanding how the various physical mechanisms--background groundwater flow, formation tilt, residual trapping, dissolution of CO2 into the groundwater, and capillary effects--interact with one-another to determine the long-term fate of injected CO2.

Student: Rebecca De Las Cuevas '13	Chemistry
Faculty: Christopher Cummins	Chemistry
Sponsor: BP	
Project: Maximizing reversibility of lithium-x batteries	

Lithium-ion batteries, although high in energy density, cheap, easy to manufacture, and, most importantly, rechargeable without significant loss of reactants, can be improved upon. Theoretically, an oxygen/peroxide recharge couple in a lithium-air battery could provide even more energy under the right conditions. I will be working on methods to maximize the reversibility of a lithium-air battery with the possibility of studying lithium-sulfur batteries.

Student: Alix de Monts '13	Mechanical Engineering
Faculty: Daniel Frey	Mechanical Engineering
Sponsor: Natalie Givans '84 *(MITEI Affiliate Member)*	
Project: Designing, building and testing a long-distance solar-powered vehicle	

The MIT Solar Electric Vehicle Team designs and builds a solar car, which competes every two years in the international World Solar Challenge in Australia, a 3000km race across the Australian outback completed in five days running on energy purely from the sun. In late 2009 the team began designing the current car, *Chopper del Sol*, and has been working on the car ever since. This summer as future Mechanical Design Lead for the team I will be testing the completed car in order to prepare for the race this coming October. I will work on debugging the car, including making modifications to the rear-wheel steer system in order to make it more stable for drivers. I will also be building a new battery pack with several teammates and test driving the car as much as possible to fully characterize the car and gather enough data on power dissipation and generation to have a model to use for race strategy.

Student: Rachel Dias Carlson '14	Mechanical Engineering
Faculty: David Wallace	Mechanical Engineering
Sponsor: Ropes & Gray LLP	ROPES & GRAY
Project: Health effects and manufacturing of agricultural waste charcoal	

In the developing world, the biomass often used for cooking and heating can cause respiratory health problems. Agricultural waste charcoal has been developed as an alternative fuel. Burning carbonized agricultural waste can reduce respiratory illness as a result of air pollution and limit deforestation. This project will test emissions from this charcoal to ensure that EPA standards are not exceeded, and demonstrate the health advantages associated with using the charcoal. The main goal of the project is to develop new machinery that can carbonize and briquette agricultural waste at the same rate the waste is available (about 1 ton per day). This will enable farmers to sell to a larger market, making the charcoal more accessible to entire communities, while also decreasing the rate of deforestation.

Student: **Nicholas Dou** '12	Mechanical Engineering
Faculty: Evelyn Wang	Mechanical Engineering
Sponsor: BP	
Project: Improving solar collector efficiency using nanostructured surfaces	

Improving solar collector efficiency is a key step to making solar-thermal energy a more economical source of renewable energy. This project will attempt to improve the heat exchange performance of a solar collector condenser by using nanostructured surfaces. Previous research has proven that nanopillars can be functionalized to induce dropwise condensation in a spatially preferential manner. By altering geometry and chemistry of these surfaces, such as the pillar dimensions, pillar spacing, and wettability, it is possible to adjust condensation properties including nucleation rate and growth rate. These studies suggest that using a nanostructured surface as a solar collector condenser can significantly reduce heat transfer resistance. Surface properties and condensation characteristics will be tuned to achieve optimal heat transfer and collector efficiency.

Student: **Jacqueline Durazo** '14	Electrical Engineering & Computer Science
Faculty: José Gómez-Márquez	D-Lab and Edgerton Center, Instructor
Sponsor: Osaka Gas	
Project: Extreme temperature design for medical devices in developing countries	

This summer I will work with the Innovations in International Health program at MIT (IIH). IIH has an innovation platform which aims to accelerate the development of global health technologies in a multidisciplinary research environment addressing the needs of patients and physicians in resource-poor settings. There are two teams with which I will work this summer: CoolComply and Solarclave. CoolComply is a personal cooling system that will be used to keep medicines at appropriately chilled temperatures and is able to accurately send a Short Message Service (SMS) to notify when the temperature is not ideal or a regular status report is requested. This is intended for home based cooling for patients with Multi Drug Resistant Tuberculosis (MDR-TB) and must maintain 15°C for up to four weeks with little energy input. Solarclave is a solar-powered sterilization system to disinfect medical instruments. This is intended for rural areas in Nicaragua where the availability of energy is limited.

Student: **Iman Fayyad** '12	Architecture
Faculty: Sheila Kennedy	Architecture
Sponsor: Dr. Alfred Thomas Guertin '60	
Project: Responsive energy harvesting textile façade	

This project is part of a collaborative research initiative at KVA MATx that aims at developing a high-tech energy-responsive façade system for the IBA-Hamburg SOFT House. To be constructed in 2013, this demonstration project focuses on smart materials and energy-efficient sustainable housing. The project explores the various ways in which sustainability and energy can influence the spatial qualities of a dynamic living space. We will be collaborating with a team of experts (including manufacturers and structural and climate engineers at the University of Stuttgart) to conduct extensive research for the designing of a low carbon construction system for Soft House, the creation of a responsive textile façade, and the designing and detailing for a set of movable curtains that distribute locally generated DC power and energy-efficient solid state lighting in the interior of the housing units. The research will involve full-scale prototyping for the testing of materials and material properties.

Student: **Aaron Fittery** '13	Mechanical Engineering
Faculty: Harry Asada	Mechanical Engineering
Sponsor: BP	
Project: Designing an underwater robot that will navigate nuclear reactor piping systems	

The chief purpose of this research project is to develop a propulsion system that allows for precise control of a robot in the narrow pipes of nuclear cooling systems. Our current research is focused on developing a robot that uses a pump and multiple jets to maneuver because propellers are unsuitable for the tight conditions. The problem with this jet and valve driven system is that commercially available valves are too bulky and inefficient with low flow coefficients, all of which cause the robot to be too large for the confined space. The project focuses on using Coanda Effect Valves which are much lighter and more efficient with higher flow coefficients. If these valves can be perfected, they will substantially increase the feasibility of a machine that can successfully and efficiently maneuver and inspect damages inside nuclear cooling pipes.

Student: Carlos Greaves '13	Electrical Engineering & Computer Science
Faculty: Sheila Kennedy	Architecture
Sponsor: Jerome I. '51 and Linda Elkind	
Project: Portable power and light for Brazil's Amazon	

The Portable Light Project is a non-profit initiative that creates new ways to deliver de-centralized renewable power and light in developing countries. Portable Light solar textile kits can be adapted to meet different needs, using local materials and sewing and weaving skills. Please see www.portablelight.org This summer, Portable Light Project, with the IADB, Instituto EDP and local NGOs *Projecto Saude e Alegria* and IDEAAS, will provide Portable Light solar textile kits to underserved *Cabloco* communities on the Amazon and Tapajos Rivers. The renewable light supports education and sustainable forest related enterprises. The recent arrival of 3G connectivity in the Amazon Tapajós Arapiuns Extractive Reserve of Brazil could provide an unprecedented vehicle for cultural self expression, economic development, education and exchange of information to reduce the geopolitical isolation of the Amazon. See http://maripa.redemocoronga.org.br/.
Our project goals are 1) to finalize the electronic solar charging circuit, test its functions empirically and characterize the circuit's functionality; 2) to create new circuitry to provide a reliable USB output that can charge a smart phone; and 3) to co-ordinate the design of a sustainable, water resistant enclosure for the circuit board and battery, using layout software to reconfigure the circuit board for a much smaller footprint.

Student: Michael Harradon '13	Electrical Engineering & Computer Science
Faculty: Marin Soljacic	Physics
Sponsor: Shell	
Project: Enhancing solar thermophotovoltaic systems with angular-selective photonic crystals	

Solar Thermophotovoltaic (TPV) systems generate electricity by collecting solar heat and using it to thermally emit radiation onto a photovoltaic cell. There is strong evidence that most of the losses seen in experimental setups are related to a mismatch between the emission spectrum of the thermal emitters in these systems, and the spectrum of the receiving devices. Bringing these two spectra into alignment has the potential to improve efficiencies by up to a factor of 45. This goal can in principle be accomplished with the use of photonic crystals: man-made materials which possess the unique property of a photonic bandgap, a range of wavelengths which are completely reflected for all incident angles and polarizations. I will be working with Professor Soljacic and with immediate supervisor Dr. Peter Bermel (a postdoctoral associate) to both numerically simulate and experimentally test the properties of angle-selective absorbers.

Student: **Rand Hidayah** '12	Mechanical Engineering
Faculty: Howard Herzog	MITEI, Senior Research Engineer
Sponsor: BP	

Project: BP Energy Sustainability Challenge: Water footprint analysis of electricity generation

My project falls under the Energy Sustainability Challenge, and specifically tackles the water footprint analysis of electricity generation in various power plants. During the course of the summer, the project seeks to understand the interactions and tradeoffs among water use, economic costs, carbon emissions, and other ecological impacts across a range of power plant technologies and configurations, including natural gas, coal, nuclear, solar thermal, and geothermal plants. Another aim of the project during the summer is to evaluate the potential for emerging technologies such as carbon capture and gasification to mitigate water consumption and/or environmental impacts within economic constraints.

Student: **Lucy Ji** '12	Chemical Engineering
Faculty: Klavs Jensen	Chemical Engineering
Sponsor: BP	

Project: Furfural production from the acid-catalyzed dehydration of xylose in a biphasic continuous flow system

Furfural, produced from the dehydration of xylose obtained from non-edible lignocellulosic biomass, is a versatile platform chemical that serves as a key intermediate in the production of renewable liquid transportation fuels as well as a substitute for petroleum-based building blocks used in the chemical industry. One promising furfural production method has been to utilize a biphasic reaction system, consisting of a reactive aqueous phase and an extractive organic phase that continuously removes the furfural as it is formed, thereby minimizing undesired side reactions and increasing yield. Branching off a team research project I completed in the past spring semester, the goal of this project is to optimize the biphasic system for furfural production in a continuous flow reactor by fine-tuning process variables including phase compositions, flow rates, residence times, recycle streams, and reactor configuration. Additionally, models of the mass transfer effects and reaction kinetics within the biphasic system will be developed that allow for scale-up production.

Student: **Charlotte Kirk** '14	Chemical Engineering
Faculty: Kristala Prather	Chemical Engineering
Sponsor: Shell	

Project: Exploration of fatty acid synthase pathway genetic inserts to produce biofuels with a higher energy density through real-time quantitative polymerase chain reaction analysis

This research project involves the production of 6- and 7-carbon branched alcohols to be used as a replacement for fossil fuels, especially gasoline in the transportation industry. The fuels being produced will be fermented from biomass and therefore will not have the high greenhouse gas emissions characteristic of fossil fuels. However, these longer saturated alcohols have a higher energy density and properties closer to gasoline than currently produced and shorter saturated alcohols such as ethanol. These alcohols will be produced through the development of a pathway in microbial hosts, specifically E. coli. A fatty acid synthase (FAS) system is the proposed pathway for the extension of the carbon chains. Quantitative polymerase chain reaction will be used to determine whether the desired pathways have been copied into the plasmid and the stability of the modified plasmid as well as to gather other relevant data.

Student: **Ben Lewis** '13	Mechanical Engineering
Faculty: William Green	Chemical Engineering
Sponsor: BP	

Project: Biodiesel@MIT

This summer I will be working for Biodiesel@MIT. My research will include biodiesel production and licensing. The basis for Biodiesel@MIT's mission is to produce biodiesel for the use of the MIT community. While actively producing biodiesel from waste vegetable oil gathered throughout the school year, I will be looking to improve how the group reclaims excess reaction products such as glycerin, water and excess alcohol. While production is important, licensing makes it possible to actually utilize the biodiesel. Over the summer I will be researching the certifications required to use our lab's biodiesel in vehicles in the MIT community.

Student: Martin Lozano '12	Mechanical Engineering
Faculty: Harry Asada	Mechanical Engineering
Sponsor: Shell	
Project: Designing an underwater robot that will navigate nuclear reactor piping systems: Communication and controls	

This project focuses on using robotics to increase the safety of nuclear power plants. Specifically the Robotics Research Laboratory in the Mechanical Engineering department is designing a compact submersible robot to be used for inspection tasks that could expose humans to dangerous levels of radiation. To control this Inspector robot, we plan to submerge a second Translator robot as a relay point. This Translator bot will detect optical commands (lights, which travel long distances in water), translate them into radio signals (capable of reaching around corners or when line-of-sight is lost) and send them to the Inspector. This method of communication will also work in the reverse direction. My initial duties within the project are creating and optimizing the reception and transmission of optical and radio signals for the translator robot using an imbedded micro-controller. I will also be developing the control system for the main Inspector robot.

Student: Benjamin Nield '12	Physics
Faculty: Peter Fisher	Physics
Sponsor: William Chao '78	
Project: Potential of one-dimensional confinement in carbon nanotubes leading to fusion	

One of the major problems in the field of fusion energy research is how to confine the plasma needed to fuse atoms together. Without a high level of confinement, a large amount of the energy put into the fusing atoms will be wasted as this energy is not efficiently directed into actually fusing the atoms. To this end, our project looks at confining Deuterium atoms inside carbon nanotubes, small tubes of carbon which theoretically confine atoms to one dimensional movement inside. Studying this confinement will lead to a better understanding of how gases behave inside carbon nanotubes and whether this is a profitable avenue to pursue in ongoing fusion energy research and will also provide data on the use of nanotubes in hydrogen storage projects.

Student: Onyinyechi Okeke '12	Chemical Engineering
Faculty: Jean-François Hamel	Chemical Engineering, Research Engineer
Sponsor: BP	
Project: Production of biofuels from lignocellulosic feedstock: sugarcane bagasse and switchgrass	

Over the past decade, a combination of rapidly increasing costs, growing demand, and scarcity of fossil fuels has compelled us to seek alternative sources for fuel. Sugarcane bagasse is the biomass waste that remains after sugar juice has been extracted from sugarcane, and switchgrass is the wild perennial plant found abundantly across North America. These are two types of lignocellulosic feedstocks that can be used for ethanol production. In industry, pretreatment of lignocelluosic feedstocks is an essential step in the overall biomass to ethanol conversion process. This step hydrolyzes hemicellulose and cellulose from the feedstocks, into xylose and glucose, respectively. In this project, the effect of temperature and acid concentration on xylose and glucose yields in the pretreatment process will be studied. HPLC analysis will be used to compile xylose and glucose concentration vs. time data for all trials. Furfural generation will also be analyzed using HPLC. Fermentation will be performed on the hydrolysates, and ethanol production will be evaluated using HPLC.

Student: Adrian Orozco '14	Electrical Engineering & Computer Science
Faculty: Una-May O'Reilly	Computer Science & Artificial Intelligence Lab, Principal Research Scientist
Sponsor: George Thompson, Jr. '53	
Project: Algorithm development for wind resource assessment	

As a promising source of renewable energy, wind turbines are pictured as a common element of the future's energy supply. The implementation of wind-power technologies must be perfected to make them a more productive source of energy. Observations of nearby small wind turbines present a troubling setback—the turbines are only producing a fraction of their estimated output during resource assessment. Our research in the Evo-DesignOpt Group will work to discover the cause of this discrepancy via data mining. Focusing on the errors in preliminary resource assessment, we will investigate various learning algorithms currently in use. The project involves analysis of data collected by the Museum of Science as well as public weather information. Ultimately, our solutions will improve the accuracy of resource assessment thereby providing a more realistic model of energy output.

Student: **Ernesto Reza-Garduño** '13	Mechanical Engineering
Faculty: Kripa Varanasi	Mechanical Engineering
Sponsor: Shell	
Project: Nanoengineered surfaces for controlling adhesion and nucleation	

The most recent World Energy Outlook predicts that energy demand in 2035 will be 36% higher than in 2008. One pressing challenge that faces oil companies to meet this demand is the formation of natural gas hydrates in oil and gas pipelines. The latter are crystalline structures formed by a lattice of water cages entrapping hydrocarbon molecules at high pressures and low temperatures. This UROP will develop novel nanoengineered surface technologies that can significantly affect adhesive strength of a solid/solid interface and can also affect heterogeneous nucleation. These surface technologies could significantly improve the efficiency and lifetime of heat exchangers by reducing scaling. Such technologies can also greatly expand deep sea operations by preventing the formation of hydrate plugs in oil and gas pipelines, or improving the flow of formed hydrate. Furthermore, there are countless applications for surface technologies that reduce adhesion of ice or control its formation.

Student: **Caitlin Sample** '14	Materials Science & Engineering
Faculty: Jeffrey Grossman	Materials Science & Engineering
Sponsor: Shell	
Project: Solvent effects on azobenzene-based solar thermal fuels	

Solar thermal fuels, which store the energy of the sun in chemical bonds, could prove to be some of the most promising sources of clean and renewable energy in the future. In particular, recent research has revealed that nanostructures composed of azobenzene and carbon nanotubes (azo/CNT) can store and release substantial amounts of solar energy in a reliably reversible process. Before we can know whether or not these nanostructures can be used as viable fuel sources, however, we must first learn how being in a solvent such as water affects their properties since it is in such solvents that this solar fuel would be used. My work this summer addresses this question by using the simulation method of molecular dynamics to model the effects of water on the storage capacity and stability of the azo/CNT structures.

Student: **Samuel Shames** '14	Materials Science & Engineering
Faculty: Michael Demkowicz	Materials Science & Engineering
Sponsor: BP	

Project: First principles modeling of hexagonal close packed (HCP) metals

This project studies the Stacking Fault Energy (SFE) and Charge Density Distribution (CDD) for HCP metals. The aim is to determine whether there is any correlation between the two. The SFE of HCP metals varies greatly depending on the different planar stacking faults which can occur across the metal. The SFE is an important parameter in determining the physical and mechanical properties. Presently, the SFE is not very well understood; there is no theory which can explain the values of the experimentally determined SFEs nor predict SFEs of yet untested metals. The goal of this UROP will be to use Quantum Espresso to build and test HCP metals with different stacking faults, as well as study the CDD using Density function theory. The purpose is to find a correlation between the two which can explain the variance in SFE between the different metals and the variance in the SFE for different lattice planes. If successful, the results will impact structural materials in Transportation and Nuclear Energy.

Student: **Amanda Valentin** '14	Civil & Environmental Engineering
Faculty: Herbert Einstein	Civil & Environmental Engineering
Sponsor: Shell	

Project: Decision Aids for Tunneling (DAT) - Applied to geothermal wells

This particular UROP project has to do with addressing the many uncertainties that influence tunnel construction. Cost and time particularly can be affected by these uncertainties, as well as by the resources required in construction and produced by it, and the DAT tool, which I will be working with, helps address these. The DAT are an interactive computer program that can be used to compute tunnel construction cost, time, materials needed, and resources produced. It uses much of the information that is standard to most contractors and designers: geological and geotechnical descriptions, geometric, structural and material characteristics of the tunnel supports, and construction parameters such as advance rates and cost per tunnel length. Since the DAT take into account the uncertainties of all these parameters, the final yield is a distribution of them. In this project, the DAT will be applied to the cost and time estimates for geothermal wells.

Student: Thomas Villalón Jr. '14	Mechanical Engineering
Faculty: James Bales	Edgerton Center, Instructor
Sponsor: Shell	
Project: The development of MIT Solar Electric Vehicle Team's next car and researching its various components	

The goal of this research is to create new vehicular designs that can efficiently use the energy put into them. Using computer simulations and CAD designs, this project seeks to improve on the current design of MIT SEVT's Chopper del Sol. This will be accomplished by finding new ways to integrate the mechanical and electrical systems while appropriately redesigning the vehicle body to produce less drag. In addition, small scale experiments on composites and plastics will determine the weight, strength, and aerodynamic characteristics of the materials. Lastly, this project will test experimental materials and production techniques (i.e. – new batteries, solar cells encapsulation, etc.) to see if they can alter the properties of the car.

Student: Joyce Wang '12	Biology
Faculty: Shuguang Zhang	Biological Engineering, Principal Research Scientist
Sponsor: Shell	
Project: Bioengineered algae for bio-hydrogen production	

I am working on purifying and crystallizing some of the proteins involved in algal production of hydrogen since we are interested in further engineering them. In order to achieve such a precise molecular level of engineering, the atomic structure of these enzymes must be thoroughly studied. First, I will master protein purification techniques which involves isolating a single protein by exploiting differences in protein size, binding affinity, biological activity, and chemical properties. I will be studying how to design and perform large screenings for optimal crystallization conditions. Among the proteins I will be purifying this summer is a genetically engineered ferredoxin-hydrogenase enzyme which increases hydrogen production by preventing electrons from being used to produce NADPH and other sugars. Instead, this fusion protein shuttles the majority of the photosynthetic energy towards hydrogen production, reaching 70% of the plant's maximal rate. In conclusion, an atomic structure of this engineered protein will give exciting insights into the electron transfer mechanism caused by this enzyme that will both advance pure scientific knowledge as well as be an important milestone towards economical use of algae. This concept of genetically engineering a fusion protein will prove useful with other organisms and possibly become a model for other protein studies.

Student: **Brook Wassie** '14	Biological Engineering
Faculty: Shuguang Zhang	Biological Engineering, Principal Research Scientist
Sponsor: BP	
Project: Bio-hydrogen production in photosynthetic organisms	

I am assisting Iftah Yacoby in the Zhang lab to produce an enzyme that catalyzes in vivo production of Hydrogen gas. Photosynthetic algae naturally produce hydrogen at low yields when they carry out photosynthesis. The creation of hydrogen occurs occasionally after the light dependent reactions of photosynthesis. The Hydrogenase enzyme catalyzes the reversible conversion of $2H^+$ ions to an H_2 molecule. Yacoby et al. have designed a fusion enzyme that couples ferredoxin, an electron carrier, with Hydrogenase. This allows for a more efficient method for the production of Hydrogen gas. During the summer, we shall work out an efficient method for cloning the designed gene and producing the fusion enyzyme. We shall also transform algal cells with the new enzyme and attempt to produce Hydrogen gas in vivo. Overall, we will hopefully design a method for the efficient production of clean burning Hydrogen gas.

Student: **Liza Xu** '13	Chemical Engineering
Faculty: Bradley Olsen	Chemical Engineering
Sponsor: Shell	
Project: Self-assembly of enzymes using block copolymers for new heterogeneous catalyst	

Enzymes are required in nearly every metabolic process within cells and are also used to catalyze reactions capable of producing energy such as the reduction of carbon dioxide. The current use of enzymes is limited by the narrow operating window for stability, low enzyme densities, and transport limitations in reaching the enzyme active site. A promising solution for addressing these limitations is to synthesize a hybrid block copolymer that self-assembles into three dimensional nanostructures. To understand the structure-property relationships in these novel block copolymers, mutated fluorescent protein, mCherry S131C, and maleimide end-functionalized poly(N-isopropyl acrylamide) (PNIPAM) will be used as a model system to examine the effect of the PNIPAM coil size on the type of nanostructure formed. Examination of coil length and conditions under which self-assembly and annealing are completed will enable us to determine the ideal parameters required to achieve the most thermodynamically stable structure for the desired application.

Student: Rick Zang '14	Mechanical Engineering
Faculty: Tonio Buonassisi	Mechanical Engineering
Sponsor: William Chao '78	
Project: Characterization of electronic band structures in novel solar energy materials	

Photovoltaics are considered by many to be the most viable option for sustainable energy production. Unfortunately, the cost of solar energy still needs to come down by factor of 3 in order to be cost-competitive with fossil fuel generated electricity. During my UROP, I will be working to help characterize novel material systems that are promising candidates to significantly reduce the cost of solar PV.

The goal of this UROP is to make a tool that helps characterize the electronic band structure of novel solar energy materials. Measuring the free carrier concentration as a function of temperature via the Hall effect can give us valuable information about the electronic band structure of a material.

This research will allow the identification and classification of the energy states of new materials. This will be especially useful for analyzing Intermediate Band Photovoltaics which are very attractive due to their high theoretical efficiency.

2011 MITEI UROP Sponsors

MITEI Founding Member

In 2007, BP joined the MIT Energy Initiative as its inaugural Founding Member. In the summer of 2010, BP launched the inaugural Founding Member UROP program by supporting eleven BP-UROP students. BP-UROPs interact and share results with BP representatives both during and after the completion of their UROP.

Shell
MITEI Founding Member

Shell is a global group of energy and petrochemicals companies with around 101,000 employees in more than 90 countries and territories. In the U.S., we operate in 50 states and employ more than 20,000 people working to help tackle the challenges of the new energy future. We are a leading oil and gas producer in the deepwater Gulf of Mexico, a recognized pioneer in oil and gas exploration and production technology and one of America's leading oil and natural gas producers, gasoline and natural gas marketers and petrochemical manufacturers.

Natalie Givans '84 *MITEI Affiliate Member*

Natalie received her bachelor's degree from MIT and master's degree from Johns Hopkins, both in electrical engineering. She is currently the Vice President of Booz Allen Hamilton, a leading strategy and technology consulting firm that is based in Herndon, VA. She leads the firm's Assurance & Resilience team, which delivers Information Assurance and IT Security capabilities and service offerings into the firm's U.S. government and commercial Cyber markets.

Gravitas & Cie International Ltd *MITEI Affiliate Member*

Gravitas is a family-owned boutique Strategic Corporate Advisory firm. It specializes in engineering of crude oil and gas pipelines, risk mitigation in large infrastructure EPC projects and project finance advisory, advisory activities for merger and acquisition (predominantly for metallurgical and mining industries), and corporate advice for dissolution of military offsets.

Osaka Gas
MITEI Affiliate Member

Osaka Gas is a leading energy supplier with its core natural gas supply business serving 6.7 million customers in the Kansai Region. With its portfolio of diversified energy businesses, Osaka Gas is developing into a multi-energy services provider of natural gas, electricity, LPG, district heating/cooling, and other services. With its affiliated enterprises, the Osaka Gas Group is also active in various non-energy business fields.

Ropes & Gray LLP
MITEI Affiliate Member

Ropes & Gray is a leading global law firm with offices in Boston, Chicago, Hong Kong, London, New York, San Francisco, Silicon Valley, Tokyo, and Washington, DC. Built on a foundation of over 140 years of dedication to forging strong client relationships, we represent interests across a broad spectrum of industries in corporate law and litigation matters. In addition, we offer counsel on labor and employment issues, tax and benefits, creditors' rights, and private client services. Our clients range in size from large to small companies and include financial institutions, government agencies, hospitals and health care organizations, colleges and universities, and families and individuals.

2011 MITEI UROP Sponsors *(continued)*

William Chao '78

Mr. Chao received his bachelor's degree from MIT in electrical engineering. He has made substantial accomplishments in the field of logic simulation for large-scale computing systems and digital IC designs, and is President of California-based Innovative Systems & Technologies. Mr. Chao is concerned about science and technology education, national energy policy and the capacity of US technology and engineering developments to meet rising energy demands in a fiscally, socially and environmentally responsible fashion.

Jerome I. '51 and Linda Elkind

Jerry Elkind received his bachelor's and doctor's degrees in electrical engineering. His early career was devoted to computer research at BBN and Xerox. He is now working on computer technology to help people with learning disabilities, co-founding Kurzweil Educational Systems and the Lexia Institute. Linda received her bachelor's degree from Smith College. Her career focused on environmental education and environmental issues in land use. Both have been concerned for many years about environmental sustainability and energy efficiency.

Dr. Alfred Thomas Guertin '60

Dr. Guertin received his PhD in Chemistry from MIT and worked at Geo Environmental Technologies—an environmental and geotechnical consulting firm. He now lives in Palm Coast, Florida.

George Thompson, Jr. '53

George Thompson, Jr. founded Commonwealth Scientific Corporation in 1968, a research and development company which deals in thin film and vacuum technology used in the semiconductor, magnetic head recording, thin film and optical coating industries. It sells to universities and government as well as commercial concerns. The company is now known as Ionbeam Scientific. Mr. Thompson received his Bachelor of Science from MIT in General Engineering.

Student	Project Title	Class Year	Student Department	Sponsor	Faculty Supervisor
Arunima Balan	Synthesis of phthalocyanine frameworks for microporous electrode materials	2014	Chemistry	BP	Mircea Dincă
Emily Chen	Producing biofuels from sorghum: a starchy plant	2014	Brain & Cognitive Sciences	Shell	Jean-François Hamel
Jared Darby	Simple experiments to study the physics of CO2 migration and trapping in saline aquifers	2012	Mechanical Engineering	Gravitas	Ruben Juanes
Rebecca De Las Cuevas	Maximizing reversibility of lithium-x batteries	2013	Chemistry	BP	Christopher Cummins
Alix de Monts	Designing, building and testing a long-distance solar-powered vehicle	2013	Mechanical Engineering	Givans	Daniel Frey
Rachel Dias Carlson	Health effects and manufacturing of agricultural waste charcoal	2014	Mechanical Engineering	Ropes & Gray	David Wallace
Nicholas Dou	Improving solar collector efficiency using nanostructured surfaces	2012	Mechanical Engineering	BP	Evelyn Wang
Jacqueline Durazo	Extreme temperature design for medical devices in developing countries	2014	Electrical Engineering & Computer Science	Osaka	José Gómez-Márquez
Iman Fayyad	Responsive energy harvesting textile façade	2012	Architecture	Guertin	Sheila Kennedy
Aaron Fittery	Designing an underwater robot that will navigate nuclear reactor piping systems	2013	Mechanical Engineering	BP	Harry Asada
Carlos Greaves	Portable power and light for Brazil's Amazon	2013	Electrical Engineering & Computer Science	Elkind	Sheila Kennedy
Michael Harradon	Enhancing solar thermophotovoltaic systems with angular-selective photonic crystals	2013	Electrical Engineering & Computer Science	Shell	Marin Soljacic
Rand Hidayah	BP Energy Sustainability Challenge: Water footprint analysis of electricity generation	2012	Mechanical Engineering	BP	Howard Herzog
Lucy Ji	Furfural production from the acid-catalyzed dehydration of xylose in a biphasic continuous flow system	2012	Chemical Engineering	BP	Klavs Jensen
Charlotte Kirk	Exploration of fatty acid synthase pathway genetic inserts to produce biofuels with a higher energy density through real-time quantitative polymerase chain reaction analysis	2014	Chemical Engineering	Shell	Kristala Prather
Ben Lewis	Biodiesel@MIT	2013	Mechanical Engineering	BP	William Green
Martin Lozano	Designing an underwater robot that will navigate nuclear reactor piping systems: Communication and controls	2012	Mechanical Engineering	Shell	Harry Asada
Benjamin Nield	Potential of one-dimensional confinement in carbon nanotubes leading to fusion	2012	Physics	Chao	Peter Fisher
Onyinyechi Okeke	Production of biofuels from lignocellulosic feedstock: sugarcane bagasse and switchgrass	2012	Chemical Engineering	BP	Jean-François Hamel
Adrian Orozco	Algorithm development for wind resource assessment	2014	Electrical Engineering & Computer Science	Thompson	Una-May O'Reilly
Ernesto Reza-Garduño	Nanoengineered surfaces for controlling adhesion and nucleation	2013	Mechanical Engineering	Shell	Kripa Varanasi
Caitlin Sample	Solvent effects on azobenzene-based solar thermal fuels	2014	Materials Science & Engineering	Shell	Jeffrey Grossman
Samuel Shames	First principles modeling of hexagonal close packed metals	2014	Materials Science & Engineering	BP	Michael Demkowicz
Amanda Valentin	Decision Aids for Tunneling (DAT) - Applied to geothermal wells	2012	Civil & Environmental Engineering	Shell	Herbert Einstein
Thomas Villalón Jr.	The development of MIT Solar Electric Vehicle Team's next car and researching its various components	2014	Mechanical Engineering	Shell	James Bales
Joyce Wang	Bioengineered algae for bio-hydrogen production	2012	Biology	Shell	Shuguang Zhang
Brook Wassie	Bio-hydrogen production in photosynthetic organisms	2014	Biological Engineering	BP	Shuguang Zhang
Liza Xu	Self-assembly of enzymes using block copolymers for new heterogeneous catalyst	2013	Chemical Engineering	Shell	Bradley Olsen
Rick Zang	Characterization of electronic band structures in novel solar energy materials	2014	Mechanical Engineering	Chao	Tonio Buonassisi