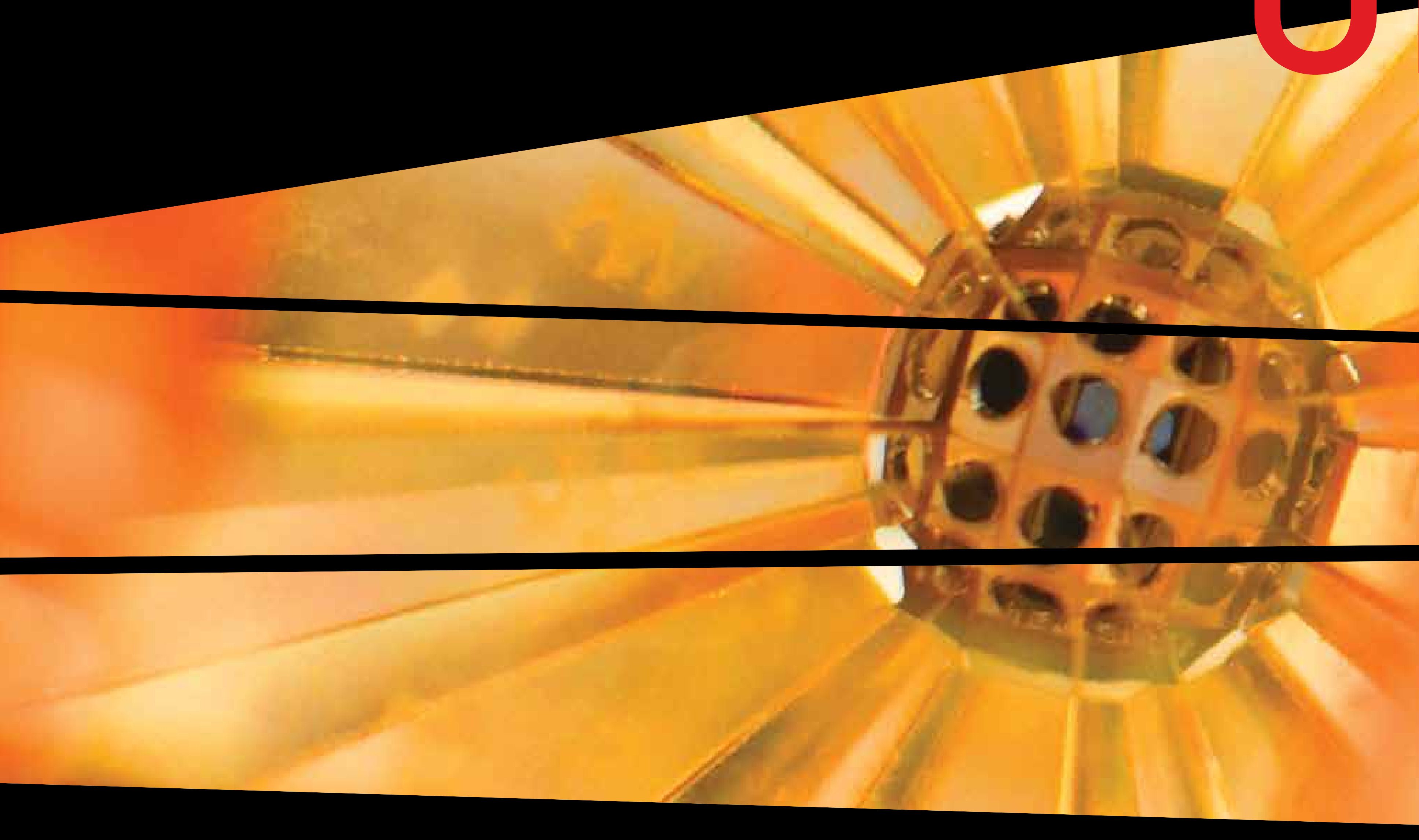
Applications for Energy UROPs for summer 2015 are due March 9, 2015 .

web.mit.edu/energyurop

ENERGY UROP



MIT Energy Initiative

Cover photos: background and top photos by Justin Knight; bottom photo by Dominic Reuter

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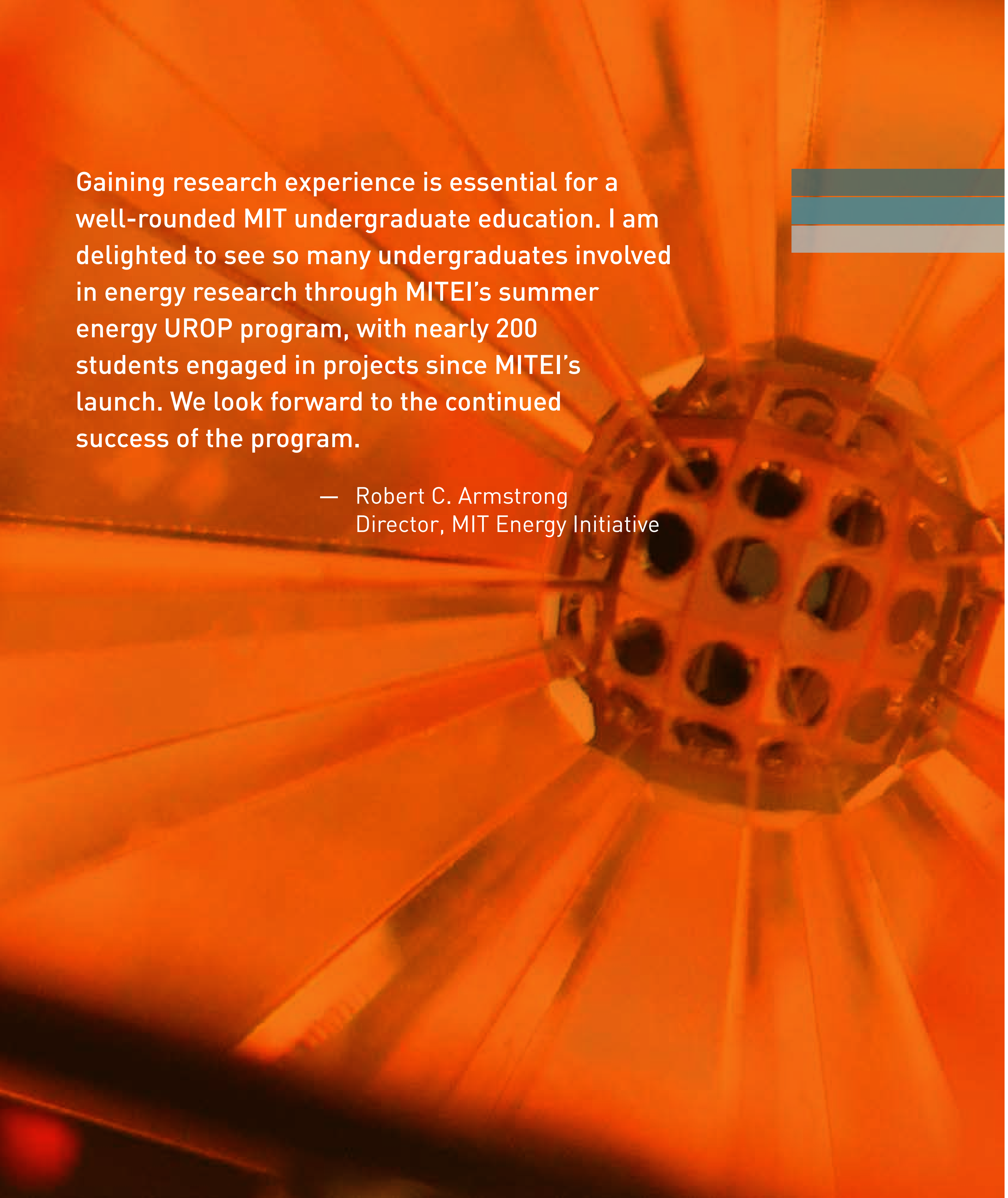


Gaining research experience is essential for a well-rounded MIT undergraduate education. I am delighted to see so many undergraduates involved in energy research through MITEI's summer energy UROP program, with nearly 200 students engaged in projects since MITEI's launch. We look forward to the continued success of the program.

— Robert C. Armstrong
Director, MIT Energy Initiative

Why an Energy UROP?

The MIT Energy Initiative is 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. Undergraduate research is a vital part of that mission.

MITEI encourages undergraduate involvement in energy and supports undergraduate participation in energy research via a summer Energy UROP program. MITEI funded more than 45 projects (see sponsors on pages 31–33) in summer of 2014. For students in all majors, from mechanical engineering to chemistry to political science, the MITEI UROP program provides skill-building workshops and organized networking opportunities for students to connect with other energy researchers on campus. Energy UROP students have opportunities to present their work to their peers in an informal setting, as well as occasions to present at other events throughout the year. Many Energy UROP students gain practical insight by connecting with their sponsoring company or donor.

Energy UROP students are funded for 10 to 12 weeks in the summer, allowing for an immersive, full-time research experience.

How do I Apply?

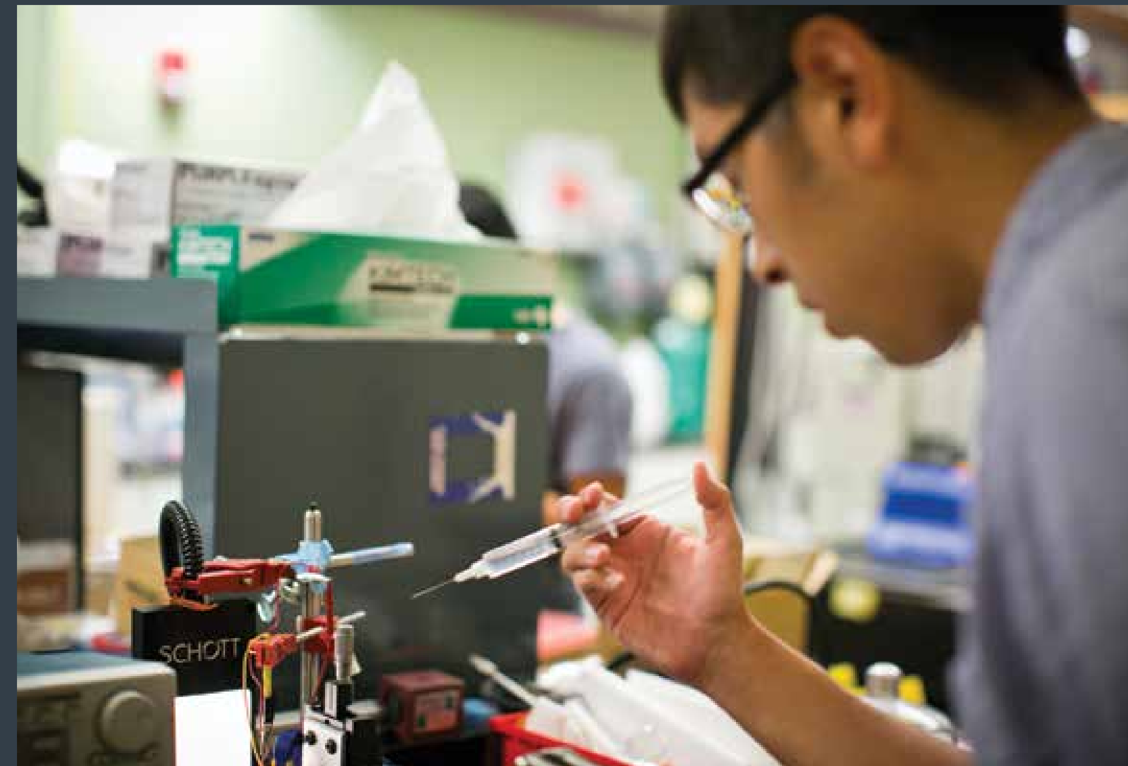
The Energy UROP program requires a MITEI-specific form as well as completion of the traditional UROP application/proposal process. The MITEI form and further details on the application process may be found at web.mit.edu/energyurop.

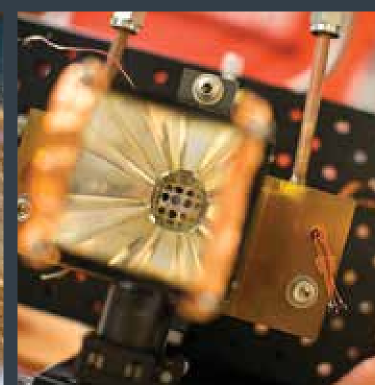
Applications for Energy UROPs for summer 2015 are due on **March 9, 2015**. Decisions will be sent out in mid-April 2015, in advance of the MIT UROP Office's summer direct funding deadline.

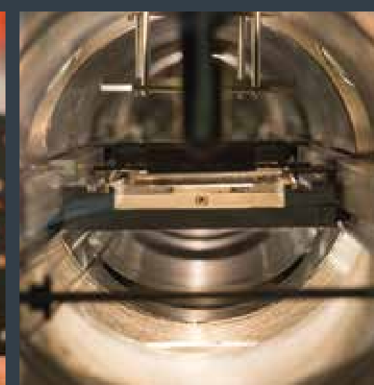
Any application or program-related questions may be directed to Ann Greaney-Williams, MITEI Academic Coordinator at agreaney@mit.edu.

Meet the 2014 Energy UROPs

In joining the Energy UROP program, I was aiming to learn as much as I could. This project allowed me to test out my previous knowledge of mechanics, giving me the opportunity to revisit the material I have learned and finally connect some physical phenomena with the analytical tools that I have learned in my math and physics courses. — Stephanie Guo '17







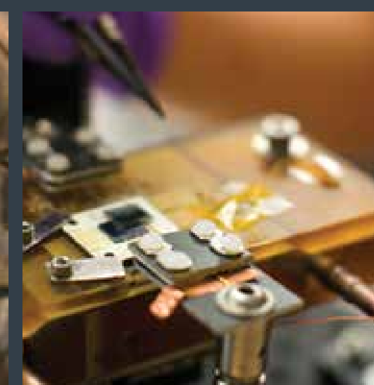


Photo by Dominic Reuter

Photo by Justin Knight

Photos top and middle three by Dominic Reuter; bottom by Cathy Zhou.

Melanie Abrams

Biology

Advisor: Gerald Fink, Biology

Sponsor: Lockheed Martin

Investigating Yeast as a Source of Heavy Alcohols for Efficient Biofuel

I worked on a multi-part project with the goal of producing heavy alcohols with yeast for more efficient and sustainable biofuels than ethanol. For example, one of the sub-projects I worked on involved running and analyzing fermentations of strains transformed with components of the metabolic pathway for isobutanol that had reduced ethanol production to see if that allowed the cells to use more of the available glucose to produce heavy alcohols. Another sub-project involved screening for nanobodies from a library designed to block an enzyme in the ethanol pathway. I enjoyed learning techniques of lab work, and I also enjoyed learning how to look at the results of an experiment and try to figure out what it means and how to address it. This summer gave me a glimpse of what is involved in research and has encouraged me to pursue a career in energy in the future.

Madeline Aby

Electrical Engineering & Computer Science

Advisor: Tomás Palacios, Electrical Engineering & Computer Science

Sponsor: Ernst & Young

Graphene-Based Supercapacitors

The goals of the project I am working on are to improve upon graphene-based supercapacitors and to work on making these devices cheap, flexible, and scalable. Supercapacitors are a type of capacitor in which charge is stored at the boundary between the electrodes (usually made of carbon) and an electrolyte. They are very promising for energy storage and delivery because of their high power density compared to batteries and high energy density compared with conventional capacitors. A very interesting part of my UROP experience was getting to work in the cleanrooms at MIT in order to fabricate some of these devices. It was also very rewarding to start a project from nothing and see it progress to some working capacitors. The Energy UROP program has led me to consider pursuing energy-related research or a career in the energy field post-graduation.

Jordan Addison

Electrical Engineering & Computer Science

Advisor: Tomás Palacios, Electrical Engineering & Computer Science

Sponsor: Friends of MITEI

3D Printing with Embedded Electronics

The goal of my project this summer was to improve the quality of graphene solutions for use in inkjet printing. Graphene – a one atom thick carbon lattice – has amazing electrical properties and mechanical ruggedness. Its mechanical strength makes it an ideal candidate for use in flexible electronics, and it is useful in optoelectronic devices like solar panels because of its transparency along with its high conductivity. Fabricating these kinds of devices – and many others – could be much more efficient with the use of a straightforward process like inkjet printing. Working on this project has shown me the scale of impact that nano and microelectronics can have on the very large issue of energy consumption.

Dheevesh Arulmani

Chemical Engineering

Advisor: Donald Sadoway, Materials Science & Engineering

Sponsor: Dr. Alfred Thomas Guertin '60

Selective Membrane Development for High Voltage Liquid Metal Batteries

My research focused on the development of ion-selective membranes for the next generation of high-voltage liquid metal batteries. Composed of two liquid metal electrodes and a molten salt electrolyte, these cells facilitate high power densities and cyclability for cost-effective grid-level energy storage. However, the miscibility of the reactant species inhibits the coulombic efficiency of these batteries. My research has focused on the development of various ion-selective membranes to alleviate this constraint. Through this research, I have acquired a range of experiences in electrochemistry, thermodynamics, metallurgy, electrochemical stability, corrosion, and X-ray/spectroscopic analyses. I particularly enjoyed the opportunity to be immersed in an environment very much conducive to cutting-edge and innovative thinking. Observing the transition of ideas from the research at Group Sadoway to Ambri, the startup that was spawned from the lab, has provided a very unique and rewarding insight into the energy industry and a possible career in the energy space.

Raul Barraza

Mechanical Engineering

Advisor: Leslie Bromberg, Plasma Science & Fusion Center

Sponsor: Tata Center for Technology and Design

Engine Reforming for Methane

The purpose of this project is to create a two-step conversion process that converts natural gas into liquids fuels. My specific Energy UROP project is focused around elucidating on specific engine properties such as inlet pressure and equivalence ratio that are required to convert methane into syngas, a necessary step in converting natural gas into liquid fuels. I enjoyed this project because it gave me the opportunity to work with an engine and some electronic components. With regards to my future in energy, I cannot say with certainty that this project has influenced me to follow such a path. It is too early in the project for me to see the impact that this research will have on the world, in terms of energy, as I will be continuing the project into the fall. This project has shown me that I want to focus my career in the automotive industry, as I really enjoy the automotive component of the project.

Dillon Battaglia

Mechanical Engineering

Advisor: Steven Barrett, Aeronautics & Astronautics

Sponsor: Lockheed Martin

Quantifying Aviation Biofuel Potential

This summer, my project involved a meta-study for the International Civil Aviation Organization (ICAO) on the potential for the use of aviation biofuel by the year 2050. I enjoyed learning more in-depth about biofuel energy as a whole. I knew the basics of biofuels and their importance in the energy debate, but examining different studies afforded a much larger breadth of knowledge on the topic. It afforded me the opportunity to examine trends in biofuels use in the aviation industry, and how additional use might be affected by availability of feedstock, public policy, and other social consequences of biofuels production. The UROP helped me identify in which ways I work best, and what environments and factors enable me to be the most productive.

Jean Bauer

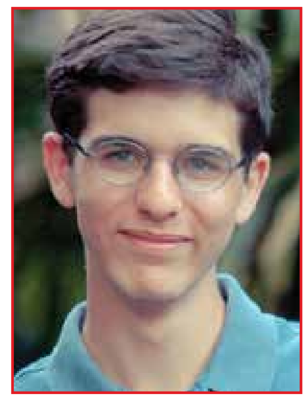
Mechanical Engineering

Advisor: John Germaine, Civil & Environmental Engineering

Sponsor: Schlumberger

Mathematical Modeling of Cement Nanocomposites Containing Carbon Nanotubes

This summer, my research investigated the electrical properties of cement-carbon nanotube and carbon fiber composites. Specifically, I studied results received from lab tests and experimented with different numerical methods to build a MATLAB model of these composites' properties. With a strong understanding of their piezoresistive properties, cement nanocomposites could be used in oil wells to monitor the condition of the well casing. It might happen that the cement surrounding the main steel casing of an oil well cracks under the extreme temperatures and pressures found downhole, but being able to monitor the condition of this cement in real time could help detect where such cracks might occur, and prevent potentially disastrous oil spills. Thus, while oil remains such a significant global source of energy, this research is important to improve the safety and lessen the environmental impact of the oil drilling process.



Marcus Boorstin

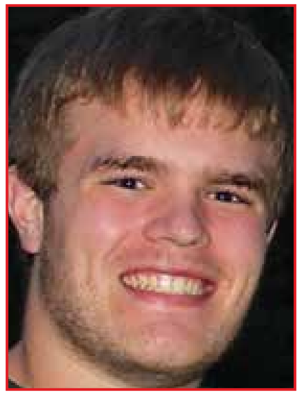
Electrical Engineering & Computer Science; Mathematics

Advisor: Pattie Maes, Media Arts & Sciences

Sponsor: Lockheed Martin

LuminAR: Steelcase Education and Transition to a New System

During the summer of 2014 I UROPed with the LuminAR project, part of the Fluid Interfaces group of the Media Lab, as a continuation of a UROP I began during IAP 2014 and continued through spring. LuminAR is a projected augmented-reality platform built from a small projector, camera, and wireless computer squeezed into a lamp-like form factor. Essentially, LuminAR transforms any surface into a gigantic touch screen capable of interpreting multi-touch gestures in three dimensions and other "natural" ways of interfacing with a computer. The user is then able to use LuminAR as they would a normal computer, but with added capabilities specifically designed to take advantage of its unique capabitilies. LuminAR therefore suggests exciting possibilities in the growing world of augmented reality. My projects over the summer included a complete classroom educational system, a backend to allow app developers to interface with serial devices such as Arduinos via a simple API, a quality control tracking system for use by manufacturers, and various internal tools to ensure software consistency across the LuminARs.



John Brown

Mechanical Engineering

Advisor: William Green, Chemical Engineering

Sponsor: BP

Automatic Reaction Generation Network for Chemical Kinetics

This summer, I increased representation of known molecular properties to the Green Group's Reactor Mechanisms Generator (RMG) website by displaying more databases and search modules. The website works with the languages Python and Django, both of which helped me improve my ability to code in order to conduct the research. A skill that I vastly improved in this project was the ability to interpret the code of others. Much of my coding involved looking at how databases and modules already in the website were coded, and making changes to those blocks of code in order to represent other databases and modules. My ability to comment code and make my own code more readable also improved throughout the summer. This project interested me because of the interdisciplinary applications of the website. It was neat to see how my representation of chemical properties on the website were able to help researchers study reactions far beyond my current understanding.

Manuel Castro

Mechanical Engineering

Advisor: Evelyn Wang, Mechanical Engineering

Sponsor: Lockheed Martin

Study of Energy Conversion for Jumping Droplets on Superhydrophobic Surfaces via Electrowetting

Condensation is a commonly used means of cooling many industry processes from power generators to HVAC systems. This can be done with filmwise condensation where a film of liquid forms on the surfaces of condensers or dropwise condensation where discrete drops form on hydrophobic surfaces, eventually collect, and fall. However, research done at the Device Research Laboratory has shown the method of jumping droplet condensation increases heat transfer by 30-40% compared to state-of-the-art dropwise condensation utilized currently. Jumping droplet condensation occurs on a scale several orders of magnitude smaller than dropwise condensation when droplets coalesce on a superhydrophobic condenser and surface energy is converted to kinetic energy, allowing the drops to jump away from the condenser, even against gravity. I worked on understanding this phenomenon, coating superhydrophobic surfaces, and running experiments using Electrowetting on a Dielectric Surface (EWOD) where high-speed footage was taken and analyzed using a MATLAB program I wrote. I calculated surface energy and its conversion to potential energy to better understand this phenomenon. I plan to continue working in the lab and study more complex manipulations of a droplet like the effects of resonance.

Krithivasan Chandrakasan

Mechanical Engineering

Advisor: Vladimir Bulović, Electrical Engineering & Computer Science

Sponsor: Ernst & Young

Large Area Quantum Dot Solar Cells

My research project focused on the development of a large area transparent quantum dot photovoltaic. Quantum dot solar cells are solution processed thus easier to manufacture and lower cost than silicon solar technology. I learned various techniques in order to fabricate these devices including spin coating and sputtering. We investigated various transparent electrode materials and developed a new device architecture that would allow us to create large area quantum dot solar cells. These devices were tested to determine device efficiency and other important metrics. We also looked into the effects of humidity on the devices and fabricated devices in two different labs to compare the results. The goal of this project was to integrate these large area transparent cells into a consumer device.

Michael Chang

Electrical Engineering & Computer Science

Advisor: James Bales, Edgerton Center

Sponsor: Jerome I. '51 ScD '56 and Linda Elkind

Optimizing Energy Use for MIT Solar Electric Vehicle Team's Solar Car

The challenge associated with a solar car's dependence on sunlight is to maintain enough battery capacity to drive, regardless of the weather. That is why I built a software program that optimizes the energy use of the MIT Solar Electric Vehicle Team's solar car. Nothing was more satisfying than working as part of a larger team to accomplish the enormous, multi-layered, and interdisciplinary project of building a solar car. I have always been interested in energy innovation, and this UROP was a great opportunity for me to contribute to this field; energy will undoubtedly be a part of my career at MIT and beyond. Lying at the intersection of energy and artificial intelligence, my project introduced me to a broader perspective of energy than I had before. As energy continues to be an ever-urgent world issue, my research has shown me that the opportunity to innovate has never been greater.

Caroline Colbert

Mechanical Engineering

Advisor: Michael Short, Nuclear Science & Engineering

Sponsor: Lockheed Martin

Self-Powered Thermoelectric Radiation Detectors

The goal of this project was to design and build a self-powered neutron radiation detector composed of a thermoelectric generator coated with a material of high neutron cross section connected to an energy-harvesting circuit and LED. As the detector is intended to be powered by the neutrons whose presence it detects, its success in detecting high-energy neutron generated by MIT's fusion reactor, Alcator C-Mod, would represent the first recorded use of fusion products to directly generate energy. I particularly enjoyed the level of independence I was given to make my own choices related to the detector's design and material composition. My experience this summer confirmed my choice of nuclear engineering as a major and gave me new insight on the wide range of energy-related research taking place at MIT.

Benjamin T. Collins

Mechanical Engineering

Advisor: Maria Yang, Mechanical Engineering

Sponsor: Tata Center for Technology and Design

Prototype-driven Participatory Design in Emerging Markets

The goal of my project was to determine the optimal application(s) of a solar thermal fuel currently being developed at MIT. The scope of the research was focused specifically on India. As part of the project I traveled to India with a team of individuals from MIT. In India we gathered information regarding typical energy usage and interviewed homeowners, business owners, teachers, community leaders, and others to gain a better understanding of energy usage in India. Spending an extended period of time immersed in the Indian culture was an amazing experience. I learned a tremendous amount about the Indian people and was lucky enough to spend time in some of the most beautiful places on earth. My work in India opened my eyes to other opportunities and sparked my interest in working with technology companies investing in developing and emerging markets.

Wesley Cox

Mechanical Engineering

Advisor: Alexander Slocum, Mechanical Engineering

Sponsor: Lockheed Martin

Design and Analysis of a Novel Non-Linear Load Cell

The goal of my project this summer was to design, fabricate, and experiment with a novel load cell design that functions nonlinearly. In other words, we created a device that measures force given a displacement in such a way that the stiffness of the device increases as the force increases. This makes the load cell capable of processing small inputs with high accuracy while still being able to function under much greater forces. This design can be used in a variety of scenarios, such as ambient energy harvesting. I enjoyed this project quite a bit, since I had the opportunity to build, test, and analyze on my own. I was given the authority to make judgment calls that impacted the final design, which is more than I thought I would get as a freshman. I was very happy with my time spent this summer. It was a great way for me to expand my knowledge.

David Fellows

Aeronautics and Astronautics

Advisor: James Bales, Edgerton Center

Sponsor: Dr. Alfred Thomas Guertin '60

Developing Mechanical Systems for a Solar Electric Vehicle

During my UROP, I was tasked with determining the most efficient way to implement mechanical systems such that a solar electric vehicle could effectively operate in outdoor conditions. In order to do this, I tested, designed, and fabricated necessary mechanical subsystems with the MIT Solar Electric Vehicle Team, including braking, suspension, steering, and chassis. I particularly enjoyed learning how to fabricate my own designs through machining, as well as learning how to optimize the different parts of the solar vehicle. Working on this vehicle definitely impacted me as it made me realize that solar energy is a viable resource, as it was surprising to see that at peak performance, our vehicle could drive at roadway speeds utilizing only the power of the sun. In the future, I will be very interested in seeing how I can tie energy research into my future career as it is such a powerful resource.

Dayanna Espinoza Silva

Electrical Engineering & Computer Science
Advisor: Michael Bove, Media Lab
Sponsor: Lockheed Martin

Big Bar Chart

The project I worked on during the summer is called the "Big Bar Chart," and its goal is to provide a physical way for people to interact with data. I particularly enjoyed debugging my code using circuits and motors. This helped me to understand how the interface between computers and hardware works. In the long-term, "Big Bar Chart" could be applied as an educational tool for people to use interactive statistics to improve the use of energy resources. I got very interested in this field because, in order to get a better long-term efficiency of the project, we need to look for special batteries that can last for a longer time so we do not have to assemble the bars every time the batteries run off of power. This necessity made me realize that computer science and energy are a great combination. I would be extremely happy to pursue this combination in the future since both make technology unstoppable. In addition, my UROP provided me with my first job and research experience, which helped me to improve my team work skills and learn how to deal with failure and success.

Jacob Fisher

Mechanical Engineering
Daniel Frey, Mechanical Engineering
Sponsor: Lockheed Martin

Investigating Battery Pack Manufacturing Methods for Small Electric Vehicles

My research project was to work with the Electric Vehicle Team to brainstorm and develop methods of manufacturing battery packs for small electric vehicles such as electric bicycles and scooters, in addition to continuing development of a custom cell-level management system for these battery packs. Being able to safely construct small battery packs is important, as the price of batteries is a major factor in cost for electric vehicles. In the case of small electric vehicles, it may be cheaper to buy individual battery cells rather than premade packs. My primary focus was the design, construction, and testing of a low-cost spot welding machine intended to electrically and mechanically adhere the battery cells together. This opportunity gave me a chance to practice the skills I had learned in both mechanical and electrical design over the past year. Working with the Electric Vehicle Team has sparked an interest into potentially working with electric vehicles in the future.

Fiona Grant

Mechanical Engineering
Advisor: Evelyn Wang, Mechanical Engineering
Sponsor: Philip Rettger '80

Developing Experimental Methods for Characterizing Efficient Thermophotovoltaic Conversion and Characterizing Solar Driven Thin-film Evaporation through Nanoporous Membranes

This summer I worked on optimizing the performance of two solar devices. The goals of the first project were to characterize and improve the performance of solar thermophotovoltaic cells. STPV cells offer an alternative and potentially more efficient way to harvest solar energy because they can store light energy as heat. The second project investigated the efficacy of vapor generation through the thin-film region of menisci formed in nanoporous membranes. The ultimate goal is to incorporate this vapor generation method into a high-performance, compact solar thermal power and cooling system. I knew before this summer that I wanted to pursue a career in energy, but this UROP has enabled me to explore renewable energy research and discover a myriad of topics that pertain to energy. I particularly enjoyed the independent, collaborative environment of the Device Research Lab and learning to transform a design or model into an experimental device.

Stephanie Guo

Mechanical Engineering
Advisor: John Germaine, Civil & Environmental Engineering
Sponsor: Schlumberger

Carbon Nanotubes as Piezoresistive Sensors in Cement

This summer, I conducted an Energy UROP in collaboration with Schlumberger-Doll Researchers and the department of Civil and Environmental Engineering at MIT. My project was focused on the analysis and characterization of the mechanical performance of cement containing functionalized carbon nanotubes/fibers used in oil wells. Specifically, I worked with using carbon nanotubes/fibers as a means of real-time sensing of mechanical stress put upon cement, to better keep track of borehole conditions. I particularly enjoyed my project because I was able, for the first time, to experience work in a real laboratory. I met many interesting and brilliant people and learned a lot. My work this summer definitely has influenced me to think more about pursuing energy. I've been able to see how important energy and energy-work is.

Photo by Justin Knight

Amelia K. Helmick

Materials Science & Engineering

Advisor: Krystyn Van Vliet, Materials Science & Engineering

Sponsor: Schlumberger

Design and Understanding the Properties of Advanced Materials for Oil-field Applications

Polymers and polymer composites provide the benefits of their excellent mechanical strength to open channels used in oil-field applications. Surface treatment of these polymers allows more control of the material behaviors under downhole environment. I worked at Schlumberger's research facilities, which was a valuable experience because I got to the see how industry and research can work together. I enjoyed researching within the energy field and the discussions I had with co-workers. I also learned that there is a wide range of energy topics, including a lot more work with materials engineering than I thought. This experience was really gratifying and I am excited to work in industry more so than in pure research, which this Energy UROP gave me the opportunity to experience.

Maura Hennessey

Materials Science & Engineering

Advisor: Jeffrey Grossman, Materials Science & Engineering

Sponsor: Lockheed Martin

Designing a Prototype to Test Solar Thermal Fuels

This summer, my project was to synthesize a catalyst for the solar thermal fuel project in the Grossman Group. Solar thermal fuels are a source of renewable solar energy without harmful emissions. My goals for this project can be stated in three simple parts: to synthesize a catalyst which would aid in discharging the energy stored by the sun; to measure the materials' efficacy as a catalyst; and to find different ways to apply the catalyst to the solar thermal fuel and/or potentially explore other materials as catalysts. Along with learning how to use different types of laboratory equipment, I really enjoyed learning the different ways to synthesize and purify materials. My Energy UROP opened my eyes to the different types of energy research, and showed me that my skills and interests can be applicable in energy-related fields, on both the individual and the global scale.

Photo by Justin Knight

Gloria Hyun

Civil and Environmental Engineering

Advisor: John Germaine, Civil & Environmental Engineering

Sponsor: Schlumberger

Expanding Cement to Prevent Cracks in Oil Well Applications

The goal of my research was to find proper cement composites to be used in oil well applications. The casing is drilled down to the foundation and cement is poured down to fill the annulus, but the casing might shrink or the foundation might shift, so cracks could form. We wanted the cement to expand on its own to fill the crevices. I liked that I am gaining necessary lab experiences and that I am working with cement and liquid nitrogen. The research certainly made me think about pursuing energy after MIT. I am also thinking about pursuing career in policy-making regarding climatic changes. As a student the research experience let me get a feel for what it is to become a researcher and to help me decide what I want to do after graduation.

Jason Hyun

Chemical Engineering

Advisor: Kristala L. Prather, Chemical Engineering

Sponsor: Shell

Microbial Synthesis of Branched Alkanes

My project involved evaluating genes in the aldehyde decarbonylase family (ADCs) as part of a larger endeavor towards synthesizing short-chain alkanes (major gasoline constituents), from sugar in engineered E. coli strains. I tested ADCs known at the Prather Lab against "ECERIFERUM1," a gene in a recent publication with purportedly unprecedented levels of ADC activity, wherein ADCs remained the bottleneck in the lab's overarching alkane biosynthesis project. I particularly enjoyed my opportunity to work in a "wet lab" for the first time, working with physical cells as opposed to simulation work I had done earlier. Having learned more about the potential and limitations of drop-in biofuels from my project, I would like to explore conventional fuels and other approaches to sustainable transportation, but I would also be excited to continue work on alkane biosynthesis, at MIT or elsewhere. Finally, my exposure to the lab has taught me much about the potential of biotechnology, and I would welcome future opportunities in that field which I had not even considered prior to my Energy UROP.

Photo by Susan Young

Joseff Kolman

Physics and Political Science

Advisor: Chris Warshaw, Political Science

Sponsor: MITEI Seed Fund

Public Opinion and State Energy Policy

The goal of my Energy UROP was to aggregate both public opinion and policy data pertaining to energy issues in the United States. The concept of a "database of information" became much more tangible to me as the processes of modifying and analyzing our data showed me the uses for databases, how they work, and how to analyze them. Additionally, it is important to understand the impacts technologies and policies are having on our environment and this UROP helped me become better informed. Previously, I held the perspective that the status of energy and the environment in the USA was that of a stagnant debate. Although things are moving slowly, I now see there is some progress being made. This research gave me additional motivation to apply the strategies I learned to a policy field in which I hold more passion: education.

Wendi Kong

Chemical Engineering

Advisor: William H. Green, Chemical Engineering

Sponsor: BP

Rate Calculations for Insertion Reactions Using a Novel Approach — Ring Polymer Molecular Dynamics

The overall goal of the project for me was to successfully run RPMDrate for particular insertion reactions, and collect data in the process, ultimately developing the scope of application for RPMDrate. I enjoyed the fact that in the process of working in this UROP, as an aspiring course 10 major, I gained experience and exposure in the scope of chemical engineering. I therefore got a taste of future career options in the field. My Energy UROP research made me realize how many things could be applied to the energy field, and how wide and interesting a scope it was. This UROP project gave me a little more insight into what I wanted to pursue for a career.

Alejandro Krauskopf

Chemical Engineering

Advisor: Yuriy Roman, Chemical Engineering

Sponsor: Chevron

Design of Organic Structure-directing Surfactants for Synthesis of Zeolite Nanosheets for Acid Catalysis

My summer research project in Professor Yuriy Román's group in the Department of Chemical Engineering focused mainly on the development, characterization, and testing of hierarchical zeolites, otherwise known as zeolite nanosheets. Zeolites are a type of catalyst with microporous, crystalline frameworks, and with highly active acid sites. For my project, I screened various conditions in which to synthesize zeolite nanosheets, which possess the advantage over regular zeolites in that they have improved molecular diffusivity properties. This makes hierarchical zeolites desirable in industry, particularly in the petrol section, as these catalysts can be used in biofuel upgrading reactions. This summer project was a continuation of my first UROP, which I started during the spring semester. I was not sure before how chemical engineering could be used in the field of energy, but now I feel that I know more about the energy applications of chemical engineering.

Sophia Li

Biological Engineering

Advisor: Anthony Sinskey, Biology

Sponsor: Dr. Alfred Thomas Guertin '60

Improving the Efficiency of Carbon Fixation in Ralstonia eutropha with Carbon-concentrating Microcompartments

In order to address global warming and sustainable energy problems, I aim to improve the bacteria *Ralstonia eutropha*'s ability to use CO_2 as the carbon source for valuable products such as biodegradable plastic and biofuels. To optimize carbon fixation through a carbon-concentrating mechanism, I introduced carboxysomes, or protein-based organelles, in *R. eutropha* strain Re2061. I found that the carbon-fixation enzymes, carbonic anhydrase and RuBisCO, have up to 11.4 times and 2.5 times higher enzyme activities, respectively, compared to a control strain without carboxysomes. I also determined that carboxysomes in *R. eutropha* strain H16 led to greater cell growth on CO_2 or formate, but led to a decrease in product formation of the plastic PHB. Thus, I have shown the utility of carboxysomes in improving carbon fixation in nonnative microorganisms, while demonstrating that other factors, such as carboxysome assembly, may interfere with plastic formation. In the future, I will continue to verify carboxysome assembly and function in Re2061 by demonstrating that the higher enzyme activity and cell growth were due to the carboxysome's carbon-concentrating mechanism. Finally, I will assess whether carboxysomes enhance *R. eutropha*'s ability to grow and produce biofuels such as isobutanol when grown on CO_2 or formate.

Melissa McGee

Materials Science & Engineering

Advisor: Michael Strano, Chemical Engineering

Sponsor: Chevron

A Plant Nanobionic Approach to Developing Self-repairing Photosynthetic Materials

During the summer, I worked on two different projects—an auto-luminescent plant using nanoparticles, and a photosynthetic self-repairing polymer. I particularly enjoyed being able to independently work on projects designing my own protocols, performing my own experiments, and analyzing my own data. I would discuss this with my postdocs, they would give me feedback, and then I would continue on with different experiments based on the results. My UROP research showed me how interesting, fun, and important lab research is, no matter the topic. The energy sector requires a lot of research, so this UROP showed me that an energy-related field could be a possible career path that involves laboratory research. I enjoyed my UROP experience so much that I am staying with this UROP through the fall term so that I can continue with my research.

Elaine McVay

Electrical Engineering & Computer Science

Advisor: Tomás Palacios, Electrical Engineering & Computer Science

Sponsor: Shell

Two-Dimensional Materials for Lighting Applications

I worked with graduate student Lili Yu in the Palacios Group to create the backplane circuitry for a flexible organic LED display. The transistors in the circuitry use molybdenum disulfide as the channel material, which could give the transistors a mobility of up to 200 cm 2/Vs. An organic LED display powered by MoS2 transistors can potentially consume less power than traditional backlit displays. The mechanical flexibility of organic LEDS also fosters the opportunity for design and fabrication of luminescent wallpaper and ceilings, which could be more suitable for the user's environment than point source lighting. Much of my UROP experience throughout July and August involved redesigning the fabrication process according to the results that we would obtain. This Energy UROP experience heightened my interest in the intersection of the microelectronics/device field with the energy sector. Through this UROP, I have gained an immense amount of fabrication and design experience.

Maria Messick

Electrical Engineering & Computer Science

Advisor: Erik Demaine, Electrical Engineering & Computer Science

Sponsor: Shell

Energy-Efficient Algorithm Compiler

My task this summer was to build a compiler with a team of two other undergraduate students for Professor Erik Demaine and graduate student Jayson Lynch to use in their research on reversible algorithms. Reversible algorithms in theory are completely energy efficient because they do not create or destroy information, the source of energy loss in a computer program. A compiler converts a high-level language into a lower-level language, by first parsing the high-level language into a grammar, separating out key words and variables, and then interpreting these and converting them into the lower-level code. Our goal for the summer consisted of developing high-, intermediate-, and low-level languages and a compiler to allow us to convert one to the other in order to help assist our professor and graduate student to assess the energy efficiency of their reversible algorithms. I loved writing the code for the compiler and working on fixing bugs I'm not sure I would want to work in theoretical computer science, like my graduate student and professor, but I am interested in developing code. Building this compiler did not directly work with new technology in the energy sector, but it will help us improve on the efficiency of our current technology. This project showed me that there is room to improve our energy efficiency in many more fields than I had previously realized.

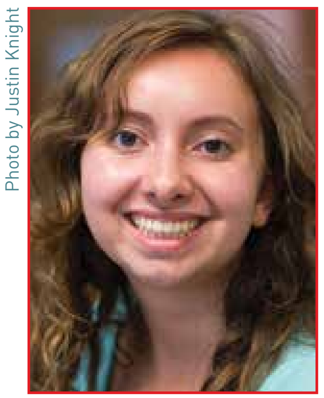


Photo by Justin Knight

Alexandria Miskho

Chemical Engineering

Advisor: Gregory Stephanopoulos, Chemical Engineering

Sponsor: Shell

Conversion of Waste to Volatile Fatty Acids for use as Biofuel Energy Source

Over the course of the summer, I have been assessing the most efficient manner of turning waste—food waste and yard waste—into biofuels. Using high-proficiency liquid chromatography, I analyzed the components of samples of broken down waste to find the concentrations of fatty acids in each sample. I tested the different types of waste, moisture content, and the importance of shaking, rather than just incubating, and found promising results in the end of each trial. From there, *Yarrowia* was grown on the fatty acids, testing to make sure that it was possible to then transform these acids into alkanes and other substances that can be used in biofuel production—which is the ultimate goal.

Devin Morgan

Materials Science and Engineering

Advisor: Carl Thompson, Materials Science & Engineering

Sponsor: George R. Thompson, Jr., '53

Production of Carbon Nanotubes for Lithium Air Batteries

While participating in an Energy UROP under Professor Carl V. Thompson, I was assigned the task of quantifying and addressing the amount of variation that occurred between the heights and areal-densities of the Carbon Nanotube (CNT) carpets grown in their Chemical Vapor Deposition (CVD) system that they had constructed to grow CNT carpets for further experiments related to Lithium-Air Batteries. The most enjoyable aspects of this project for me involved being able to conduct true research for the first time in my life. By growing CNTs, massing them, and using Scanning Electron Microscopy (SEM) to measure their heights, I can now relate to the stresses, pressures, and excitement of being a research scientist at MIT. In addition to doing research, the other impactful experiences I had while in the Energy UROP program were the extensive conversations that I had with my mentor, Duanhui Li. We talked about everything ranging from the differences in approaches to education between China and America to the future of lithium-air batteries. As a result of this experience, I would like to pursue an energy-oriented degree at MIT.

Thomas Needham

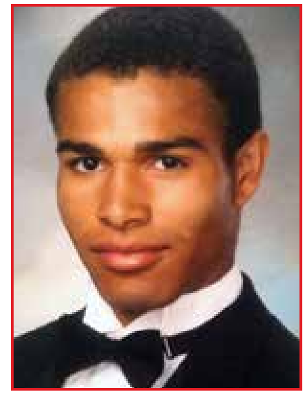
Mechanical Engineering

Advisor: Leslie Bromberg, Plasma Science & Fusion Center

Sponsor: Tata Center for Technology and Design

Engine Modification for Hydrocarbon Reformation/Syngas Production

This summer entailed making a stable platform to reform methane-rich gas collected from sources normally wasted and convert it to syngas to be further catalysed into common liquid fuels. While this process is common, the aim of this project was to crack the methane in an easily scalable and robust diesel engine with some modifications, rather than a complex and costly reactor. My main focus throughout the summer was aiding in designing the experiments, as well as maintaining and improving the test cell setup—my personal favorite. Being able to work hands-on with a large-scale research project was a fantastic opportunity, and it allowed me to 'see behind the curtain' of research that so often makes big headlines. While this was excellent exposure in an interesting field, I see myself devoting my studies to domestic problems of manufacturing and automation.



Taylor Njaka

Mechanical Engineering

Advisor: Franz Hover, Mechanical Engineering

Sponsor: Chevron

Design and Construction of Ocean Wave Energy Converters

This summer, I worked with the Marine Robotics Team on generating electricity from ocean waves. The goal was to design a generator that is small, easy to build, and cheaper than its maritime solar equivalent. With a basic design in mind, we used extensive Matlab simulations for optimization and to get an idea of how many watts we could actually generate. Many of the models Matlab tested could potentially generate over 1 watt for every 10 dollars spent on materials. The prototype we made produced 6.8 watts continuously at 1.5' tall waves, but the parts cost about $350. The glory of this project is that we were actually able to design and optimize generators that are nearly indestructible, with only one moving part, which could generate power at all times - day or night, sunny or stormy - so long as the surrounding water is not perfectly still.

Morgan O'Brien

Electrical Engineering & Computer Science

Advisor: Amy Glasmeier, Urban Studies & Planning

Sponsor: Chevron

Developing Interactive Tools for a Textbook on Economic Geography

The goal of my project was to help create and code tools to go along with a new textbook that combines economic geography and energy. The tools are interactive web-based modules relating to certain topics of the book that will allow students to get a more thorough understanding of the information. I not only further developed my computer science skills by learning web development, but also learned more about economic geography and global energy systems. I really enjoyed how my Energy UROP combined very different areas of studies; one that I was familiar with, computer science, and another that I did not have too much prior knowledge about, the economic geography of energy. The new knowledge I have gained about energy has caused me to consider doing an energy studies concentration or minor.

Julia O'Donnell

Materials Science and Engineering, Wellesley University

Advisor: Yang Shao-Horn, Mechanical Engineering

Sponsor: Chevron

Photoelectrocatalysis in Nanostructured Hematite Thin Films

I worked to improve the surface coverage of nanostructured hematite samples for photoelectrochemical applications. The summer Energy UROP gave me an appreciation for the fine-detail precision necessary for repeatable results, and I learned that an energy device's "efficiency" might be reported in several fashions difficult to compare. I learned that energy academia emphasizes theoretical possibilities, which are intriguing but of less personal interest than more immediate real-world applications. Although I enjoyed the freedom to design my own experiments, this summer experience helped me realize that I would like to pursue a career in the hands-on discipline of engineering.

Akwasi Owusu-Akyaw

Mechanical Engineering

Advisor: James Kirtley, Electrical Engineering & Computer Science

Sponsor: Lockheed Martin

Improving Solar Technology and Micro-grid Efficiency Using Microinverters

My Energy UROP consisted of two projects: helping to create an efficient micro-inverter and improving the efficiency and power factor of a single-phase induction motor. One of the best parts of this UROP was the ability to have hands on experience in a graduate lab. By having this experience, I was able to understand what tools are used to measure values such as torque, power, and voltage. To be honest, this UROP has increased my interest in the energy field because it revealed the effects of reactive power on devices such as motors and micro-inverters. Initially, I thought that the only main issue related to power was heat dissipation. However, if not managed correctly, reactive power can have a serious effect on the efficiency of a device. In addition, this UROP has enhanced my organizational skills, especially in situations when my advisor was not actively overlooking my progress.

Paola M. Perez

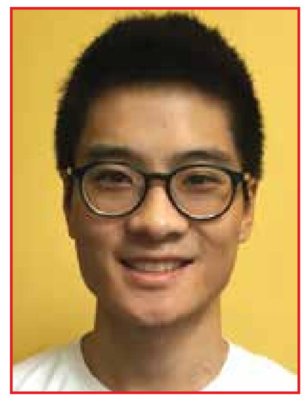
Biological Engineering

Advisor: Bradley Olsen, Chemical Engineering

Sponsor: William Chao '78

Assembly of Globular Coil Fusion Proteins for Biofuels Catalysis

My project aims to develop block copolymer fusion systems containing a globular protein and a coil-like protein as analogues to protein-polymer conjugates, and investigates the self-assembly and nanostructure formation for biofunctional catalysis applications. With no prior experience in this area, I enjoyed learning different techniques by doing as opposed to reading or hearing about them. I do not have a clear vision of what I want for my future, but I do know that I am invested in this project and will continue working on it during the upcoming fall semester. Applying biology for a potential application in biofuel catalysis made me realize the importance of multidisciplinary topics in modern energy research. This project has required me to learn about molecular biology, energy, materials science, and chemical engineering, making this project a valuable experience for me moving forward in energy research and my future career.



Licheng Rao

Mathematics

Advisor: Erik Demaine, Electrical Engineering & Computer Science

Sponsor: BP

Energy-Efficient Algorithm Compiler

The purpose of my research project with a team following Professor Erik Demaine is to analyze the energy efficiency of current compilers and help establish a framework that would optimize the performance and the energy cost of future compilers. Even though there was a steep learning curve to this area of study, the team was very helpful at answering my questions and helping me understand the necessary material. In the end, the discussions and the collaborative effort to construct a prototype of the end result were particularly rewarding. My first project dealing with energy made me realize the power of energy in the study of optimization, and consequently, how interconnected it is with everything we do. As a student, I have also improved many interpersonal skills that were essential to working in a team.

Madeleine Severance

Electrical Engineering & Computer Science
Advisor: Sheila Kennedy, Architecture
Sponsor: Shell

Reducing Portable Solar Footprints: Development and Testing of Portable Light Circuit with Mono-Crystalline Solar Cell

This summer I worked on the Portable Light Project, a nonprofit organization that provides low power solar kits to developing areas that do not have electricity. The kits contain an LED for light and a USB port for cell phone and other electronics charging. I worked specifically on the branch of the project located in the Amazon. One of my main objectives was to test two different solar panels on their quickness in charging lithium ion batteries. In addition, I optimized the LED light levels and runtimes to better match the needs of the people in the Amazon by studying the LED driver, calculating theoretical runtimes, and modifying resistors on the circuit. I enjoyed learning about electronics and seeing my work impact the greater project. This UROP reinforced my desire to pursue an energy-related career and also the importance of moving towards more renewable energy, especially in emerging markets.

Jarrod Smith

Mechanical Engineering
Advisor: Daniel Frey, Mechanical Engineering
Sponsor: Chevron

Developing an Electric Porsche 914

My summer research focused on a number of different projects for the Electric Vehicles Team. My primary focus was continuing work on our electric 1976 Porsche 914. After we recently restored the car to working order, my work included going through the electrical systems and updating the documentation and wiring schematics. I also used LabVIEW to implement a National Instruments touch screen system for displaying the battery and motor data. Other team projects included completion of a long-range trike and trailer combination that we designed over the course of the past year. Towing a 300 pound trailer of batteries, we successfully rode from campus to Albany, NY on a single charge. I am glad that this Energy UROP and the Electric Vehicles Team have given me an opportunity to gain extensive firsthand experience working with alternative forms of transportation, and I'm looking forward to continuing related work in the future.

Photo by Justin Knight

Rebecca Steinmeyer

Mechanical Engineering
Advisor: John Germaine, Civil & Environmental Engineering
Sponsor: Schlumberger

Conceptual Design of a Set-Up that Enables Electrical Measurements Downhole

The goal of my UROP project this summer was to develop a conceptual design for a downhole system to monitor the resistivity of oil well cement in order to detect microcracks as soon as they occur, which will prevent environmental damage due to gas leaks and oil spills. My project was sponsored by Schlumberger, so I was able to get a taste of both research and industry in a field that I had not previously had the chance to explore. I enjoyed the collaborative environment at Schlumberger and the opportunity to work on a team with three other MIT students, with the four of us each focusing on a specific area of the overall project in order to achieve a mutual goal. I look forward to applying the skills I learned with my UROP this summer in my future endeavors as an engineer.

Joseph Valle

Materials Science & Engineering
Advisor: Yang Shao-Horn, Mechanical Engineering
Sponsor: NYSERDA

Understanding the Reaction Kinetics of Vanadium-Redox Flow Batteries

The goal of my project was to obtain an improved fundamental understanding of the reaction kinetics of Vanadium Redox Flow Batteries (VRFB). I enjoyed gaining a greater understanding of the electrochemistry and electrochemical techniques, which are used to investigate batteries. My UROP research reaffirmed my initial belief that I would like to investigate batteries because I found the theory behind how batteries worked and what limits them very interesting. My UROP did make me want to try my hand at more applied research, because I felt at times that I could not see an application for the work which I was doing. However, overall I was left with a very positive experience in which I learned many new things and had fun while doing it.

Daniel S. Wang

Mechanical Engineering
Advisor: Richard Fletcher, D-Lab
Sponsor: Tata Center for Technology and Design

Development of Machine Learning Algorithms for Pulmonary Diagnostics

The goal of my project was to develop an Android-based app that can diagnose pulmonary disease from recordings of breathing. Currently, the project is still in the planning phase and my job was to determine the mathematical approach that the algorithms would utilize. I enjoyed reading journal articles and learning about the state of the art in subfields of machine learning. This project opened my eyes to the diverse topics present in the world of energy and how seemingly unrelated subjects can be united in surprising ways. I had not planned to work in energy after graduation, but this project showed me that the energy field is much larger than I thought. While I don't plan on seeking out a career in the energy sector, I may very well work on energy-related projects and would be happy to do so.

Phoebe Wang

Mechanical Engineering
Advisor: Leon Glicksman, Architecture
Sponsor: BP

Energy Efficiency in MIT Labs

The goal of the project was to detail the energy use distribution of Buildings 16/56, 18, and 76 in order to 1) identify the best practices and system choices in use, and 2) identify and quantify solutions for energy use improvement. I enjoyed unraveling the complex workings of a modern building and seeing how they fit together. While participating as an Energy UROP this summer, I learned to further appreciate the breadth and multi-disciplinarity of the energy field; as a Course 2 I would not be surprised to encounter energy-related work sometime in my career. This UROP led me to a greater appreciation of the fundamental humanity of energy research (and research in general, for that matter); much of my work was based on information gathered from meetings with various administrators, staff engineers, and industry members. I also gained experience working intimately with a group on an extended project.

MITEI and the Energy UROPs were saddened by Phoebe's passing this fall — she was actively engaged in our community and is greatly missed. [http://newsoffice.mit.edu/2014/phoebe-wang-obituary-1002]

Shell aims to be the world's most competitive and innovative energy company, seeking to tackle the challenges of the new energy future. In this effort Shell champions open innovation to share knowledge, generate new ideas, and accelerate technology development and deployment. The MIT UROP program is a component of this effort and allows Shell to sponsor and engage with promising MIT undergraduate students on research projects that further its goals.

— Jonathan Kane
Shell-MIT Liaison

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Chevron
Chevron is one of the world's leading integrated energy companies. Our success is driven by our people and their commitment to get results the right way—by operating responsibly, executing with excellence, applying innovative technologies and capturing new opportunities for profitable growth. We are involved in virtually every facet of the energy industry. We explore for, produce and transport crude oil and natural gas; refine, market and distribute transportation fuels and lubricants; manufacture and sell petrochemical products; generate power and produce geothermal energy; provide renewable energy and energy efficiency solutions; and develop the energy resources of the future, including research into advanced biofuels.

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 was instrumental in helping to launch the IBM PC Clone industry. He is President of California-based Innovative Systems and Technologies, and is concerned about science, technology, engineering, and mathematics (STEM) education and policy, national energy policy, and the capacity of US technology and engineering developments to meet rising world energy demands in fiscally, socially, and environmentally responsible manners.

Jerome I. '51 ScD '56 and Linda Elkind
Jerry Elkidn received his bachelor's and doctoral 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.

Ernst & Young

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Dr. Alfred Thomas Guertin '60

Dr. Guertin received his PhD in Chemistry from MIT and worked for American Cyanamid Company.

Lockheed Martin

Headquartered in Bethesda, Md., Lockheed Martin is a global security and aerospace company that employs about 116,000 people worldwide and is principally engaged in the research, design, development, manufacture, integration, and sustainment of advanced technology systems, products, and services. The Corporation's net sales for 2012 were $47.2 billion.

New York State Energy Research & Development Authority (NYSERDA)

NYSERDA is a public benefit corporation created in 1975 under Article 8, Title 9 of the State Public Authorities Law [PDF] through the reconstitution of the New York State Atomic and Space Development Authority. NYSERDA's earliest efforts focused solely on research and development with the goal of reducing the State's petroleum consumption. Today, NYSERDA's aim is to help New York meet its energy goals: reducing energy consumption, promoting the use of renewable energy sources, and protecting the environment.

Philip Rettger '80

Phillip Rettger has been active in a range of energy activities for more than 30 years, starting with MIT UROP assignments in energy conservation and renewable energy development at the Massachusetts Energy Office. Mr. Rettger subsequently worked in invention, commercialization, development and finance of projects that span solar PV, low-impact hydroelectric, biomass and waste fuel power generation, recycling, gasification, natural gas cogeneration, and unconventional oil recovery and processing. As a serial entrepreneur in the energy sector, Mr. Rettger was a co-founder of companies including OptiSolar, OPTI Canada, and Oxford Energy. Mr. Rettger also serves on the Board of Directors of the Mohegan Tribal Utility Authority.

Schlumberger

Schlumberger is the leading oilfield services provider, trusted to deliver superior results and improved E&P performance for oil and gas companies around the world. Through our well site operations and in our research and engineering facilities, we are working to develop products, services and solutions that optimize customer performance in a safe and environmentally sound manner.

Shell

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.

Tata Center for Technology and Design

The Tata Center for Technology and Design in alliance with the Office of Undergraduate Research Opportunities Program (UROP) offers MIT students an opportunity to work with faculty and Tata Fellows throughout the year in several focus areas: water, health, energy, housing, and agriculture. Tata Center UROPs have the opportunity of attending ProSeminar events hosting influential speakers on topics relevant to emerging societies. The Tata Center links MIT to India and other developing communities around the world through a focus on innovation that is relevant to global societal needs and challenges.

George R. Thompson, Jr., '53

George R. Thompson, Jr., '53, BS, Course IX, General Engineering; served in Air Force as R & D procurement office and employed System Research Laboratory, Dayton, OH; Machine and Foundry, Alexandria, VA. Founded Commonwealth Scientific Corporation in 1968, a leading R & D firm in ion beam technology and ion beam etching and deposition systems. Mr. Thompson was Chairman of the Marshall National Bank, serving on the Board of Directors for 30 years; founded the Virginia Chapter of The American Chestnut Foundation and is active in conservation and historic restoration.

Sponsor an Energy UROP

Undergraduate energy research at MIT flourishes with the support of donors interested in outstanding students and a wide range of energy topics. MITEI invites donors and members to sponsor one or more summer Energy UROPs. The Energy UROP application and selection process begins in earnest each February.

Contact Ann Greaney-Williams, MITEI Academic Coordinator, at agreaney@mit.edu if you are interested in learning more about sponsoring Energy UROPs.

Global warming is of great concern to me, and as such, I am interested in helping to diminish our carbon footprint in our world. This Energy UROP project afforded me the opportunity to actively participate in research related to solving this worldwide issue. — Alejandro Krauskopf '16

This UROP was a tremendously valuable experience to me. I was out to learn about MIT lab procedure, working with graduate students, how to do research that has a purpose — and obligation to — industry, and how to jump into the middle of a project and make myself useful. In all these respects this summer, and the continuation of my project into this fall, has been excellent. — Thomas Needham '17