Department of Civil and Environmental Engineering

The Department of Civil and Environmental Engineering (CEE) has undergone many transformations during the 150-year history of MIT. The department is at the forefront in framing the challenges of global environmental issues that now affect all aspects of engineering, from the intelligent use of resources to the design of sustainable infrastructure systems. In its biennial review, the CEE Visiting Committee noted that no department at MIT is more affected by global social and environmental changes. With expectations of a large turnover in faculty over the next few years, the committee members conclude that this presents a "rare opportunity" to define future frontiers in the integration of civil and environmental engineering.

This year it has been exciting to see the creativity, enthusiasm, and intellectual leadership of our nine junior faculty members. They collaborated in organizing a very successful cross-departmental "Research Speed Dating" event in February. The program included short presentations by selected faculty, postdoctoral fellows, and graduate students that provided a unique perspective on the scope of research activities across the department. Professor Pedro Reis (dual appointment in CEE and the Department of Mechanical Engineering) has collaborated with professor Herbert Einstein in redesigning the core sophomore design subject (1.101), while professors Carolina Osorio (who joined the department in October 2010) and John Williams developed a new systems analysis subject (1.041) for the 1C curriculum. Professor Ruben Juanes will be lead investigator of a large interdisciplinary research team that aims to address scientific challenges associated with geological CO2 storage. This project will be funded jointly by the Masdar Institute in Abu Dhabi and ADCO (Abu Dhabi Company for Onshore Operations). We anticipate that the ceremonial signing of the agreement will be held in October 2011. Professor Markus Buehler served as area leader for the mechanics group within the department, while professors Roman Stocker and Marta González played active roles in the faculty search committee.

It has been another very successful year in terms of faculty promotions and recognition. Eric Alm (dual appointment in CEE and the Department of Biological Engineering) was promoted to associate professor without tenure and Charles Harvey to full professor. Markus Buehler received tenure (after just five years on the faculty) and was also the recipient of a major award from the American Society of Civil Engineers (ASCE).

We have hired two new faculty members through a broad faculty search. Saurabh Amin will join the department as an assistant professor effective November 1, 2011. Dr. Amin received his PhD from the University of California, Berkeley, in 2011. His research focuses on robust control theory applied to networked infrastructure cybersecurity (including significant field implementation and testing). His background (BS, MS, and PhD in civil and environmental engineering with a strong focus on electrical engineering and computer science) and research can contribute to all areas of the department. Cyberphysical systems and control of networked infrastructure are seen as important areas of growth in both research and practice. Colette Heald will join the department as an assistant professor effective January 1, 2012. She holds a PhD from Harvard (2005) and has been on the faculty at Colorado State University since 2008. Professor

Heald's research focuses on atmospheric science with an emphasis on modeling and observational analysis. Her expertise provides a natural connection with transportation (emission sources), biology/hydrology (biosphere-atmosphere interactions), and fluid mechanics (atmospheric transport).

This has been an unusually busy year for special events, mainly associated with celebrations of the MIT sesquicentenary. Professors Cindy Barnhart and Penny Chisholm chaired sessions for the symposium on "Leaders in Science and Engineering: The Women of MIT," while the department organized eight exhibits for the April 30 open house, including the very popular presentation by Professors Stocker and Reis on "cat lapping." The department cosponsored a community workshop on the Deep Horizon oil spill in the Gulf of Mexico (September 2010) that included presentations by Dr. Eric Adams on oil plumes and mixing and Roland Pellenq on concrete materials used for drilling and completions. Several CEE faculty were also involved in a workshop to develop a research agenda relating to the future of the oceans (December 2010), one of the key theme areas proposed for the MIT global environmental initiative (chaired by professor Dara Entekhabi).

CEE also organized two special symposia to recognize the careers of professors David Marks and Chiang Mei, who retired from MIT in July 2010. The Complexity and Sustainability symposium (November 2010) offered a series of perspectives on environmental technologies and global systems, including a keynote address by Jarod Cohon (president, Carnegie Mellon University), and brought together many former colleagues and associates who have worked with David Marks. The Mei symposium (May 2011) featured presentations on recent research in fluid mechanics in a wide range of application areas. The department has also raised funds for an annual Chiang C. Mei Lectureship as a testament to his profound influence on the field of applied mechanics.

Educational Activities

Undergraduate Programs

Twenty-four freshmen selected CEE as their home department for 2012. During the 2010–2011 academic year, CEE had an enrollment of 110 undergraduates: 56 civil engineering (Course 1C), 40 environmental engineering science (Course 1E), and 14 CEE general (Course 1A). In spring 2011, CEE awarded 48 SB degrees. Twenty-three of them were in 1C, 17 in 1E, and eight in 1A.

We have now had four classes complete the integrated CEE undergraduate curriculum. As sophomores, the 1A, 1E, and 1C majors take the common core classes together, including the sophomore engineering design lab. In their junior year they split into their respective majors, and in their senior year they come together again for the capstone course in civil and environmental engineering design.

Undergraduate Research and Practical Applications

Coursework

The spring semester of the engineering design class 1.102 Introduction to Civil and Environmental Engineering Design II again followed a distributed energy-harvesting theme this year. The juniors pursued a diverse array of projects, including helping MIT assess its role as a source of phosphate flowing into the Charles River. The sophomores built their own generators as well as energy machines of their own design that converted kinetic energy to electrical energy and powered low-output devices.

CEE seniors once again capped their undergraduate engineering education with subject 1.013 Senior Civil and Environmental Engineering Design, taught by professor Herbert Einstein and lecturer Pete Shanahan. This year's major project topics included the redesign of coastal structures in south Florida to deal with rising sea levels and consequent flooding, restoring south Florida's Cowbone Marsh after an illegally dug canal altered the hydrology, and rehabilitating MIT's overcrowded, aging sailing pavilion. Students made and tested a physical model of their designs, rewrote their reports to incorporate feedback they received throughout the process, and made a formal presentation of the results. The students also designed portable bridges according to a set of specifications. As in previous years, the students assembled and load-tested the bridges in an afternoon exhibition on the Student Center plaza.

Published Papers and Books

Course 1C senior Kallie Hedberg and junior Julia Hopkins are coauthors of a paper, "Vaccine Availability in the United States during the 2009 H1N1 Outbreak," that appeared in the American *Journal of Disaster Medicine* (2011, 6(1):23–30). Professor Richard Larson of the Engineering Systems Division (ESD), another of the article's coauthors, said the 1C students "worked tirelessly" with the ESD Flu Team (supported by the US Centers for Disease Control and Prevention), performed the majority of the research that led to the paper, and did much of the writing.

Efforts to prevent or reverse eutrophication in fresh water typically aim to decrease the amount of phosphate entering the lake or river in runoff from the watershed. But a study published in the June 2010 issue of *Water Research* (44(12):3645–3665) by professor Harry Hemond and Katherine Lin '05 (who performed the research as an Undergraduate Research Opportunities Program [UROP] student) suggests that phosphate control measures that simultaneously decrease nitrate inflow could, paradoxically, result in an increased release of phosphate from lake sediments that have become enriched after years of heavy phosphate inflow. Incorporating this information into engineering models of lake eutrophication could make these models more accurate and useful.

Junior Monica Oliver's UROP research from spring 2010 led to the publication of a role-play simulation that will be used as a teaching tool in Harvard Law School's Program on Negotiation. "Helping Cities Adapt to Climate Change Risks" helps city officials and other stakeholders understand the technical and policy issues created or exacerbated by climate change, particularly issues at the interface of urban planning and civil engineering, such as housing retrofits.

Senior Edna Ezzell wrote the sustainability and humanities chapters, among others, of *Fundamentals of Civil Engineering: An Introduction to the ASCE Body of Knowledge* (CRC Press, 2011). Coauthors were professor Richard McCuen and student Melanie Wong of the University of Maryland, where Ezzell studied before transferring to MIT as a junior. Wong plans to attend graduate school at MIT next fall.

Senior Emily Moberg is coauthor of a soon-to-be-published book, *Multi-Criteria Decision Analysis: Environmental Applications and Case Studies* (CRC Press, October 2011), with Igor Linkov of the US Army Corps of Engineers. Moberg worked with Linkov at the US Army Engineer Research and Development Center in Concord, MA, the summer after her sophomore year.

Steel Bridge Team

After placing second in the regional competition held at the Université Laval in Quebec City April 29–30, the MIT steel bridge team continued its climb in the national rankings by placing fifth in the national competition at Texas A&M University May 20–21. This is an extraordinary feat for a young team of undergraduates now in its fifth year competing against much larger and more experienced teams from state schools, which often have significant involvement of graduate students and faculty members. MIT was the top-ranked team among the private universities competing in the 20-year-old competition.

Every year contestant teams must create a 21-foot-long bridge for a specific hypothetical situation. This year's scenario required a bridge to carry traffic over a scenic river in a state park. It had to be light and stiff without being visually intrusive, and it had to provide clearance for boats and passageways for utility lines. Restrictions to protect wetlands during construction required the builders to sometimes work in inconvenient locations and limit the size of nearby supply depots.

Bridges are graded according to construction speed, lightness, economy (construction time and number of builders), efficiency (how well the bridge resists deflection), and display (appearance and poster), resulting in a single overall score. As in real life, teams must constantly make tradeoffs, such as deciding on a heavier design that might result in lower scores in some categories but higher scores in others.

Team members earn four credit units for their work by enrolling in a steel bridge design competition (1.055 for undergraduates and 1.58 for graduate students) during the fall, Independent Activities Period (IAP), and spring terms. Professor Jerome Connor teaches the course.

Members of the 2011 team are CEE graduate students Matt Bono, Daniel Jimenez, and Jana Marjanovic; seniors Kimberly Huppert, Alex Jordan (cocaptain), and Emily Moberg; juniors Jennifer de Bruijn, Leonidia Garbis (architecture), Julie Harrow, Catherine Johnson, Scott Landers, Lorna Ogolla, Reece Otsuka, Breanna Peterman, and Nicholas Soane; sophomore Maria Tou (chemical engineering); and freshmen Andrew Hyer, Christine Labaza, Alexander McCarthy, and Sharone Small. Advisors included professor

Jerome Connor, CEE graduate student advisor Pierre Ghisbain, CEE technical instructor Steve Rudolph, and Jimmy Duffy and Jimmy O'Donnell from Boston Bridge Services.

The competition is sponsored by the American Society of Civil Engineers and the American Institute of Steel Construction.

Extracurricular Activities

This was the second year in a row that a CEE student project won the $100K competition. Senior Joel Veenstra and his teammates on Sanergy won the grand prize in the MIT $100K Entrepreneurship Competition on May 11 for their proposal to build toilets in Kenyan slums and convert the waste to income-generating fertilizer and fuel. Their pitch about the critical need for clean, affordable sanitation in areas badly needing it also earned them the audience-choice award and first place in the Emerging Markets category in the competition against 279 other teams.

CEE undergraduates participated on three teams in the MIT Global Challenge: senior Tiffany Cheng on Showergy, junior Scott Landers and senior Connie Lu on GrubCycle, and senior Ingrid Chaires on Flour Power.

Many CEE undergraduates are active in the MIT chapter of Engineers Without Borders (EWB), which is involved in a project attempting to provide electricity and clean water to the residents of Ddegeya, Uganda. This community of about 1,000 people spread over 5 square kilometers relies on a single pond and one working well for water. The residents have no electricity and limited access to health care, because the local clinic faces the same constraints as the community. CEE sponsored an EWB exhibit led by sophomore Marisa Simmons at the Franklin Park Zoo's Earth Day celebration held April 16.

Traveling Research Environmental Experiences

Traveling Research Environmental Experiences (TREX) is a six-credit field research course offered during IAP in January to undergraduates majoring in civil or environmental engineering. TREX (subject 1.992) gives students an opportunity to gain hands-on fieldwork and research experience in a global context. Each expedition focuses on one or more environmental issues in three dimensions: scientific, political, and economic. Students who participate in TREX gain valuable insights into real-world ecological issues as well as practical experience outside the classroom.

After three days in the classroom (January 4–6) learning about GPS and infrared photography; volcano formation; soil sedimentation, classification, and erosion; the biology and ecology of corals; infiltration experiments; soil characterization; and good fieldwork practices, a group of 17 undergraduates headed to Hawaii on January 11 to begin TREX 10, a three-week stay on the western coast of the big island of Hawaii.

Sheila Frankel, senior lecturer and assistant director of the Parsons Laboratory for Environmental Science and Engineering, is the director and founder of TREX. The program began in 2000 and has been held most years since then; the exceptions are 2006, when a trip to Lake Pontchartrain in Louisiana following Hurricane Katrina was made in lieu of TREX, and 2009 and 2010, when TREX was not held. Frankel and her

husband, scientist Don Frankel; professor Heidi Nepf; and professor Janelle Thompson accompanied the students, teaching and directing their research on the island. CEE graduate students Mitul Luhar, Tony Parolari, and Jeff Rominger served as teaching assistants. Jonathan Stock, a geophysicist from the Menlo Park office of the United States Geological Society, spent the first week with the group directing intensive fieldwork to determine an annual sediment budget for the Waiulaula watershed. Carolyn Stewart, the watershed manager of Waiulaula, hosted the field research.

The 17 undergraduates attending were Polina Bakhteiarov, Adam Bockelie, Caroline Bogdan, Samantha Cohen, Jennifer de Bruijn, Tracey Hayse, Elise Hens, Fatima Hussain, Elizabeth Jones, Laurie Kellndorfer, Scott Landers, Columbus Leonard, Trinity Leonard, Joann Lin, Emily Moberg, Lorna Omondi, and R.N. Tharu. The students took turns blogging about the trip.

Terrascope

In spring 2010, associate professor Charles Harvey, associate director of the Terrascope freshman program, and lecturer Ari Epstein made significant changes to the CEE Terrascope subject 1.016 Communicating Complex Environmental Issues: Building Solutions and Communicating Ideas. The aim was to offer freshmen the opportunity to participate directly in faculty-guided research while working more rigorously on solutions to the problems they had studied in the fall Terrascope class, 12.000 Solving Complex Problems. During the fall semester in 12.000, students study a complex environmental problem, develop potential solutions, and build a website describing the work. Subject 1.016 in the spring formerly focused on communicating an aspect of the problem through student team-designed and team-built museum exhibits targeted for an audience with a high school level of science knowledge. In the new class format, students work in teams with faculty members on prototype or research projects related to an aspect of the problem they studied in 12.000, display their work along with posters and demonstrations at a bazaar of ideas held in Lobby 13, and receive feedback from a panel of experts. This new format gives students a true engineering design/build experience as they work on projects overseen by faculty, and the subject continues to provide the important element of learning to communicate technical information clearly to an MIT audience.

In the spring of 2011, Harvey and Epstein continued and refined the new structure of the class. The focus of Terrascope in 2010–2011 was food production and world hunger. Six teams of freshmen were formed (each with an undergraduate teaching fellow) and assigned to one of the six most popular projects that had been offered, as follows:

- A prototype of a system to use low-cost cell phones to facilitate efficient medical treatment in rural India.
- A working scale model of a system built from inexpensive materials to efficiently dry crops.
- A prototype of a bicycle-powered butter-making device to help the Maasai during the dry season.

- A prototype of a system for "self-watering" agriculture that reduces urban runoff. The system collects rainwater from rooftops and then uses a wicking mechanism to distribute water to plants only as the water is needed.
- A multiplayer game in which players compete to optimize food security.
- A prototype for an add-on module to a solar-powered milk-chilling device • developed for dairy farmers in rural India that allows the device to be used to cool animal vaccines as well as milk.

The course met twice weekly, with a Friday recitation. By all accounts, the new format was successful. Student evaluations of the class were very favorable, and the expert judges were impressed with the sophistication of the final projects.

Graduate Programs

In the course of AY2011, the department awarded 104 graduate degrees: 14 doctorates, 13 master of science in transportation (MST) degrees, 18 master of science degrees, and 30 master of engineering (MEng) degrees.

While many of our graduate students go on to doctoral studies and careers in academia, most students in two of our programs—MEng and MST—typically accept jobs in industry or government, where they often hold leadership positions by the time they reach the midpoint of their careers.

Our doctoral students are critical to the department's mission to educate intellectual leaders for academia and national research laboratories. Although research is often interdisciplinary, the program curricula are organized around the following areas of study: aquatic sciences, hydrology, environmental fluid mechanics and coastal engineering, information technology, transportation, civil and environmental systems, geotechnical and geoenvironmental engineering, and structures and materials. During AY2011, CEE had 78 doctoral students in the total population of 198 graduate students. Of the 14 who received a PhD, seven accepted faculty or postdoctoral positions at academic institutions.

As always, the level of funding for doctoral students continues to be a priority, because this support helps the department recruit the most highly qualified applicants. In addition to the students who receive internal fellowships and teaching and research assistantships awarded by the department, 30 of our graduate students were awarded named fellowships from MIT and other organizations, including three Presidential fellowships, three Fulbrights, one Singapore-MIT Alliance Computational fellowship, three National Science Foundation fellowships, one Environmental Protection Agency fellowship, one fellowship from the TOTAL Foundation, one from the US Department of Energy, one from the Arab Republic of Egypt, and two from the MIT Energy Initiative.

Student and Postdoctoral Research

The past few years have seen large increases in the number of postdoctoral associates and fellows in the department. We currently have about 50. Postdocs enrich the research, educational, and social aspects of the CEE community through their participation in,

and at times oversight of, undergraduate and graduate student research and their involvement with graduate student sports teams and other social activities.

Our postdocs and graduate students continue to be engaged in cutting-edge research in a variety of disciplines. Those in the environmental science and engineering fields often perform fieldwork as part of their research, and others write papers with their advisors that are published in peer-reviewed journals.

For example, graduate student Ange-Therese Akono was first author on a paper that appeared online in *Physical Review Letters* (coauthors were professors Franz-Josef Ulm and Pedro Reis). This work showed that the age-old scratch test measures crack resistance rather than a material's strength and is valid on material samples of any size.

Doctoral student Dipanjan Sen played a key role in a research project with professors Markus Buehler and Pedro Reis and Nobel laureate Konstantin Novoselov (of the University of Manchester) that used atomistic-level simulations to explain the mechanics behind the triangular tears in graphene. Details of the project were published in the May 21 issue of the journal *Small*.

A paper by postdoctoral associate Chris Leonardi was selected as the Best High Performance Computing paper at the 2011 Spring Simulation Multiconference in Boston. Other examples of published research by graduate students and postdocs can be found in the Research and Student Awards and Notes sections of this report.

MEng Students

Student teams in the MEng water quality and engineering track continued the practice of spending January participating in on-site research and fieldwork. Projects included working with the Capes Province Department of Health in the Philippines to complete the first comprehensive drinking water quality testing program in the region, studying the water quality of the Kranji Reservoir and Catchment in Singapore, and helping with development plans for a water filter factory in Ghana. Three of the MEng students blogged about their fieldwork.

Students in the high performance structures and geotechnical MEng tracks designed replacements for the Longfellow Bridge, auditoriums on Fort Point Channel, and a new CEE headquarters building on the Charles River. They also joined professor Jerome Connor on a January study tour to Paris.

Transportation Students

Graduate students in our transportation students group participated in several networking and research events over the past year. Many alumni, faculty, and students attended the MIT Transportation Club alumni networking event November 17 at the Redline restaurant in Harvard Square; the Transportation Club, founded in spring 2010, now has more than 300 members from across the Institute. And in January, dozens of transportation students and faculty members attended the Transportation Research Board's annual meeting in Washington, DC, where many of them presented papers and posters. MST student Naomi Stein blogged about the event.

The transportation students group also participated in the third annual MIT Distinguished Speaker Series in collaboration with the New York City Transportation Diversity Council. Graduate students Stein and Kevin Muhs organized the April 15 event, which was held at the McGraw-Hill companies in Manhattan. The theme of the event was "Transportation's Roadmap to the Future." The morning session featured distinguished speakers and opportunities for speed mentoring with transportation professionals. During the afternoon, students took guided technical tours of transportation systems, including Grand Central Terminal, JFK Airport, and the Brooklyn Battery Tunnel.

Several MST students also helped plan the first annual MIT Transportation Showcase, held at the MIT Museum on February 24 and hosted by the MIT Transportation Club. The showcase brought together more than 250 students, faculty, alumni, and representatives of transportation companies and agencies for an evening featuring transportation research posters and industry networking. Christopher Grillo (MCP/MST '11) won a first-place prize for his poster presentation in the Finance and Policy category at the event.

Extracurricular Activities

A reality-based smartphone game that lets users help a village in Tanzania and a portable, low-cost water quality testing kit are two of the four projects involving CEE students or alumni that won awards in the MIT IDEAS and Global Challenge Competitions May 2. Eighty-six teams entered the contests, which aim to foster innovative and practical public service inventions for the developing world. The CEE winners were doctoral student Peter K. Kang (SM '10) for Project AQUA, graduate student Samantha O'Keefe '09 for Safe Water World, MEng student Joanna Cummings for Kosim Water Keg, and Jean Pierre Nshimyimana (SM '10) for HydroHarvest.

A team with two CEE doctoral students and an alumna won the $100,000 first-place award in the ConocoPhillips Energy Prize competition, beating about 150 other entrants from around the country. The students, Matthew Orosz and Amy Mueller, worked with professor Harry Hemond to develop the science and technology behind their pilot project, which uses solar energy to provide heat, hot water, and electricity for schools and clinics in the developing world.

Lectures and Symposia

The department cohosted the annual John R. Freeman Lecture with the Boston Society of Civil Engineers on April 11 in Wong Auditorium. Vladimir Novotny, Professor of Civil and Environmental Engineering at Northeastern University, spoke on "Closing the Water Cycle, Recovering Energy and Resources in Future Sustainable Communities." The lecture series is named for the MIT alumnus who designed the original Charles River Dam.

This year, rather than holding the annual Charles L. Miller Lecture, a Charles L. Miller Symposium honoring Professor Daniel Roos on his retirement from MIT was held the afternoon of April 20 in MIT's Bartos Theater. The symposium was moderated by Joseph Sussman, the JR East Professor of Civil and Environmental Engineering and Engineering

Systems Division. Speakers included CEE Professors Robert Logcher (emeritus), Nigel Wilson and Roos. Roos joined the MIT faculty after earning the PhD here in 1966. Charles L. Miller was CEE department head from 1962 to 1969. The symposium was cohosted by CEE, the Center for Transportation and Logistics, the MIT Portugal Program, and the Center for Technology, Policy, and Industrial Development.

Many CEE faculty participated in the Institute-wide workshop on "The Future of the Oceans: Building a New Agenda for Research and Education," held December 2, 2010, in the McGovern Auditorium of the Whitehead Institute for Biomedical Research. The goal was to identify a new agenda for a coordinated research and education effort within the broader context of the MIT initiative on global environment being designed by the Environmental Research Council, which is headed by CEE professor Dara Entekhabi.

On May 20, an afternoon symposium and dinner honoring Professor Chiang C. Mei on his retirement was held at the American Academy of Arts and Sciences in Cambridge, attended by scientists and engineers from around the world. Mei, the Ford professor of engineering, joined the MIT faculty in 1965 after earning his PhD in engineering science from the California Institute of Technology. He is widely known and appreciated for his work in wave and fluid mechanics and hydrodynamics, and in 2009 two international symposia on wave mechanics were held in his honor. He has also done research on geomechanics and soil remediation theory. He was acting CEE department head during 2001 and 2002.

On September 28, 2010, CEE cosponsored (with the Department of Earth, Atmospheric and Planetary Sciences; the Department of Urban Studies and Planning; and the MIT Energy Initiative) a half-day symposium on "The Gulf Oil Spill: What Happened?" Researchers at the symposium, which focused on lessons learned from the Deep Horizon oil spill in the Gulf of Mexico, said that it should be possible to drastically reduce the chances of a repeat occurrence and that, if there is another, responders should be able to deal with it more rapidly and effectively than before. A news story and a video on the symposium are available at MIT World.

The weekly CEE seminar series in AY2011 included the Environmental Fluid Mechanics/Hydrology series, the Microbial Systems Seminar series, the MEng Friday Noon Seminar, Materials and Mechanics seminars, the interdepartmental Transportation@MIT series, the Building Technology Lecture Series, and the Center for Transportation and Logistics seminar series.

MIT 150th Anniversary Open House

CEE presented eight exhibits during the Institute-wide open house on April 30.

Molecular Secrets of Building Materials! (Shhh!)

Associate Professor Markus Buehler and Roland Pellenq, Senior Research Scientist
Concrete, steel, and other man-made materials are used to create structures such as bridges, roads, and buildings. In nature, bone forms the structural basis for the bodies of humans and many other organisms, and spider silk is the spider's building material of choice. CEE researchers are using molecular modeling simulations to try to reduce

the carbon footprint of concrete and design a man-made material that is as strong and lightweight as spider silk. Viewers of this exhibit watched computer simulations based on quantum mechanics that showed the electrons in cement interacting with water. They also saw how weak hydrogen bonds in spider silk actually make the material marvelously strong.

The Gravity-Defying Lapping of a House Cat

Associate Professor Roman Stocker and Assistant Professor Pedro Reis
In this exhibit, researchers shared their story of a pet cat that inspired them to conduct a study of how cats lap. In a high-speed video, the cat demonstrated how it controls a balance of the physical ingredients of gravity and inertia when it laps milk.

Living Sunlight: How Plants Bring Earth to Life

Professor Sallie W. Chisholm and Graduate Student Jessie Thompson
This session, intended for both children and adults who want to learn how life on Earth works, was centered around a children's book on photosynthesis coauthored by professor Sallie W. Chisholm and the award-winning children's book writer Molly Bang. The presenters offered a book reading and demonstration of photosynthesis in action.

Eye in the Sky

Professor Dara Entekhabi
This exhibit showed how remote sensing instruments work and what it takes to put together a satellite in the service of environmental science. The exhibit included a tabletop scale model of a NASA satellite, scheduled to launch in November 2014, that will measure moisture in the surface soil all around the Earth. The model rotates to simulate how it collects data on a large swath of the Earth as it orbits around it at 680 km. The Soil Moisture Active and Passive (SMAP) mission will provide global measurements of soil moisture and its freeze/thaw state. These measurements will be used to enhance our understanding of the processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models. SMAP data will also be used to quantify net carbon flux in boreal landscapes and to develop improved flood prediction and drought monitoring capabilities.

See in the Seas

Professor Harold Hemond
The underwater mass spectrometer is a new technology that provides the capability of measuring dissolved gases and volatile chemicals, a broad class of substances that have been heretofore very difficult to measure continuously, underwater, in real time. Deployed aboard a mobile platform such as an autonomous underwater vehicle (AUV), mass spectrometers measure substances such as hydrocarbon pollutants and metabolic gases, thus monitoring pollution as well as providing key data needed in fundamental Earth systems research. This exhibit featured a pioneering instrument, NEREUS, that has been integrated with the Odyssey II, an AUV originally designed by the MIT Sea Grant College Program. NEREUS was designed and built in the lab of professor Harold Hemond.

Constructing a Steel Bridge

Matt Pires '10
The MIT Steel Bridge Team has been competing in the National Student Steel Bridge Competition since 2007. In 2010, the team broke into the top 10, placing first in several categories. In this exhibit, the 2010 steel bridge was on display along with a short video showing the team constructing the bridge.

Renewable Energy, Cheap Charcoal, Rainwater Harvesting and Water Purification in Uganda

Sophomore Marisa Simmons
The MIT Chapter of EWB is in the process of providing electricity (via solar panels) and clean water to the Engeye Health Clinic in Ddegeya, Uganda. EWB is also showing villagers how to make a renewable charcoal fuel for cooking food and creating new water systems (e.g., a rainwater harvesting tank and SODIS water purifiers) for the entire village, which now relies on one dug pond and a single well. This exhibit demonstrated how to make charcoal using banana leaves, corn cobs, and banana peels; displayed a prototype of the rainwater harvesting system; and demonstrated the SODIS water purification process, in which plastic jugs of water are purified by UV rays and heat from the sun.

Terrascope: Reducing Atmospheric CO2

Professor Charles Harvey and Lecturer Ari Epstein
Terrascope is a learning community in which freshmen study and find solutions to real-world problems. This exhibit showed posters describing some of the student projects, which included building and testing a model of a geological carbon-sequestration site, developing less greenhouse-intensive forms of concrete, prototyping a new energy-storage mechanism for offshore windmills, and designing a multiplayer game to teach players about control of atmospheric carbon; and creating an interactive museum about greenhouse gases and methods of mitigation.

Research

The department's research is both broad and deep and covers a wide variety of focal areas in civil and environmental engineering, with about one book published and many papers appearing in peer-reviewed journals and presented at scientific conferences each year.

The department's monthly research newsletter, On Balance, focuses on one paper or book each month to provide a sampling of CEE research. The titles of the issues from AY2011 and the CEE researchers' names follow.

- "Weather Forecasting Problem is in the First Mile," Dara Entekhabi, former graduate student Pierre Gentine (PhD '10, SM '06, now an assistant professor at Columbia University) and co-author, September 2010.
- "Sulfuric Compound Cues Microbial Forages," Roman Stocker, former postdoctoral fellow Justin Seymour, graduate student Tanvir Ahmed and coauthor, October 2010. Seymour is now a research fellow at the University of Technology Sydney.

- "Global Change May Radically Affect Groundwater," Dennis McLaughlin, Dara Entekhabi and former graduate student Gene-Hua Crystal Ng (PhD '09, now at the US Geological Survey in Menlo Park, CA) and coauthor, November 2010.
- "Study Reveals the Elegance and Complexity of the Fluid Mechanics Underpinning How Cats Lap," Roman Stocker and Pedro Reis with coauthors, December 2010.
- "New Approach Improves Ability of Environmental Chemists to Characterize Atmospheric Aerosols," Jesse Kroll with chemical engineering graduate student Sean Kessler and coauthors, January 2011.
- "Analysis of Modern Genomes Uncovers Origins of Oxygen-Related Genes and a Vast Genetic Expansion," Eric Alm and graduate student Lawrence David, who is now a junior fellow in the Harvard Society of Fellows, February 2011.
- "Nitrate Plays Unsuspected Role in Lake Eutrophication," Harold Hemond and then-undergraduate Katherine Lin (SB '05, now an attorney in Chicago), March 2011.
- "Cement's Basic Molecular Structure Decoded At Last," Roland Pellenq (senior research scientist), Franz-Josef Ulm, Markus Buehler, former graduate student Rouzbeh Shahsavari (PhD '11) and coauthors, April 2011.
- "Need to Mix Fluids in Tight Spaces? Research Shows That Viscous Fingers Can Do the Job of Stirring," Ruben Juanes, postdoctoral associate Luis Cueto-Felgueroso, and graduate student Birendra Jha, May 2011.

The following news stories and news releases were written about CEE research during AY2011.

- "Researchers Redefine the Old Scratch Test," June 2, 2011
- "In the Mix: Research Finds 'Viscous Fingers' Can Induce Efficient Mixing of Fluids in Tight Spaces," May 19, 2011
- "Study Shows Nitrate Plays Counterintuitive Role in Lake Eutrophication," March 30, 2011
- "Researchers Say Ocean Currents Cause Microbes to Filter Light," March 16, 2011
- "Committee Says DOD Should Pay Some of the Costs of Transportation Infrastructure Near US Military Bases," March 7, 2011
- "Scientists Decipher 3 Billion-Year-Old Genomic Fossils," December 21, 2010
- "Minor Changes in Precipitation May Have Major Impact on Groundwater Supplies in Arid Regions," December 6, 2010
- "Genomic Comparison of Ocean Microbes Reveals East-West Divide in Populations," December 3, 2010
- "The Surprising Physics of Cats' Drinking," November 12, 2010
- "Laws of Attraction: Ocean Microorganisms Are Shown to Behave Like Larger Animals in the Presence of Sulfur," November 2, 2010

- "A Greener Way to Grow Carbon Nanotubes: Study Suggests New Way for Manufacturers to Minimize Environmental Impact of Carbon Nanotube Production," November 10, 2010
- "Sulfur Chemical Cues Microbes' Forages," October 22, 2010
- "Going Nature One Better: MIT Researchers Aim to Learn Biology's Secrets for Making Tough, Resilient Materials," October 22, 2010
- "CEE Researchers Collaborate with Nobel Prize Winner," October 12, 2010
- "Stately Killian Court Serves as Testing Ground for New Geotechnical Tool," September 30, 2010
- "Galileo Revisited: How ribbons roll. MIT researchers discover how flexible cylinders behave when rolling down a slope," September 8, 2010
- "The Salp: Nature's Near-Perfect Little Engine Just Got Better," August 31, 2010

Faculty and Staff Notes

In the midst of the Deep Horizon oil spill in the Gulf of Mexico, senior research engineer Eric Adams was a cowinner of the tongue-in-cheek 2010 Ig Nobel Prize in chemistry for disproving the adage that oil and water don't mix. Adams and his co-investigators shared the prize with British Petroleum, one of the funders of a research project completed in 2000 that demonstrated that most oil from a spill in the deep ocean would in fact mix with water, rather than rise directly to the surface.

Professor Cynthia Barnhart of CEE and the Engineering Systems Division served as acting dean of the School of Engineering from September 8, 2010, to February 7, 2011, after Subra Suresh left to direct the National Science Foundation.

Two CEE faculty members chaired sessions in the MIT 150th anniversary symposium on "Leaders in Science and Engineering: The Women of MIT" on March 28–29. Barnhart chaired the session titled "Celebrating Science and Engineering Breakthroughs II," and professor Sallie (Penny) Chisholm chaired "Celebrating Science and Engineering Breakthroughs III." Chisholm was also a panelist in a session on "Tiny Cells, Global Impact: Microbes in the Sea."

Professor Moshe Ben-Akiva and his research group, the MIT Intelligent Transportation Systems (ITS) Program, received the Institute of Electrical and Electronics Engineers (IEEE) ITS Outstanding Applications Award for the creation of DynaMIT, a computer system designed to provide real-time information to travelers and traffic managers. The work of Charisma F. Choudhury (PhD '07), who was advised by Ben-Akiva, won the 2010 Gordon Newell Memorial Prize from the Hong Kong Society for Transportation Studies for the best dissertation paper in the field of transportation completed within the last three years by a researcher of Asian origin. Choudhury is now an assistant professor in her home country at the Bangladesh University of Engineering and Technology. In addition, Ben-Akiva was profiled by the *Wall Street Journal* on December 4 in a list of five innovative thinkers in the transport industry for his work on DynaMIT.

Assistant professor Eric Alm will be promoted to associate professor effective July 1, 2011.

Associate professor Markus Buehler will be promoted to associate professor with tenure effective July 1, 2011. Buehler received the ASCE Engineering Mechanics Institute's Leonardo da Vinci Award for his "pioneering research in the integration of atomistic simulation with methods of continuum mechanics, applied to the multiscale modeling of the structure and mechanical behavior of biological and protein-based materials." Also, Buehler was invited to present six lectures for a course at the International Centre for Mechanical Sciences in Udine, Italy, in July 2011.

Professor Oral Buyukozturk received the Golden Mirko Roš Medal from Empa, the Swiss Federal Laboratories for Materials Science and Technology, during the NDTMS 2011 International Symposium on Nondestructive Testing of Materials and Structures held at Istanbul Technical University May 15–18. The award honored Buyukozturk's "valuable and sustained contribution to materials science and engineering in the domain of civil engineering and also for his outstanding research support to Empa over the past two decades," said professor Urs Meier of Empa. Buyukozturk also chaired the conference. In addition, his research proposal "Remote Detection of Damage in FRP-Retrofitted Concrete Structures Using Acoustic-Laser Vibrometry" received the 2011 National ASNT Fellowship Award from the American Society for Nondestructive Testing.

Professor Edward DeLong was named a fellow of the American Association for the Advancement of Science.

Sheila Frankel, lecturer, senior researcher, and assistant director of the Parsons Laboratory, received an Infinite Mile Award from the School of Engineering for her tireless work for the department and specifically for founding, organizing, and leading the TREX program each year. (More information is available in the Undergraduate Research and Practical Applications section of this report.)

Senior research associate and senior lecturer John Germaine cohosted a meeting of the GeoFluids Consortium at the University of Texas, Austin.

In April engineering systems graduate student Jameson Toole, who works with professor Marta Gonzalez, spoke at the TEDx conference, which was held at the University of Michigan in Ann Arbor. Toole's topic, "Big Data for Tomorrow," dealt with two projects in Gonzalez's lab. Gonzalez integrates methods of complex systems with statistical physics approaches, computational sciences, geographic information systems, and network theory to characterize and model human dynamics. A video of Toole's talk is available on YouTube.

Professor Philip Gschwend received the 2011 Samuel M. Seegal Prize from the School of Engineering. This award is presented to a faculty member who inspires students in pursuing and achieving excellence. Gschwend also was the recipient of an Excellence in Review Award from *Environmental Science & Technology*, a journal of the American Chemical Society.

Associate professor Charles Harvey will be promoted to full professor effective July 1, 2011.

The research of professor Harry Hemond played a key role in studies of the Deep Horizon oil spill. Richard Camilli (PhD '00, PhD '03) reported in the August 20 issue of *Science* that the plume from the spill could remain in the Gulf of Mexico for many months. Camilli used TETHYS cycloidal membrane inlet mass spectrometers, which are based largely on commercialization of technology developed by Camilli and others in Hemond's lab.

In a March 22 opinion piece in *Technology Review*, professor Eduardo Kausel wrote about the engineering and planning aspects of rebuilding that will be required in the wake of the earthquake and tsunami that hit Japan on March 11.

Professor Jesse Kroll received a National Science Foundation CAREER award for his project "Photochemical Aging of Atmospheric Organic Aerosol: Chamber Studies of the Chemical Evolution of Oxidized Organic Species."

A paper by postdoctoral associate Chris Leonardi and others was selected as the Best High Performance Computing paper at the 2011 Spring Simulation Multiconference. Coauthors include former postdoctoral associate David Holmes and professor John Williams.

Senior research associate (retired) Carl Martland has published a new book titled *Toward More Sustainable Infrastructure: Project Evaluation for Planners and Engineers* (Wiley, 2011). Martland, a railroad transportation specialist, was also quoted in an article appearing in the *Boston Globe* on February 14 about the new CSX rail yard in Worcester, which uses cranes to lift and move cargo containers between railcars and trucks, rather than the older, less efficient forklift-like side loaders.

A new book coauthored by professor Chiang C. Mei, *Homogenization Methods for Multiscale Mechanics* (World Scientific, 2010), provides researchers with a concrete treatment of the theory of homogenization for treating inhomogeneous media.

Fred Moavenzadeh, the James Mason Crafts professor of civil and environmental engineering and systems engineering, was named president of the Masdar Institute of Science and Technology last spring and will begin his new responsibilities in Abu Dhabi in July 2010.

An article and photo gallery on Pure Home Water (PHW) and its success in improving drinking water quality for rural Ghanaians appeared on the America.gov website in March. PHW, a nonprofit company based in Tamale, Ghana, was founded in 2005 by senior lecturer Susan Murcott.

Professor John Ochsendorf and his students prepared a full-scale prototype of a timbrel vault for an exhibit in the National Design Triennial at the Cooper-Hewett National Design Museum in New York City. An article in the February 26 *Boston Globe*

focused on Ochsendorf and his new book, Guastavino Vaulting: The Art of Structural Tile (Princeton Architectural Press, 2010). Ochsendorf also is one of three MIT faculty members (two of whom are in CEE) selected to attend the National Academy of Engineering's 17th US Frontiers of Engineering symposium September 19–21 at Google headquarters in Mountain View, CA.

A paper by assistant professor Carolina Osorio won the Graduate Student Best Paper Award at the Transportation Research Forum in March. The paper, "A Simulation-Based Optimization Framework for Urban Traffic Control," is based on a chapter in Osorio's PhD thesis.

Pedro Reis, the Esther and Harold E. Edgerton professor in CEE and the Department of Mechanical Engineering, was one of 60 engineers under the age of 45 who attended the US National Academy of Engineers' Japan-America Frontiers of Engineering Symposium in Osaka, Japan, June 6 to 8. Two Reis lab members, postdoctoral associate Arnaud Lazarus and graduate student Bastiaan Florijn, won the best poster prize at the Freund Symposium: Future Directions in Mechanics Research held June 3 at Brown University. The title of the poster was "Geometry-Induced Rigidity in Pressurized Elastic Shells."

Senior lecturer Frederick Salvucci won MIT's Graduate Student Council Teaching Award.

Professor David Simchi-Levi was elected as an academic member of the Board of Governors of the Technion Israel Institute of Technology, a post similar to an MIT Corporation member. His research focuses on the development and implementation of robust and efficient techniques for manufacturing and logistics systems. In his new book, *Operations Rules: Delivering Customer Value through Flexible Operations* (MIT Press, 2010), Simchi-Levi identifies a set of scientifically and empirically based rules on issues such as price, product characteristics, and information technology to help companies transform their operations and supply chain management.

Professor Roman Stocker wrote an invited news commentary, "Reverse and Flick: Hybrid Locomotion in Bacteria," in the February 2 early edition of the *Proceedings of the National Academy of Sciences* about a paper on a newly discovered mechanism of locomotion used by marine microbes. Stocker is also one of three MIT faculty members selected to attend the National Academy of Engineering's 17th US Frontiers of Engineering symposium in September at Google headquarters in Mountain View, CA.

Professor Joseph Sussman chaired a congressionally mandated committee for the National Research Council's Transportation Research Board; the committee developed case studies for six military bases located in metropolitan areas that are among the 18 bases that will receive a large influx of military personnel as mandated by the 2005 Defense Base Closure and Realignment (BRAC) process. Sussman is chair of the Intelligent Transportation Systems Program Advisory Committee of the US Department of Transportation. He gave the keynote speech at the World Bank Transportation Sector's annual meeting in September 2010.

Professor Franz Ulm delivered the Maurice A. Biot Lecture hosted by the Department of Civil Engineering and Engineering Mechanics at Columbia University in October. His lecture was titled "Poromechanics: From Atoms to Concrete Structure." Ulm also gave a presentation titled "Breaking the Wall of Concrete Pollution: How Green Concrete Can Reduce the Giant Carbon Footprint of Construction" at the 2009 Falling Walls Conference, which commemorated the 20th anniversary of the fall of the Berlin Wall.

Green concrete, one of the goals of the Concrete Sustainability Hub, was the topic of a video news report by BBC TV's Ian Hardy, who interviewed Ulm, professor Hamlin Jennings, and senior research scientist Roland Pellenq of CEE and the Concrete Sustainability Hub. Hardy also included shots of graduate students Ange-Therese Akono and Muhannad Abuhaikal working in the lab.

Professor John Williams has been elected to the Learned Society of Wales.

Student Awards and Notes

Ten students were welcomed into the civil and environmental engineering honor society, Chi Epsilon: seniors Victoria Brumbaugh, Joshua Hester, Ivy Huang, Kimberly Huppert, Connie Lu, and Meena Viswanat and juniors Michael Chen, Lorna Ogolla, Breanna Peterman, and Tzipora Wagner.

Senior Connie Lu was awarded a 2011–2012 Legatum Fellowship from MIT's Legatum Center for Development and Entrepreneurship. The fellowship will allow her to continue developing the company GrubCycle while she pursues an MEng in environmental and water quality engineering at MIT. Lu, junior Scott Landers, Caroline Hunting '11, and sophomore Coyin Oh (biology) entered the GrubCycle business plan in the 2011 MIT Global Challenge.

The spring issue of *Komaza*, a student-run magazine about the international development experiences of MIT students, included a story about the work of MEng students Claudia Espinoza and Maclyn O'Donnell on senior lecturer Susan Murcott's Kanchan Arsenic Filter project in Nepal. Also, Murcott's advice appeared in an ask the experts piece about international development.

Four seniors were elected to Phi Beta Kappa: Fatima Hussain (1E), Alexander Jordan (1C), Khalea Robinson (1C), and Katherine Turner (1C).

Khalea Robinson was also named as the School of Engineering's 2011 Henry Ford II Scholar, and she was one of only two MIT students (both from CEE) giving invited talks at MIT's 37th annual Martin Luther King Jr. breakfast in February.

Doctoral student Pierre Fuller, whose research applies computing techniques to solve problems in civil engineering, was the other MIT student who spoke at MIT's Martin Luther King Jr. celebration.

Course 1A senior Alorah Harman was awarded an MIT Eloranta Summer Undergraduate Research Fellowship.

Course 1E senior Fatima Hussain was a winner of the Association of MIT Alumnae (AMITA) Senior Academic Award.

Course 1C senior Aissata Nutzel received a Ronald E. McNair Scholarship Award.

Course 1C senior Michelle Bentivegna received the Laya Wiesner Community Award.

Three graduate students in professor Ruben Juanes' research group received Outstanding Student Paper Awards at the 2010 American Geophysical Union fall meeting in December: Birendra Jha ("Fluid Mixing From Viscous Fingering"), Peter Kang ("Effective Transport in Lattice Fracture Networks with Uncorrelated and Correlated Velocity Field"), and Christopher MacMinn ("Spreading and Dissolution of CO2 in Horizontal Aquifers: Theory and Experiments").

Doctoral student Denvid Lau was selected as a 2011 Harvey Fellow by the Mustard Seed Foundation. Lau's doctoral research with professors Oral Buyukozturk and Markus Buehler focuses on the debonding of bilayer material systems under moisture effects.

MEng student Marne Zahner won the spring 2010 Marvin E. Goody Award for his thesis proposal, "Energy Dissipation Behavior of the Modified Friction Device."

Tiffany Cheng, a junior majoring in environmental engineering science and minoring in applied international studies, was named a 2011 Burchard Scholar.

Kari Hernandez, a graduate student in transportation, was awarded one of nine spots by the International Union of Railways to attend its High Speed Rail World Congress in Beijing in December 2010. In her work with research associate Mikel Murga and senior research associate Frederick Salvucci, Hernandez studies the role of intermodality in long-range transportation system development, focusing on the value of high-speed rail and airport integration.

The *International Journal of Applied Mechanics* selected a paper by CEE graduate students Zhao Qin and Steve Cranford, former visiting graduate student Dr. Theodor Ackbarow, and professor Markus Buehler as one of the best papers published in the journal during 2009 and 2010. "Robustness-Strength Performance of Hierarchical Alpha-Helical Protein Filaments" was the cover story for the journal's inaugural issue in March 2009.

Working with a student-spawned company, One Earth Designs, environmental engineering graduate Wesley Koo '09 helped write the business plan for a low-cost solar cooker that won the top prize in the Netherlands Green Challenge.

CEE junior Monica Oliver's UROP research from spring 2010 led to the publication of "Helping Cities Adapt to Climate Change Risks," a role-play simulation that will be used as a teaching tool in Harvard Law School's Program on Negotiation. (More information can be found in the Undergraduate Research and Practical Applications section of this report.)

MIT selected CEE postdoctoral associate Hector Hernandez as a Martin Luther King Jr. scholar. Hernandez received his PhD in chemistry from MIT in 2008 and has since worked in the lab of professor Janelle Thompson on a study of deep-earth microbes in environments with very high levels of carbon dioxide.

Doctoral student Simon Laflamme hosted a seminar in September ("Self-Organizing Inputs for Black-Box Modeling of Large-Scale Nonstationary Dynamic Systems") for the Center for Dynamics of Complex Systems, Nonlinear Dynamics Group, and Theory of Chaos Group at the University of Potsdam in Germany. "A Sensing Skin for Large-Scale Surface Monitoring of Infrastructures," a paper by Laflamme and professor Jerome Connor (and coauthors), received the Boston Society of Civil Engineers Section's Herzog Award.

Graduate student Rouzbeh Shahsavari, advised by professor Franz-Josef Ulm, was a silver medalist in the Graduate Student Award competition at the 2010 Materials Research Society fall meeting. A poster by Shahsavari on the "Transferability of Empirical Force Fields" received the Best Poster Award from the Cements Division of the American Ceramic Society at the organization's annual meeting in July. In addition, Shahsavari's paper "From Atoms to Microstructure of Cement Hydrate" was one of five finalists for best paper at the Engineering Mechanics Institute's 2010 conference in August.

Departmental Awards

Professor Philip Gschwend was recognized with the Maseeh Award for Excellence in Teaching. He also received the 2011 Samuel M. Seegal Prize from the School of Engineering.

The Maseeh Award for Excellence as a Teaching Assistant went to Steven Cranford, teaching assistant for the undergraduate subject 1.050 Engineering Mechanics I.

The Trond Kaalstad (Class of 1957) Fellowship was awarded to doctoral student Simon Laflamme. He served as a teaching assistant for three classes each year, helping students with both their group projects and their individual theses, providing tutorials for computer software systems such as SAP and MATLAB, and handling airplane and hotel reservations for approximately 20 students during their IAP study tours.

Meena Viswanath, a senior majoring in civil engineering, received the Steinberg Prize, which is awarded to an undergraduate student for academic achievement and demonstrable interest in construction management.

Rebecca Heywood, a junior majoring in civil engineering, received the Leo (Class of 1924) and Mary Grossman Award, which is given to an undergraduate who has a strong academic record and interest in transportation.

Fatima Hussain, a senior in environmental engineering science, received the Paul L. Busch (1958) Prize, which goes to an undergraduate in environmental science and engineering for academic achievement and contributions to the CEE community.

MEng student Longfeil (Michael) Shentu received the Tucker-Voss Award for his thesis titled "3-D Numerical Manifold Method Simulation." The award is given to a student who shows particular promise in the field of building construction.

Andrew J. Whittle
Department Head
Edmund K. Turner Professor