Department of Civil and Environmental Engineering

Current Goals, Objectives, Priorities

Course 1, the Department of Civil and Environmental Engineering (CEE), is one of the oldest departments in the School of Engineering. Historically, the divide between the disciplines of civil engineering and environmental science has presented challenges. However, over the past year, the department has undergone dramatic changes that are enabling the department to become a more robustly multidisciplinary organization.

Sustainability concerns have naturally led the department to become a focal point in cross-disciplinary areas that address the world's current issues. These include climate change, "smarter" cities, ecosystems, water and energy resources, coastal zones, and benign design, infrastructure, and materials. The department is refocusing its efforts to address big societal challenges through intellectual leadership in scholarship and innovation and the application of cutting-edge tools, including genomics, nanotechnology, and computation. A newly approved flexible undergraduate curriculum, 1-ENG, offers CEE students the opportunity to blend disciplines in their educational foundations and to prepare themselves for coming challenges in sustainability. The students in 1-ENG, through multidisciplinary study, will build knowledge and skills on a solid foundation of work in mathematics, statistics and data, computation, and hands-on laboratories.

CEE is a vibrant leader in scholarly contributions and innovation in the broad areas of the environment (that which exists as natural systems) and infrastructure (that which is created by human activity). This past year was one of significant change for CEE, reflecting the development of a new and exciting identity. Focusing on excellence and building on the strengths of its people, several strategic initiatives and changes were implemented as a direct result of a departmental task force charged to conduct a strategic analysis of the vision, goals, and directions of the department. Chaired by Cindy Barnhart, the task force was active between fall 2012 and the end of the spring 2013 term; it engaged faculty across the department through deliberations, discussions, and a faculty retreat. The task force concluded that the status quo was untenable and recommended urgent and significant changes to the department's direction and strategy. A key recommendation of the task force was the development of a new educational model designed to engage all of the department's faculty members actively in education, the core mission of the department. This recommendation ultimately resulted in the new CEE undergraduate program, 1-ENG. The department has developed and endorsed a set of five long-term strategic priorities:

- Renewing, developing, and implementing inspiring and sustainable educational programs at the undergraduate and graduate level;
- Establishing an effective departmental structure;

- Focusing on the future: accelerating faculty hiring and junior faculty development;
- Showing leadership in MIT-wide initiatives: showing outward focus and engagement;
- Renewing and improving facilities; and
- Building new opportunities for exciting research that will reach across all of MIT.

Administrative Changes and Leadership Appointments

The administrative structure of CEE underwent a complete remodeling, with a new department head, a new administrative officer, and several newly created leadership roles—including associate department head and director of the Henry L. Pierce Laboratory for Infrastructure Science and Engineering (Building 1). The department head met regularly with staff, including at a plenary session held to communicate and discuss new strategic priorities.

Reflecting the core mission of CEE, education has also been an area of intense focus and engagement over the past year. Professor Elfatih Eltahir was appointed associate department head, effective September 2013, and has focused on undergraduate education and Institute-wide initiatives. Professor Daniele Veneziano was named director of the Pierce Laboratory and Professor Phil Gschwend was named director of the Ralph M. Parsons Laboratory for Environmental Science and Engineering (Building 48). These directorships will help each group shift the department in a direction that better reflects the work being done in CEE and will help provide effective channels of communication.

Because of these significant changes, an interim meeting with the CEE Visiting Committee was held in November 2013 at MIT. Approximately 10 members of the Visiting Committee attended, under the leadership of committee chair Susan Whitehead. The Visiting Committee strongly endorsed the leadership and direction of the department.

Engagement with the Student Community

Given the significant changes, CEE has engaged intensely with the MIT student community through listening tours, surveys, town halls, coffee hours, and activities shared between the department administration and various student groups. Students and staff worked together to identify, create, furnish, and manage the newly created Pierce Lounge. (A ribbon-cutting event formally opened the Pierce Lounge to the Course 1 community on February 14, 2014.) Students and staff continue to work to ensure that all Course 1 students have a place to socialize and work together in Building 1.

Engagement with the Postdoctoral Researcher Community

Because of the department's growing number of postdoctoral researchers, a new postdoctoral committee was formed and placed under the leadership of professor

John Williams. The committee was charged with understanding and addressing the professional and career development needs of the postdoctoral researchers, identifying and improving mentoring, and providing the researchers both with opportunities to contribute to the department's educational programs and with an overall enhancement of their experience at MIT. The committee facilitated communication between the department head and the community of postdoctoral researchers. Specific activities included a town hall, an online survey, planned networking events for CEE postdoctoral researchers and faculty members, a series of lunch-and-learn meetings on such topics as web presence and job search skills, and the introduction of teaching fellowships to provide postdoctoral researchers career development through involvement in teaching. New plans for mentoring are being rolled out.

Intellectual Focus, Mission, and Vision Statements

Following the introspection required of the task force and the introduction of the new leadership, the department has reformulated its intellectual focus and its mission and vision statements to reflect the composition of the faculty and their aspirations.

The department's intellectual focus is discovery and innovation intended to understand the world and to invent and lead with creative designs for sustaining life and society in ever-changing environments. Emphasizing the use of quantitative approaches, CEE features two vibrant centers of gravity: environment, that which exists as natural systems, and infrastructure, that which is created by human activity.

The department's faculty and staff are dedicated to educating its students such that they are best equipped to serve the nation and the world as professionals, scholars, academic leaders, and entrepreneurs. Its research and educational programs challenge the status quo, advance the frontiers of knowledge, and expand the limit of the possible. CEE develops and applies pioneering approaches that range from basic scientific principles to complex engineering design, at scales from the nano to the global.

The core mission of the department is to educate, inside and outside the classroom. CEE offers undergraduate degree programs in the broad areas of infrastructure and environment. Its graduate programs provide limitless possibilities at the frontier of knowledge and innovation. CEE consists of people from a very broad range of academic disciplines who work together to contribute to exciting intellectual networks within the department and across MIT. CEE is defined by our singular strengths, collaborative synergies, and commitment to excellence, part of the fabric of MIT. It fosters diversity of people, research, and interests, and champions the careers of our students, research scholars, staff, and faculty.

Infrastructure—Pierce Laboratory (Building 1)

CEE's efforts in the area of infrastructure focus on innovative science and engineering approaches that advance the design of infrastructure materials, transportation systems, cities, and energy resources. Emphasizing collaborations across MIT, the department seeks to address fundamental issues that are critical to society and the environment,

and to serve as a center of excellence in the design, manufacturing, and operation of infrastructure. CEE is especially interested in advancing areas such as benign materials design, infrastructure data analytics, smart infrastructure, and geo-chemo-mechanics for subsurface energy and other material resources, as well as resilient cities. An overarching priority is to identify and apply radically new approaches to the design, manufacturing, and characterization of infrastructure materials.

Environment—Parsons Laboratory (Building 48)

CEE's long-term objective in the area of the environment is to understand and engineer human adaptation to a changing environment. Human activities are affecting the global environment at rates that are likely to increase dramatically. In light of global effects such as changing weather patterns and rising temperatures and sea levels, the specific local impact of global environmental change on water supply, agriculture and food, water and air quality, natural hazards, and public health remain largely unknown. A priority is to understand what local changes must be made in response to global weather changes, how marine and terrestrial ecosystems respond to such global changes, and how local ecosystem services are affected and utilized. We are particularly interested in advancing knowledge in areas such as microbial ecology, terrestrial ecology, coastal processes and engineering, and the chemical impacts of materials design and manufacturing.

New Faculty Initiatives and Hires

Lydia Bourouiba and Ben Kocar joined the faculty as assistant professors on January 1, 2014. They both work in areas of sustainability encompassed in the disciplines of biology, fluids and mathematics, and chemistry.

Professor Bourouiba is an applied mathematician who works on problems at the interface of fluid dynamics and disease transmission. Her aim is to elucidate the physical mechanisms that shape disease transmission dynamics in human, animal, and plant populations, and her approach uses fundamental fluid dynamics to examine pathogen mobility, rather than the more traditional study of host mobility and interaction. Bourouiba has been active in the MIT Institute for Medical Engineering and Science and has been appointed an associate faculty member at the institute.

Professor Kocar is a biogeochemist who studies chemical, physical, and biological processes governing the cycling of elements in ecosystems. He uses laboratory experiments and advanced analytical methods to decipher the molecular-scale mechanisms that control the fate of nutrients, contaminants, and other environmentally relevant chemicals. He then tests the relative importance of these various processes—microbially mediated and abiotic reactions, effects of physical structure, redox processes—in soils, sediments, and natural waters using field-scale observations and reactive transport (mathematical) modeling. His analytical methods include synchrotron-based techniques that employ extremely powerful X-rays to reveal an element's atomic structure. Kocar is developing novel synchrotron X-ray methods to examine microbially mediated metal reduction in real time.

Results from 2013–2014 Faculty Search

The department conducted an intense faculty search that resulted in the hiring of Otto Cordero, who will join the faculty in July 2015. Another candidate, Xuanhe Zhao, accepted an offer in the Department of Mechanical Engineering and will have a joint faculty appointment in CEE. The department continues its effort in faculty renewal in all areas through active efforts to recruit world-class faculty candidates and a newly created standing faculty search committee.

MIT Environment Initiative

Markus Buehler was actively involved with envisioning, designing, and implementing the Institute's Environment Initiative, following on the work of several committees that had been active at MIT over several years. He also chaired an Institute-wide search committee that involved faculty representatives from all five Schools, identifying professor Susan Solomon as the inaugural director of the initiative. Both the Environment Initiative and Professor Solomon's appointment were announced formally in a letter to the MIT community in May 2014.

This initiative brings exciting opportunities for research and education to CEE, and it was received with much anticipation, appreciation, and excitement. It was decided that the Earth Systems Initiative will be discontinued, with its activities to be embodied in its faculty members' home departments and the new Environment Initiative. This transfer of responsibilities puts CEE in a great position to complement the new endeavor, and adds new research accounts to CEE's ledger.

CEE Cross-Disciplinary Seed Funding

To foster cross-cutting collaboration within CEE, reward excellence, and nurture high-impact projects with great scientific merit and potential, the department established a new seed funding program. Recipients were selected through peer review by an ad hoc faculty committee. The program provides a one-year graduate student fellowship for each selected project, and encourages faculty and graduate students to take new approaches to solving grand challenges in energy, the environment, sustainable materials, infrastructure, and cities.

Two projects demonstrating the exciting opportunities from combining the diverse research interests of faculty in CEE have received inaugural CEE cross-disciplinary seed funding. The winning teams and projects are professors Dennis McLaughlin and Saurabh Amin for Decentralized and Adaptive Environment Resource Management Strategies and professors Benjamin Kocar and Martin Polz for Deciphering Coupled Biogeochemical-Physical Processes Responsible for Methane Emission and Consumption within Structured Soils and Sediments.

Teaching and Curriculum

Over the past academic year, CEE awarded 16 PhD, nine SM, 26 MST, 41 MEng, and 18 SB degrees. Of the 16 students to earn a PhD, at least a third have gone on to careers in academia.

Undergraduate Programs

The department underwent an exercise in data gathering and self-examination in order to prepare and put forth a proposal to expand and change the undergraduate curriculum. The new program, named 1-ENG, is an option-driven curriculum designed to enhance the educational experience of CEE undergraduates, enabling them to gain extra exposure to fields of special interest and to design an educational plan that works for them.

The Committee on Curricula formally approved 1-ENG in the spring of 2014; the program will begin in the fall of 2014. The development of a curriculum that follows the composition of the faculty and the research priorities of the department, and one that opens new opportunities for our students to make a difference in today's world, was a significant accomplishment. The new curriculum will give students the ability to design unique and challenging educational programs to suit their individual interests, career goals, and aspirations. It also places CEE in a competitive niche in undergraduate education, as it offers an engineering science approach to sustainability.

The 1-ENG program lets CEE students create their own courses of study by combining foundational courses with the core subject areas of mechanics and materials, environmental engineering science, systems, or any combination of these. Students can focus on energy, bio-inspired mechanics, environmental engineering science, civil engineering, sustainable buildings and cities, systems, transportation, or structures (architecture and design). The program emphasizes quantitative approaches, and it offers opportunities to apply coursework through hands-on laboratory and project-oriented subjects. Students also have the option of taking a project-based senior capstone subject or writing a thesis. The 1-ENG program also offers a first complete curriculum in systems.

In addition to the requirements of the three core subject sets, track-related subjects, and electives, all students in 1-ENG will take five required subjects: mathematics, computation, engineering probability and statistics, data analysis, and a capstone or thesis subject that teaches the basic skills needed to engage in a design project or write a thesis. This set of subjects complements and enhances the rigorous foundations established through the general institute requirements taken in freshman year.

The main feature of the new program is its unprecedented flexibility. The program will allow students to work closely with their faculty advisors to design tracks of study that are tailored to fit each student's needs and interests. It will also create entirely new opportunities, such as giving CEE students the opportunity to use the tools of big data, network theory, and statistical mechanics as they apply to civil and environmental applications.

To support the new curriculum, the department will launch several new and updated undergraduate subjects in the 2014–2015 academic year. New subjects include data analysis for analyzing real-world data sets, a computational course based on MATLAB 1.000 (Computer Programming for Scientific and Engineering Applications), and a new field-based environmental subject that is based on the Traveling Research Environmental Experience that is now formally part of the undergraduate curriculum. (CEE also offers a JavaScript-based computation course, 1.00.) Other CEE subjects and courses will be added in the coming semesters. CEE seniors took a completely redesigned capstone subject, 1.013 Senior Civil and Environmental Engineering Design, taught by professors Jesse Kroll and Colette Heald. Students designed an air-quality monitoring device that could measure the levels of pollution in an area over time (CLAIRITY). This device was featured by the local media and has been selected for a show at the MIT Museum.

The department has created additional opportunities and annual events that involve all of CEE to engage our students. We held the "Cirque de CEE" event during Departmental Exploration, an MIT-wide event that is intended to inform rising sophomores about the diverse and innovative department that is CEE. CEE continued its involvement in the freshman learning community through Terrascope, collaborating, in this learning community, with the Department of Earth and Planetary Sciences through the spring-term 1.016 Communicating Complex Environmental Issues: Building Solutions and Communicating Ideas. This subject offers freshmen the opportunity to participate directly in faculty-guided research while working more rigorously on solutions to the problems they studied in the fall Terrascope subject.

Graduate Programs

A new graduate student committee (informally referred to as "Gradcom") was formed, consisting of six student members to create a communication channel between the graduate community and the department's leadership. A new, much-needed discourse on how to improve the CEE community for graduate students came from this effort. A useful byproduct of the newly formed committee was the formation of a social committee for the Pierce Laboratory community. The new social committee organized monthly get-togethers that were open to the entire community in the Pierce Laboratory (a practice adopted from their colleagues in the Parsons Laboratory). Friday get-togethers in the Pierce and Parsons laboratories were staggered to allow attendance across the department, and they became popular networking events.

Admissions were held for the first time for a new PhD program in computational science and engineering, a cross-department collaboration with the School of Engineering's Center for Computational Engineering. This new program, with CEE as one of two inaugural departments, met with significant interest across CEE. Professor John Williams led the effort.

In spring 2014, the department formed a committee to review and improve the graduate qualifying examination. Reflecting feedback from students and faculty, the overall goal was to improve the educational experience of the examination. The proposed new format takes a new approach to its two-part structure. In part one, in place of a written,

take-home exam that took three and a half days to complete and covered the subjects included in the core program, there will now be a three-subject core in the students' selected field of study. A student must receive an A grade in each of the subjects selected for the three-subject core in order to pass part one. Part two, the oral portion of the exam, will now include a review of a relevant publication and presentation. A member of the student's qualifying committee must now be from outside his or her research group to test the student's ability to answer questions at a basic level, in a way that a non-expert would understand.

Committee on Transportation Graduate Education

In an effort to renew the interdepartmental transportation programs that are administered and housed in CEE, the department formed a committee on transportation graduate education, co-chaired by professors Moshe Ben-Akiva and Emilio Frazzoli (Department of Aeronautics and Astronautics). The committee was charged to determine educational objectives for CEE's master's and doctoral programs in transportation, to enhance the programs' flexibility, and to identify specific subject offerings that reflect the interests and composition of the faculty and are likely to define transportation education for the future. The committee will also seek opportunities to coordinate with the all-Institute Transportation@MIT initiative.

Graduate Student Activities

Other activities included:

- Doctoral student Aleja Ortiz attended the Annual Society for Advancement of Hispanics/Chicanos and Native Americans in Science conference in fall 2013 to recruit graduate students for the department.
- Doctoral students Alexandra Konings and Alison Hoyt arranged a two-day software workshop taught by volunteers from the nonprofit organization Software Carpentry. About 40 graduate students and postdoctoral researchers participated in the workshop (held January 28–29, 2014, with a half-day extension on January 30, 2014).
- CEE graduate student Thomas Petersen ran the Boston Marathon on April 21, 2014, with the MIT Strong team. Peterson has been running competitively for a decade, and he participated to honor the memory of Sean Collier, the MIT police officer who was slain April 18, 2013, in the wake of last year's Boston Marathon bombing.

Accomplishments and Events

Laboratory Renovations

- The Pierce Laboratory has begun a renewal effort, expanding the laboratory in the area of energy and mechanical design. Professor Ruben Juanes will move his research laboratory from Building 48 to Building 1, offering exciting possibilities

for synergistic activity with the research efforts in materials (the geotechnical area as well as mechanics and structures).

- The department has begun an expansion of Pedro Reis's laboratory to bring a refreshed and renewed atmosphere to a growing department and support the growing needs in creative mechanics. Pedro Reis continues to inspire his students and colleagues at MIT and around the world with his work in mechanics and design.

NAE Video Contest

The department challenged the CEE community to create a two-minute video in order to generate entries for a contest sponsored by the National Academy of Engineering (NAE), which is celebrating its 50th anniversary. NAE asked contestants to submit a video about advances in engineering that made a significant impact on humanity from 1964–2064. Ten groups responded to the department's call for entries. All but one of the final videos were shot, edited, and produced entirely by students. The videos were screened for a crowd of more than 80 attendees—the video makers themselves, their friends and peers, and faculty and staff from CEE. At the conclusion of the event, the audience voted for its favorites. Christopher Kaiser, biology professor and former provost, and CEE's John Williams were the official judges; they weighed audience data and added their own assessments. The winners were announced after the final screening. As of this writing, one of the 10 entries is still in the running at NAE for the grand prize of $25,000, with a winner to be announced in September.

- First prize went to CEE undergraduate Sid Pai for a video chronicling a project, called Protoprint, in which waste-pickers in India retrieve and clean plastic waste that is then broken down and used in a three-dimensional (3-D) printer to create objects that the pickers can sell. The result is an earned income that is 15 times greater than that from just collecting the plastic alone.
- Second prize was awarded to a team of CEE and Department of Mechanical Engineering graduate students, Leon Dimas, Dieter Brommer, and Tristen Giesa. Their submission, a rap video narrated by students and faculty from CEE, highlighted advances in their fields—the oldest engineering disciplines, which are now undergoing renewal with the introduction of new tools from statistical physics, quantum chemistry, and biologically inspired engineering.
- Third prize went to Jennifer Apell, a CEE graduate student, for a video titled "New Samplers for Old Problems." Her video looks at lowering pollutant levels in contaminated sediment through the use of a plastic sampler that will help focus cleanup efforts to areas where it matters most.

A full list of student entries includes:

- Zhandos Orzalin, Geotechnical Engineering Advancements
- Sam Levy and Rebecca Heywood, Sharing Track: A Trainificent Solution
- Billy Ndengeyingoma, Keep Calm, Grab a Mouse, and Engineer On!

- Sid Pai, Engineering Waste for 3D Printing
- Jennifer Apell, New Samplers for Old Problems
- Ruby Fu, CEE: Caught in Action! The True Faces of CEEers
- Ryan Westrom and S. Joel Carlson, Engineering Achievement of the 20th Century? A Primer on Induced Demand
- Maria Cassidy and Mehdi Akbarian, The Road to Better Pavement Design
- Leon Dimas, Dieter Brommer, and Tristan Giesa, A Vision of the Future of Civil and Environmental Engineering by Students and Professors of CEE

Alumni Outreach Programs

The department held its first research breakfast event in October, hoping to increase the level of engagement with CEE alumni. The event emphasized the need to think outside disciplinary boundaries in research and education, to build and invent, and to foster an entrepreneurial spirit among students and faculty. CEE's department head, professor Markus Buehler, laid out his vision for the department to the alumni, and several faculty members made presentations on their cutting-edge research. Colette Heald lectured on "How Air Pollution and Climate Impact Global Food Security"; Pedro Reis on "Smorphs: Turn Mechanical Failure into Functionality"; Marta González on "Mining Cellphone Data to Improve Urban Livability"; and Philip Gschwend on "Benign Design of Materials Now Can Avoid Problems in the Future."

Research Speed Dating Event

CEE held its annual Research Speed Dating event at the MIT Media Laboratory on February 7, 2014. The event was organized by the CEE junior faculty and featured short research presentations by many faculty members, postdoctoral researchers, graduate students, and research associates, followed by a wine and cheese reception. This year the event was captured with an in-house application developed by graduate students that could track audience members and participants as they created a network of technical interest groupings.

To speed up the discovery of new research connections, two MIT students devised a conference takeaway called the Speed Dating Network App that helps attendees keep track of people with whom they want to connect and to see how those people connect with everyone else at the event. The app was introduced at the CEE Research Speed Dating event, where it showcased exciting opportunities for faculty, students, and staff to connect on research methods and domains. Designed by graduate students Christos Nicolaides and Jameson Toole, working with assistant professor Marta González and assistant professor Pedro Reis, the app builds a network map during a conference based on real-time input from attendees who are using computers or mobile devices.

The event itself featured 25 four-minute talks followed by one minute of questions and answers that could lead to research "matches" or collaborations. The interactive map

built by the Speed Dating Network App reveals these potential matches, allows users to move nodes around to see all the connections on the network, and remains in existence after the conference has ended. The app could eventually be used in other ways—for example, by corporations that want to maximize creative synergies by placing key employees' offices near one another.

The data generated at this event showed how interconnected the people in CEE are, and what tremendous opportunities lie ahead.

John R. Freeman Lecture

The department cohosted the annual John R. Freeman Lecture with the Boston Society of Civil Engineers on April 8 in Wong Auditorium. Professor Perry L. McCarty of Stanford University spoke on "Capturing Domestic Wastewater's Resource Potential." The annual lecture is named for the MIT Course 1 alumnus who designed the original Charles River Dam.

MIT Steel Bridge Team

The MIT Steel Bridge Team placed second in the national competition held May 24–25, 2014, at the University of Akron in Akron, OH. The goal is to create the lightest, but stiffest, structure, precisely assembled by the fewest number of people as rapidly as possible. This year's team built a bridge that weighed 107 pounds, was able to hold 2,500 pounds, and was erected by three students in slightly over 11 minutes.

Professional Education

Several CEE faculty members participated in the MIT Professional Education program, focusing on areas such as cybersecurity, traffic, materials design, and supply chain management.

Research

The department's research volume is growing steadily, with a 9.2% increase over last year. Fifty-six percent of the new awards went to the department's junior faculty members, who make up less than a third of the faculty. This, combined with continued renewals of faculty contracts, has brought about considerable demand for more office space, more and new types of laboratory space, and much-needed renovations. The department's research is diverse and crosses many disciplines, making it possible for the research and education activities in CEE to form a focal point of sustainability research at MIT. A sample of research highlights appears below.

- **Hidden risk in supply chains**: A new study by CEE professor David Simchi-Levi helps explain why risk in a complex supply-chain network often remains hidden. There is no correlation between the total amount a manufacturer spends

with a supplier and the loss in profits that the manufacturer would incur if that supply were suddenly interrupted. This counterintuitive finding defies a basic business tenet that assigns the greatest supply-chain risk to so-called strategic suppliers, with whom manufacturers often spend the most, and overlooks the risk associated with other suppliers. When applied to Ford Motor Company's supply chain, the quantitative analysis shows that the supply firms whose disruption would inflict the greatest blow to Ford's profits are those that provide the manufacturer with relatively low-cost components.

- **Homing in on stressed coral:** Coral reefs, the most biodiverse ecosystems in the world's oceans, are declining because of bleaching and disease. Little is known about the microscale interactions between pathogens that cause disease and weakened corals. Professor Roman Stocker, postdoctoral researcher Melissa Garren, and graduate student Kwangmin Son have identified one mechanism by which pathogenic bacteria identify their prey: Stressed corals produce up to five times more of a sulfurous compound called dimethylsulphoniopropionate (DMSP). Abundant DMSP appears to incite the pathogens' cells, which sense the amplified chemical and charge in to attack, changing their swimming direction and speed as they home in on the weakened corals.
- **Understanding the strength of a mussel's underwater attachments could enable better glues and biomedical interfaces:** Unlike barnacles, which cement themselves tightly to surfaces, the bivalves called mussels dangle more loosely, attached by a collection of fine filaments known as byssus threads. This approach lets the creatures drift further out into the water, where they can absorb nutrients. Despite the outwardly thin and fragile appearance of these threads, it turns out that in the dynamic, sloshing environment of waves and currents they can withstand impact forces that are nine times greater than the forces exerted by stretching in only one direction. The secret to these tiny natural bungee cords has been unraveled by CEE's research scientist Zhao Qin and professor Markus Buehler.
- **Controlling contagion by restricting mobility:** In an epidemic or a bioterrorist attack, the response of government officials could range from a drastic restriction of citizens' mobility to simple suggestions that people remain at home. A new study by professor Ruben Juanes, graduate student Christos Nicolaides, and research associate Luis Cueto-Felgueroso shows that even moderate measures of mobility restriction would be effective in controlling contagion in densely populated areas with highly interconnected road and transit networks. The researchers called the difference between infection rates in the two scenarios the "price of anarchy," a concept from game theory that is frequently used as a metric in studies of transportation networks.
- **Malaria transmission in Africa in a changing climate:** Wide variation in rainfall predictions for sub-Saharan Africa and lack of a malaria-transmission model that adequately describes the effects of local rainfall on mosquitoes makes it difficult to predict the spread of malaria. A new study by professor Elfatih Eltahir and graduate student Teresa Yamana solves this problem by combining a model of malaria transmission with global forecasts for temperature and rainfall. They found that although the capacity for malaria transmission will change in some areas of West Africa, overall infection rates are not likely to increase.

- **How anthropogenic emissions interact with organic compounds emitted by trees:** Professor Jesse Kroll, postdoctoral researcher Eben Cross, and graduate student Jon Franklin are doing fieldwork this summer at a site in the Talladega National Forest in Alabama as part of the National Science Foundation's Southeast Atmosphere Study (SAS), an umbrella study comprising five projects undertaken by scientists from 30 research institutions. The goal of the SAS is to learn more about the processes that control biosphere-atmosphere interactions that affect regional climate and air quality in the southeastern United States, one of the few places in the world that has cooled during the last century. At the field site, Kroll's team is looking at the chemical reactions that take place between the molecules present in anthropogenic air pollution and the organic compounds emitted by trees.
- **Transforming troubles to technology:** Professor Pedro Reis transforms today's annoyances, such as cables kinking and columns buckling, into tomorrow's technology, according to the spring 2014 issue of Spectrum. By exploring the mechanics and physics underlying natural and manufactured structures, he identifies and predicts how thin objects deform, and uses that knowledge to solve other engineering problems. "The ultimate goal is to discover, understand, and harvest mechanical instabilities in soft mechanical structures," he says, "and then exploit those as novel functionalities over a wide range of length scales."
- **Ocean microbes display remarkable genetic diversity:** Professor Sallie (Penny) Chisholm and former postdoctoral associate Nadav Kashtan performed a cell-by-cell genomic analysis on a wild population of the marine microbe Prochlorococcus found to be living in a milliliter—less than a quarter teaspoon—of ocean water, and found hundreds of distinct genetic subpopulations. Each subpopulation is characterized by a set of core gene alleles linked to a few flexible genes—a combination the CEE scientists call the "genomic backbone"—that endows the subpopulation with a finely tuned suitability for a particular ecological niche.
- **Coughs and sneezes float farther than you think:** A study by professor Lydia Bourouiba and professor John Bush of the Department of Mathematics shows that coughs and sneezes have associated gas clouds that keep their potentially infectious droplets aloft over much greater distances than previously realized. The study finds that the smaller droplets that emerge in a cough or sneeze may travel five to 200 times further than they would if those droplets simply moved as groups of unconnected particles—which is what previous estimates had assumed. The tendency of these droplets to stay airborne, re-suspended by gas clouds, means that ventilation systems may be more prone to transmitting potentially infectious particles than had been suspected. With this in mind, architects and engineers may want to reexamine the design of workplaces and hospitals, or air circulation on airplanes, to reduce the chances of airborne pathogens being transmitted among people.
- **Benign design of materials now can avoid future problems:** Professor Philip Gschwend describes the "legacy of problems buried in our environment" that often arise as side effects of products—such as PCBs and catalytic converters—

that were designed to solve already existing problems. His research group has developed inexpensive sheets of polyethylene that can be placed in mud or water to soak up chemicals and measure their availability as they move through the environment. But the real answer, he says, is to prevent such problems in the first place by involving environmental chemists at the outset of materials and chemical design.

Development and Fundraising

The department has expanded its effort to increase opportunities for philanthropists to support faculty, students, groundbreaking research, innovative educational programs, and extracurricular student educational and research activities. CEE development officer Paul Hohenberger leads the resource development effort.

The development officer's role is to implement a strategy to increase outreach to alumni and potential supporters by developing collaborative relationships with the department head, the faculty, and MIT's central resource development office in the critically important work of supporting department fundraising initiatives. Over the 2013–2014 academic year, Paul Hohenberger engaged in significant planning to align the needs of the department with the strategies and initiatives of MIT's central resource development office.

On April 8, 2014, department head professor Markus Buehler presented his overview of the department's fundraising needs to more than 30 officers from MIT's central Office of Resource Development. The presentation was part of an effort to reach out to, and to educate, MIT's central resource development team about the department's fundraising priorities and strategic initiatives.

The department showed a steady increase in new gifts and pledges to support students and CEE educational initiatives, including a newly endowed fund from the estate of Col. David B. Powers, '26 CE. The purpose of the new fund is to support "faculty or students in the Institute's Department of Civil and Environmental Engineering."

Markus Buehler, CEE's department head, has been host to business, government, and alumni delegations from around the globe to discuss CEE's new vision and the latest developments in its research. CEE has also been represented across the nation, with resource development trips to Washington and California that included the active participation of the department head.

Personnel Information

Faculty Promotions and Leadership Appointments

- Markus Buehler was promoted to full professor and was appointed department head, effective July 1, 2013.
- Ruben Juanes was promoted to associate professor with tenure, effective July 1, 2013.

- Cynthia Barnhart was appointed MIT's chancellor in February 2014.
- Heidi Nepf was selected for the Donald and Martha Harleman Professorship, effective January 1, 2014, reflecting her significant stature and contributions to fluid mechanics. Her contributions include scholarly research in the area of environmental fluid mechanics, with a focus on shallow aquatic systems such as lakes, rivers, wetlands, and coastal waters, emphasizing experimental analysis in both the laboratory and the field. She has also served as chair of the Graduate Committee, as a graduate officer, on the MacVicar Fellowship Selection Committee, and in many more capacities. The Donald and Martha Harleman Professorship was established in honor of Don's and Martha's lifelong dedication to the Parsons Laboratory's research agenda and students.
- Pedro Reis was promoted to associate professor without tenure, effective July 1, 2014.
- Several faculty members in other departments were appointed to joint professorships with CEE, including Eric Alm (Biological Engineering), Mick Follows (Earth, Atmospheric, and Planetary Sciences), and Xuanhe Zhao (Mechanical Engineering). These appointments reflect CEE's strategic priority to connect across departments and to foster cross-cutting research and education.

Faculty Retirements

- Professor Ole Madsen retired on January 15, 2014.

Faculty Awards

- The faculty in CEE have received numerous significant awards, reflecting the excellence of their work and its impact within and beyond MIT. The government of Catalonia, an autonomous community in Spain, announced that Sallie (Penny) Chisholm has been selected to receive the Ramon Margalef Prize in ecology. The prize, named for a distinguished Catalonian scientist and founding father of modern ecology, is one of the most prestigious scientific awards dedicated exclusively to ecological and environmental sciences. Chisholm, the Lee and Geraldine Martin Professor of Environmental Studies in the Department of Civil and Environmental Engineering and the Department of Biology, will receive the $100,000 prize from Artur Mas, president of Catalonia, at a ceremony in Barcelona in October 2014.
- Pedro Reis was named to Popular Science's Brilliant 10 list of young stars in science and technology. Reis studies the mechanics of slender structures, with a particular focus on devising new ways of turning mechanical failure into functionality.
- Sallie (Penny) Chisholm was the 2014 recipient of MIT's highest honor for full-time faculty members, the James R. Killian Jr. Faculty Achievement Award, in recognition of her extraordinary professional accomplishments. Chisholm has been widely recognized for her groundbreaking work on photosynthetic

organisms in the ocean. As stated in the Killian Award's citation, "This discovery—a microorganism with global impact—is symbolic of Professor Chisholm's career."

- Jesse Kroll (who holds a joint appointment with Chemical Engineering) was awarded the Macelwane Medal by the American Geophysical Union at its annual meeting in December 2013. The Macelwane Medal is awarded each year to young scientists for significant contributions to the geophysical sciences. Kroll's research focuses on experimental studies of the properties and chemical transformations of organic molecules in Earth's atmosphere that are emitted by both anthropogenic activities and biogenic processes.
- John Ochsendorf, Class of 1942 Professor of Architecture and professor of Civil and Environmental Engineering, was named a MacVicar Faculty Fellow in recognition of his exceptional undergraduate teaching, educational innovations, and mentoring.
- Professor Carolina Osorio was awarded the 100 Colombians Award by the Fusionarte Association of Colombia. She was honored for her work using operations research techniques to improve the design and operation of transportation systems.
- The National Science Foundation has given its most prestigious award for young researchers, the 2014 Early Career Award, to professors Carolina Osorio and Pedro Reis.
- Professor Joseph Sussman was presented with the Transportation Research Forum's Distinguished Researcher Award, which recognizes individuals with distinguished careers as research scholars in transportation. For more than 40 years, Sussman has been a leader in various fields of transportation research; he has been especially effective in building long-term collaborative research and education programs with both public and private support.
- The American Society of Civil Engineers awarded the Karl Emil Hilgard Hydraulic Prize to a paper, "Dynamics of Particle Clouds in Ambient Currents with Application to Open-Water Sediment Disposal," by James Gensheimer SM '10, senior lecturer Eric Adams, and Adrian Law (a professor at Nanyang Technological University).
- A stunning image by professor Roman Stocker, postdoctoral researcher Vicente Fernandez, and former postdoctoral researcher Orr Shapiro that reveals the path of water flowing around coral won the photography category of the 2013 International Science and Engineering Visualization Challenge. The picture appeared on the cover of Science on February 7, 2014.
- Senior lecturer and senior research associate John Germaine has been elected chairman of ASTM International's Committee D18 on Soil and Rock, beginning January 1, 2014. Previously he had been chair of Committee D18's Subcommittee D18.26 on Hydraulic Fracturing.

Student Awards and Recognition

- Billy Ndengeyingoma was elected vice president of the MIT Undergraduate Association in March 2014.
- Izunna Okonkwo, a sophomore in 1.00 Introduction to Computation and Engineering Problem Solving, received the $5,000 Creative Breakthrough Prize in the Data Science Challenge in May. Sponsored by Accenture and the MIT Alliance in Business Analytics, which is headed by professor David Simchi-Levi, the competition asked contestants to analyze and visualize large data sets from Chicago to try to improve life in the city.
- Marisa Fryer, a junior with a minor in literature, was named a 2014 Burchard Scholar. The award recognizes 31 sophomores and juniors who have demonstrated academic excellence in the humanities, arts, and social sciences, as well as in science and engineering.
- Khalid Jawed, a member of professor Pedro Reis's research group, won the Best Student Speaker Award given by the Group on Statistical and Nonlinear Physics at the March meeting of the American Physical Society. Jawed spoke on "Coiling Rods Onto Moving Substrates."
- In March, Philip William Kreycik G led an MIT team that won a Best Proposal award in the US Department of Energy's Better Buildings Challenge for "Experimenting with Efficiency: Greening the Grant Process for Research Institutions."
- *MIT News* published a profile story about graduate student Leon Dimas and the outreach organization he co-founded, MITxplore, on May 28, 2014. The organization had held a Math Treasure Hunt on the MIT campus earlier in May.
- Senior Sid Pai has won the $10,000 first place award of the MIT Ideas Global Challenge for his company Protoprint, which is a social enterprise based in India that empowers urban waste pickers with the technology to convert waste plastic into 3-D objects.
- Graduate student Zhandos Orazalin won the Geotechnical Master Thesis Competition sponsored by Plaxis and presented his work at the European Plaxis Users Meeting in Karlsruhe, Germany, in November 2013. Orazalin's presentation, "3D Finite Element Analysis of the Stata Center Excavation," simulated ground deformations, pore pressures, and diaphragm-wall deflections at the building site of MIT's Stata Center. The presentation is based on his master's thesis and research under professor Andrew Whittle.
- Transportation students Krishna Kumar Selvam (who works with professor Carolina Osorio) and Setareh Borjian (who works with chancellor Cynthia Barnhart and professor Patrick Jaillet) were jointly awarded the second-place prize in the recent Institute for Operations Research and the Management Sciences (INFORMS) Railway Applications Section Competition.
- Doctoral student Anna Tarakanova has won a poster award at the Gordon Conference for "Elastic Network Model of Tropoelastin Implicates Bridge Region in Assembly and Cell-Binding." Tarakanov works in professor Markus Buehler's laboratory.

- Graduate student Yingxiang Yang won best paper award at the second ACM SIGKDD International Workshop on Urban Computing (UrbComp 2013). Yang, a member of professor Marta González's research group, shared the best paper award with graduate students Gaston Fiore of the Department of Aeronautics and Astronautics and Shan Jiang of the Department of Urban Studies and Planning.
- Two graduate students, Linsen Chong and Franco Chingcuanco, both in professor Carolina Osorio's research group, have each been awarded a 2013 Dwight David Eisenhower Graduate Fellowship. The Eisenhower Fellowship is a competitive fellowship administered by the Federal Highway Administration for the US Department of Transportation.
- Lorna Ogolla Omondi '12 won a Gates Cambridge Scholarship to pursue an MPhil in management science and operations at the University of Cambridge. After completing this program, she will go to Stanford University for a master's degree in management science and engineering in financial analytics. Since graduating from MIT, Omondi has worked as an energy analyst at Charles River Associates and Greylock McKinnon Associates. Her long-term goal is to return home to Kenya and hold a position where she can have an impact on public policy and the regulation of energy markets.
- Urban transportation expertise gave professor Marta Gonzalez's Human Mobility and Networks (HuMNet) Laboratory an edge in the MIT Big Data Challenge. When the MIT Big Data Challenge asked, "What can you learn from data about 2.3 million taxi rides?", graduate students in HuMNet had some answers. The students were able to predict the number of taxi pickups that had occurred in 700 time intervals at 36 locations in the Boston area, thus winning the competition. González and the students in her HuMNet Lab use statistical physics and network theory on massive passive data generated by cellphones and other networked systems to identify relevant patterns and make inferences about human mobility and other aspects of city science.
- The MIT chapter of the civil engineering honor society, Chi Epsilon, welcomed eight new members at its banquet, held Monday, May 5, at the Kendall Hotel. The CEE students joining the honor society are seniors Derek Chang, Sidhant Pai, Priscilla Soto, and Katherine Spies, and juniors Michelle Dutt, Noor Khouri, Shante Stowell, and Ashley Wheeler.
- Sharone Small was elected to Phi Beta Kappa, the nation's oldest honor society.

Staff Awards

The CEE administration strives to cultivate a community of caring as well as of excellence for all employees. Below are examples of how CEE employees and staff are contributing to MIT and the community at large and achieving recognition for their excellence.

- CEE personnel administrator Borislava Stoyanova won an MIT Infinite Mile Award for Excellence from the School of Engineering. The award recognizes staff members who stand out because of their high level of commitment and because of the enormous energy and enthusiasm they bring to their work.

- CEE personnel administrator Borislava Stoyanova also received the MIT Laya Wiesner Community Award, established as a memorial to the wife of the late MIT President Jerome Wiesner. The award celebrates a member or friend of the MIT community for conspicuously effective service that reflects the concern Laya held for enhancing life at the Institute. In addition to her work with CEE, Stoyanova plays an active role in the MIT community.
- Administrative assistant Sharon Lacey received an Arts at MIT grant to fund the creation of a new series of paintings. For this project, "Psychomachia," Lacey will use a manuscript painting technique called tinted drawing to produce a series of figurative works on full-size sheets of calfskin vellum. The completed paintings will be backlit to capitalize on the translucency of the materials and to emphasize ideas related to inner luminosity that are explored in the works. The project is related to Lacey's research at the University of London in medieval painting techniques, early workshop practice, and theories of light and optics among early philosophers.

Staff Retirements

- Patricia Dixon retired in February 2014 after 40 years of service to MIT. The department celebrated her many years of service with an event in May.
- George Kocur, a lecturer and longstanding contributor to the educational initiatives, retired in May 2014.

CEE Annual Departmental Awards: Faculty, Staff and Students

This past year, CEE added several new awards to stimulate the local community to identify and further excellence within the department.

- The CEE Leadership Award was established to recognize an undergraduate student, at any level, who has made exemplary contributions to improve the CEE community, has fostered excellence and diversity, and has contributed to CEE's culture of inclusiveness. This year's recipient was Catherine Chang for her leadership as the Chi Epsilon president, her extraordinary dedication to the well-being of the department, and her significant efforts to improving the CEE community, such as her work in establishing the student lounge in Building 1.
- Another new award was the CEE Excellence Award for Staff. This award recognizes a member of the CEE staff for excellent contributions to the community, including commitment to professionalism, dedication, and best practices, as well as fostering a culture of diversity, inclusiveness, and innovation. This award is expected to acknowledge the work of support, administrative, and service staff; it is not intended to recognize research or teaching. The establishment of the award met with such an overwhelming response from the community that the department decided to recognize two recipients, Kris Kipp and Steve Rudolph, for outstanding performance. Kris Kipp

is the academic administrator and Steve Rudolph is CEE's technical instructor and laboratory technician. Both recipients are extremely involved with students and this award is a great testament to their efforts and to the benefits reaped by our students.

- The Maseeh Excellence Award in teaching was awarded to professor Carolina Osorio-Pizano for her exemplary contributions to our undergraduate program (1.041) and our graduate program (1.200). The students praise her for her "exceptional teaching style" and her "well-organized lectures." One student wrote: "I like the way she explains concepts to make them sound so much easier!"
- The Maseeh Award for Excellence as a Teaching Assistant went to Steve Morgan for exceptional contributions as a teaching assistant in 1.013 Senior Civil and Environmental Engineering Design, and 1.101 Introduction to Civil and Environmental Engineering Design, as was evidenced by faculty and student testimonials.
- The Trond Kaalstad (Class of 1957) Fellowship was awarded to Despina Maria Zymnis, who is passionate about the department and has contributed significantly to improving the academic and extracurricular environment. She established the Civil and Environmental Engineering Student Association mentoring project (linking graduate and undergraduate students), and displayed exceptional leadership in Gradcom, the student committee that organized the Friday gatherings in the Pierce Laboratory and the "Coffee & Donuts" meetings between the department head and graduate students. This award recognizes an outstanding graduate student who has displayed leadership and/or contributed significantly to the well being of the CEE community.
- The Leo (Class of 1924) and Mary Grossman Award is given in honor of Leo Grossman, who had a professional career in highway design and planning. The Grossman Award is given to an undergraduate student with a strong interest in transportation and a strong academic record. David Ogutu, a double major in Course 1 and Course 6, and the main architect and principal developer of the cyber-physical systems testbed, Joining Analytics-based Units for Network Trustworthiness (JAUNT), was an obvious choice for this award. In the JAUNT project, David combined his skills in software development and data analytics to design an automated computational platform. He has demonstrated a great work ethic and tremendous intellectual potential. David is unique. He has acquired core CEE fundamentals and also has a deep interest in applying theory and system-building approaches from Electrical Engineering and Computer Science to the design of computational tools for operations management of large-scale infrastructures.
- Paula Gonzalez received this year's Paul L. Busch (1958) Prize, which goes to an undergraduate in environmental science and engineering for academic achievement and contributions to the CEE community. Paula's contributions to and leadership in the design and implementation of the air quality network as part of the senior capstone project, as well as her other contributions to the CEE community, made her a great candidate for this award.

- The Tucker-Voss Award was established in memory of professors Ross F. Tucker and Walter C. Voss, who were the first two heads of the Department of Building Construction, Course 17. In the 1950s, Course 17 merged with the Department of Civil Engineering and the first Tucker-Voss Award was presented. This award is given annually to an undergraduate or graduate student who shows particular promise in the field of building. This year's recipient, Linda Seymour, has demonstrated exceptional abilities in her work as a student in the Undergraduate Research Opportunities Program and as an intern at the Smithsonian Institute, in public science outreach, and as vice president of CEESA. She has also been a member of the Steel Bridge Team.
- Senior lecturer George Kocur received the CEE Distinguished Achievement and Recognition Award for exceptional contributions to academic and research programs.

Markus J. Buehler
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