Civil and Environmental Engineering

In the Department of Civil and Environmental Engineering (CEE), we use cutting-edge science and engineering to maintain a strong focus on fundamental issues related to infrastructure and the environment. CEE strives to make an impact on the world by conducting research that begins with a fundamental understanding at the micro level, knowledge needed to achieve solutions to benefit society at the macro scale. We work daily, in and out of the classroom, to expose our students to small-scale change that translates into large-scale global impacts.

The department continued to grow during academic year 2018, with noteworthy accomplishments displayed through our groundbreaking research, newly launched educational programs, and local, regional, and global gains in recognition. Through new faculty hires, we continue to enrich our leadership in the fields of infrastructure and the environment. Our new faculty complement our current faculty roster with the cross-disciplinary talents, experiences, and skills necessary to redefine and push the boundaries of civil and environmental engineering in the 21st century.

Our students seek to rework traditional problems and discover unconventional solutions that include new approaches to and insights on existing challenges. Whether students are in the classroom, out in the field, or in the labs, they are at the center of everything we do in the department. Through scaling and innovating from the nano to the global level, our students are always focusing on improving human lives and conditions, anywhere in the world. We believe that the department's research and education will shape lives today and, in the decades, to come and that these opportunities and lessons will live on through the efforts of our alumni.

In AY2018 we made efforts to further reach and interact with the MIT undergraduate student population. These efforts included increased outreach to potential students through events, posters, email campaigns, new events, symposiums, and other initiatives such as the CEE blog.

Our highly integrated department works to solve previously unsolvable big engineering and scientific challenges. During AY2017, we launched our new department website to reflect this vision, and we have made continuous efforts throughout 2018 to enhance the site and make the content accessible and appealing to all members of the community. At CEE, we are dedicated to creating an inclusive and diverse community. We appreciate and welcome a community that comes from various backgrounds and holds diverse opinions.

In 2017, the CEE Executive Council created the CEE Faculty Statement on Student Well-Being, Diversity and Inclusion, which reads as follows:

- CEE is a community of people united in our pursuit of intellectual, creative, and technical excellence, to make a better world. We care about the mental and physical health of our students, faculty, and staff of any age and background as a human priority before the nature or progress of their work.

- We value diversity in and inclusion of our students, post-docs, faculty, and staff and appreciate their backgrounds and opinions. We believe that diversity in its many dimensions is critical for our Department to achieve its mission in education, research, and to best serve the nation and the world.
- We pledge to better approach the goals stated in MIT's 2004 pledge to increase diversity, as well as the recommendations of the 2010 report on Faculty and Diversity.
- We remain committed to MIT's goals of increasing the percentage of faculty, postdocs, and students from under-represented groups and to continuing to diversify our Department and the Civil and Environmental Engineering field more broadly.

In 2017–2018, the Academic Programs Office (APO) and Communications teams worked together to create cohesive marketing campaigns across print and digital mediums that align with the imagery and aesthetic of the CEE website. In addition to advertisements for events, new subject offerings, and for the department, we increased our social media presence across various platforms. APO and Communications continued a series of recurring email marketing campaigns, targeting MIT freshmen with specific outreach and events designed to strengthen interaction, engagement, and understanding of our goals and mission.

The effects of the new and improved CEE have become evident across several strategic research areas. For instance, faculty in the Ralph M. Parsons Laboratory for Environmental Science and Engineering have expanded our understanding of complex atmospheric and ocean ecological systems, providing strong insight into these dynamic ecosystems. Researchers in the Henry L. Pierce Laboratory for Infrastructure Science and Engineering have contributed to groundbreaking methods and are actively designing impressively strong materials that will forever alter the landscape of civilizations, creating more sustainability and eco-friendliness. In addition, CEE has continued to offer fieldwork opportunities to undergraduate students.

Our cross-disciplinary research culture also links seemingly disparate projects, such as Professor Benedetto Marelli's application of silk fibers to preserve fresh fruit and other research focusing on optimal mechanical devices to effectively coat the fruit. A community working across boundaries toward broad-scale solutions is an effective way to continue innovating and keep up with the pace of civilization's immediate and emerging needs.

Realizing a new, broadly empowered vision and a redefined civil and environmental engineering profession continues to require extraordinary efforts. As educators, our role requires that we anticipate these shifts and give students more in-depth learning experiences so that they have a well-rounded and solid foundation. This commitment is reflected in the core mission of the department to educate at all levels, from undergraduate to postdoctoral.

Our newly developed and continually evolving Course 1 undergraduate program, established in 2014, integrates civil, environmental, and systems engineering into a single program. The program features increased flexibility, allowing students to fulfill Institute and department requirements while encouraging personalization of tracks that best match career interests.

In 2017–2018, the department has made great strides towards highlighting the diverse field of civil and environmental engineering. The Undergraduate Education Committee put together new roadmaps to demonstrate subject paths to complete a degree in each CEE core (environment, mechanics and materials, and systems) while satisfying the minor requirements in departments such as Electrical Engineering, Computer Science, and Architecture.

The Academic Programs Office collaborated with the Undergraduate Education Committee, the CEE Student Association (CEESA), and CEE Communications to promote and publicize the 1-ENG undergraduate program through various channels including posters and email campaigns, student blog posts, career-oriented brochures, and social media campaigns. The department continues to provide the three minors introduced in fall 2016: civil engineering, environmental engineering science, and civil and environmental systems.

In spring 2017, the National Academy of Engineering (NAE) Grand Challenges Scholars Program (GCSP) at MIT was approved. The impetus in creating the program was to easily connect scholars with resources that will help them assemble their undergraduate portfolio in order to address the five main calls outlined by NAE: research, an interdisciplinary curriculum, entrepreneurship, global dimension, and service learning. In fall 2017, a steering committee reviewed the NAE proposal to determine whether GCSP would be a good fit for MIT. The committee members are as follows:

Ali Jadbabaie (chair; CEE/Institute for Data, Systems, and Society)

Herbert Einstein (CEE)

Ruben Juanes (CEE)

Dennis McLaughlin (CEE)

Sanjay Sarma (Open Learning and Department of Mechanical Engineering)

Andrew Whittle (CEE)

Heidi Nepf (CEE)

Vladimir Bulovic (Department of Electrical Engineering and Computer Science)

Elazer Edelman (Institute for Medical Engineering and Science [IMES])

Wesley Harris (Department of Aeronautics and Astronautics)

Caroline Ross (Department of Materials Science and Engineering [DMSE])

Babi Mitra (New Engineering Education Transformation [NEET])

The committee met monthly throughout the fall term to review the proposal and offer recommendations for the implementation of a program at MIT. However, some of the complexities of the program have raised questions for the committee that need to be resolved, and the roll-out of this program is currently under review by the School of Engineering dean's office. Professor Anette Hosoi is working with the NAE members of the committee to determine whether there is a willingness among faculty leadership to implement this initiative.

Selected department highlights from the past year include the following.

- Over the past year, the department hosted the New Research Reception (replacing the New Research Alumni Breakfast), the second CEE Rising Stars Workshop, the "Course 1 Carnival," the fifth annual CEE Video Competition, and CEE Research Night.
- On May 17, the department hosted the Senior Celebration and Awards Banquet, where members of the CEE community gathered together to celebrate the class of 2018 and to recognize the outstanding accomplishments of the past year. CEE department head and McAfee Professor of Engineering Markus Buehler announced the winners of the CEE awards, including student, faculty, researcher, and staff awards. "The Senior Celebration and Awards Banquet is one of my favorite events of the year because we get to recognize the outstanding members of our community who make CEE so vibrant and inviting," says Buehler. "It's a really special time because we also get to celebrate the accomplishments of the Class of 2018 and their contributions to MIT and the department over the past four years."
- Heightened exposure through various CEE social media channels—LinkedIn, Facebook, Instagram, YouTube, and the @MIT_CEE handle on Twitter—is enabling greater dialogue and engagement with many audiences, especially current and prospective students. The department head has his own Twitter handle (@ProfBuehlerMIT) and uses his tweets as an innovative way to communicate with students, faculty, alumni, and other stakeholders. More details about our social media channels are provided below.

Goals, Objectives, Priorities

The Civil and Environmental Engineering Department has made great strides this past year toward realizing the full potential of a more integrated and enhanced program. It is experiencing a transformation similar to the major disruptions of the 1960s and 1980s when the introduction of computation, and then environmental science, genomics, and microbiology, influenced its direction. However, now the influences are around the Earth and its atmosphere, agriculture, and building sustainable cities.

Our students continue to change the world. From alumni entrepreneurs desalinating ocean waters to engineers designing more resilient, sustainable, and energy-efficient cities, MIT is redefining what it means to work in this increasingly comprehensive field. Other institutions may continue to teach practitioners while we prepare new generations of global thinkers and doers. Working together across disciplines and educational and experience levels, our students, faculty, and researchers address the many questions and challenges civilization faces today.

As engineers, we continue to build, but our direction is now better informed by discovery and innovation at small nano levels. Data characterization, modeling, and analysis also have lent new insights to our work, allowing design experimentation to be accomplished in hours compared to what would have previously taken days, weeks, or months. New tools and instruments, such as high-powered Raman spectroscopy, along

with renovated and newly created lab spaces increase our capacities. Collaboration with other scientific and engineering disciplines brings its own rich set of rewards, allowing many types of new research paradigms and relationships.

CEE's five strategic objectives remain the same as we continue our important work and build upon past accomplishments. This report articulates our advancements during AY2018 with respect to each objective.

- Objective 1: renew, develop, and implement inspiring educational programs at the undergraduate and graduate levels, including the postdoctoral level
- Objective 2: establish an effective departmental structure
- Objective 3: focus on the future of CEE with accelerated faculty hiring and junior faculty development
- Objective 4: show leadership in MIT-wide initiatives through engagement across the Institute, defining a clear positioning of CEE at MIT
- Objective 5: enhance alumni engagement and resource development

The visiting committee continued to support the department's vision and activities under the leadership of Markus Buehler. It was recognized that the department is energized and fast moving and that the execution of its vision is a work in progress.

Objective 1

Over the past academic year, 225 students were enrolled in CEE (42 undergraduates and 183 graduate students). The graduate student population includes students in the Interdepartmental Program in Transportation as well as dual-degree students in our Leaders for Global Operations program who are jointly registered with the Sloan School of Management.

CEE awarded 17 PhD, 15 SM, 14 MST, and 16 MEng degrees in the graduate program and 12 SB degrees in the undergraduate program. Of the 17 PhD graduates, approximately two thirds are proceeding to careers in academia.

Undergraduate Programs

AY2018 saw the fourth full-year cohort of students in the department's new 1-ENG ABET-accredited bachelor of science degree program. The new undergraduate program is a comprehensive curriculum that better prepares graduates for their professional lives while emphasizing a strong foundation in math, computation, probability and statistics, data analysis, and design.

The department was reviewed by ABET in 2016–2017, and the positive accreditation outcome was communicated to the CEE community in September 2017. The new accreditation was well received and is a tremendous opportunity for CEE students to further their careers. When reviewing academic programs, the ABET Engineering Accreditation Commission takes into consideration curriculum and subject offerings, student outcomes, educational objectives, and signs of continuous improvement.

The Undergraduate Education Committee (UEC), led by Professor Colette Heald and made up of two faculty from each CEE core, made significant strides in AY2018, working to add new subjects, improving the undergraduate curriculum, and creating new administrative policies and processes for the development and evolution of subjects. The committee also developed new policies to assess undergraduate students' degree progress (now documented in our advising guide) and worked with APO to optimize the subject schedule as a means of minimizing teaching conflicts with general departmental requirements and core subjects. In addition, the committee worked with APO to create new undergraduate brochures and guides to help better define career paths for our undergraduate students.

CEE became involved in the Institute-wide New Engineering Education Transformation (NEET) initiative during the past year. CEE's faculty developed NEET tracks that aim to recruit new students to the department through project-centered learning. Also, faculty submitted several proposals over AY2018 for the NEET committee to consider. One of the CEE proposals (low carbon energy) was selected. A collaboration of Course 1 with Courses 22 and 2, the low carbon energy NEET thread introduces students to the rapidly developing and increasingly vital field of energy production and distribution without generation of greenhouse gases.

The 1-ENG program prepares students for today's jobs as well as emerging new positions such as chief resilience officer, 3D infrastructure engineer, urban agriculturist, and global system architect. Class discussions in 1.007 Big Engineering: Small Solutions with a Big Impact showed that students studying civil engineering leaned toward careers in innovating structures, architectural design, material testing, promoting net-zero energy buildings, sustainable infrastructure, and geo-technology. Environmental engineering students expressed interest in exploring bio-remediation, atmospheric modeling, hydrology modeling, pollution control, enhancing food security, and mitigating climate changes. Finally, systems engineering cohorts gravitated toward applications in biological networks, traffic and transportation engineering, carbon sequestration, city planning, and mitigating infectious diseases.

To provide students with more accessible opportunities to advance their careers, the department launched an internship program in spring 2018 that utilizes connections with CEE alumni in industry to provide high-level internships for students. The Academic Programs Office also works to maintain an alumni mentor network to connect current students with meaningful mentorship experiences. During the year, APO met with 14 students regarding internships and the summer Undergraduate Research Opportunities Program (UROP). Students were placed in prominent companies such as AECOM, Skanska, Opti, and Transurban.

Professor Admir Masic was excited to lead the third annualONE-MA^3 (Materials in Art, Archaeology and Architecture) fieldwork experience, in which undergraduates learn first-hand about the sustainability of art, archeology, and architecture over time and against the threats of nature. The program, held in Italy in June and July 2018, involved 15 undergraduate students who will continue their research through the 1.057 Heritage Science and Technology subject. The students traveled to Sermoneta, Pompeii, and Turin for this unique in-field, hands-on opportunity to research the complexities of long-term preservation strategies and techniques. Students were granted exclusive access to private

research laboratories in the Vatican and were able to visit areas of Pompeii that are closed to the public.

Professor Otto Cordero led his first annual agricultural microbiology fieldwork subject in Israel over Individual Activities Period (IAP). This three-week experience allows students to learn state-of-the-art techniques used in the cultivation and analysis of the microbial communities that digest complex plant fibers in the cow rumen. These microbial communities, which live in symbiosis with their hosts, are unique in their ability to transform recalcitrant plant material into energy and as such have tremendous biotechnological potential.

The CEE Student Association's new leadership continued to work constructively with APO and the department's leadership. The CEESA president meets regularly during the academic year with the Academic Programs Office to discuss upcoming events, provide feedback on the undergraduate curriculum and printed materials, and serve as a voice for the undergraduate student body.

CEESA hosts numerous events throughout the year, including game nights, a career fair, study sessions, and monthly faculty luncheons. The faculty luncheons, at which undergraduate students are invited to have lunch with a CEE faculty member, are a great way for students to get to know the faculty on a more personal level and gain exposure to areas of research they may not have otherwise considered.

During AY2018, the senior capstone class (1.013 Senior Civil and Environmental Engineering Design) focused on diverse research projects supported by multiple CEE faculty. Students enrolled in the class were invited to present their research to members of the community at the CEE Senior Celebration and Awards Banquet through an electronic poster session. Faculty in attendance heard from the students, voted on the poster presentations, and awarded first-, second-, and third-place Capstone Poster Prizes. Jillian Dressler won the first-place prize for her research focused on machine learning with Massachusetts Department of Transportation traffic cameras, Clio Macrakis won second place for her work on metamodel traffic calibration, and Mikayla Murphy won third place for her research on the evolution of the bacterial genome.

Building on the success of last year's unique mini-UROP, the department again hosted 20 freshmen during the 2018 IAP. In the program, spearheaded by Course 1 graduate students, graduate students and postdocs are paired individually with first-year students, and the mini-UROP students work at least 30 hours per week in direct research over IAP. As a result of their interest and progress in their projects, a number of the participants continued as full UROP students during the spring term.

As the program has grown, the organizers have realized that there are opportunities to extend program benefits to include not only course credits but also community building. New projects have been added to build the students' hard science and engineering skills, and other activities are now included to develop soft skills such as collaboration and networking and help improve students' mentoring skills. In addition, the Academic Programs Office hosts weekly luncheons to give freshmen a glimpse of the department's wide variety of research topics and opportunities.

The department is offering three undergraduate minors (civil engineering, environmental engineering science, and civil and environmental systems) that debuted in fall 2016. The minors are intended to attract MIT students who are majoring in disciplines outside civil and environmental engineering but want to enhance their career path with complementary knowledge and experience. CEE also endorsed and participates in the environment and sustainability minor offered by the MIT Environmental Solutions Initiative.

Graduate Programs

CEE's graduate education programs also saw changes, improvements, and several new activities over the past year. For example, new ways to support graduate student and doctoral candidate initiatives were introduced, including increased departmental sponsorships of events and activities. Also, staff and faculty volunteered to serve as judges at competitions.

As mentioned above, the successful reprisal and enhancement of the mini-UROP program held over IAP would not have been possible without the leadership of the graduate students who set up the program with the assistance of the CEE APO administrators.

AY2018 also saw the introduction of a new graduate subject. Professor Dara Entekhabi launched 12.834 Land-Atmosphere Interactions in the spring term, a subject focusing on the exchange of mass, heat, and momentum between the soil, vegetation, or water surface and the overlying atmosphere.

Our graduate committee (GradCom), along with other graduate students in the CEE community and CEE faculty and staff, worked closely together during this past year in developing stronger relationships with the department head and tapping mutual resources for improved program delivery and support.

Postdoctoral Program

CEE's postdoctoral committee has continued its path of success, providing a forum for discussion and involvement with the approximately 65 postdoctoral researchers in the department. The committee has made great progress in understanding and addressing the professional and career development needs of postdoctoral researchers, identifying and improving mentoring networks, providing the researchers with opportunities to contribute to the department's educational programs, and enhancing their MIT and CEE experience. In addition to workshops and seminars geared toward the specific needs of postdoctoral scholars, a CEE postdoctoral social committee has been formed to enhance opportunities for networking among faculty, postdoctoral scholars, graduate students, and staff. Professor John Williams serves as the postdoctoral committee chair. New this year, postdoctoral liaisons have been recruited to ensure that there is ongoing communication between the postdoctoral community and the department leadership.

Specific program activities included once-a-semester town halls with the department head, a series of "lunch and learns" on topics of interest to postdoctoral researchers (e.g., web presence, publishing, digital education, grant writing), and networking events for CEE postdoctoral researchers and faculty members with a focus on enhancing

mentoring networks beyond postdocs' immediate faculty supervisors. Also, teaching fellowships are available that allow postdoctoral researchers to be involved in teaching and education as part of their career development. On April 24, the department hosted CEE Research Night, an event at which a number of CEE postdocs and students had a chance to present their research via electronic posters. Featuring more than 30 posters, the night was filled with research presentations and networking. Attendees also helped determine the overall winners of the event.

Postdocs continue to contribute to CEE teaching activities through the postdoctoral teaching fellows program. This program has been very successful for postdocs, faculty, and students, and it continues to provide valuable training for our postdocs. We keep track of the career paths and feedback of exiting postdocs and continue to customize our offerings to the CEE postdoctoral community.

Objective 2

The administrative staff continues to evolve and engage with all communities, including current and prospective students, their parents, faculty, other MIT faculty and staff, external peers, alumni, and news media. We accomplish this outreach through speaking engagements, seminars, stories in print and online, and other activities. Additional accomplishments and events are listed elsewhere in this report.

The department strengthened the collaboration between its two laboratories, the Ralph M. Parsons Laboratory for Environmental Science and Engineering (Building 48) and the Henry L. Pierce Laboratory for Infrastructure Science and Engineering (Building 1). The Parsons Laboratory focuses on natural systems and on understanding and engineering human adaptation to a changing environment. The Pierce Laboratory engages in science and engineering research critical to improving living conditions for humankind, advancing the innovation of materials, transportation systems, cities, and energy resources. This increased interaction continues to bind the disparate locations and was apparent at many formal and informal gatherings throughout the year. Examples include CEE Research Night and the continuation of the CEE Band, an inclusive department-sponsored ensemble featuring students and researchers from both labs.

CEE continued to refine its strategic focus around five challenge areas: ecological systems, resources and sustainability, structures and design, societal systems, and global systems. Our research and education within and across these strategic objectives are imperative to help create a better world and improve lives.

MIT Context for the Role of Civil and Environmental Engineering

The department's intellectual focus is discovery and innovation to sustain life and society in changing conditions. CEE's two research labs, the Pierce Laboratory and the Parsons Laboratory, conduct research designed to better understand and solve the grand challenges of our time, from problems created by human activity to those that exist as natural systems. Our contributions are at the core of new products and applications that are being developed today in agriculture, wetlands management, renewable energy, sustainable structures, and large-scale systems design. The Department of Civil and Environmental Engineering is committed to playing a central role to support MIT's leadership in these domains.

Our long-term objective in the area of infrastructure, implemented in the Pierce Laboratory, is to become a center of excellence in the design, manufacturing, and operation of infrastructure. The Pierce Laboratory pushes the frontiers of infrastructure science and engineering by exploring fundamental issues critical to society and the environment. Through our faculty's diverse expertise and collaborations with others, CEE addresses such critical issues as infrastructure sustainability, resilience to catastrophic events, durability, and improved energy management.

The research at CEE is not limited to Earth. Assistant Professor Caitlin Mueller, postdoctoral fellow Valentina Sumini, and undergraduate student Zoe Lallas won an international competition focused on building sustainably on Mars for their urban design project, Redwood Forest.

Our long-term objective in the area of the environment, implemented in the Parsons Laboratory, is to engineer human adaptation to a changing environment. Human activities are affecting the global environment at historically high rates, and the impact of these changes on people and the environment is not known at present. Working from very small discoveries to large-scale solutions, researchers in the Parsons Laboratory aim to better understand global environmental changes in water, agriculture and food, species evolution and coexistence, environmental quality, natural hazards, and public health, among other areas.

In terms of advances made this year, Professor Heald, Associate Professor Jesse Kroll, and James Hunter PhD '15 (now a technical instructor in DMSE) published research that fills in significant gaps in the inventory of organic compounds in the atmosphere. The result of a large, collaborative field study (published in *Nature Geoscience*), the research identifies previously unknown organic compounds. Also, Donald and Martha Harleman Professor Heidi Nepf and a multidisciplinary team of MIT researchers created a solution for urban storm flooding: engineered green spaces. The researchers detailed their study in a report freely available to the public in hope that cities will utilize the approach.

Space Renovations

The department's efforts to improve laboratories and other departmental space over the past several years have been extraordinary. With our faculty renewal efforts come new faculty laboratories, and we have a constant flow of renovations including state-of-the-art laboratories and workspaces in both the Pierce Laboratory (Building 1) and Parsons Laboratory (Building 48). In addition to technical laboratory spaces, other spaces for computation, offices, and general teaching spaces are being renovated at a pace commensurate with the growing needs of CEE. Examples of laboratories and facilities that have been renovated include the following:

- Materials Mechanics Laboratory (Building 1)
- Plant Growth Facility (Building 48)
- Environmental Chemistry Laboratory (Building 48)
- Advanced Biopolymer Laboratory (Building 1)

- Fluid Dynamics of Disease Transmission Laboratory (Building 1)
- Atmospheric Chemistry and Composition Modeling Laboratory (Building 48)

Also, a new student lounge and a new space for the MEng program have been installed in Building 1, and renovations have been made to faculty and student offices.

The Fluid Dynamics of Disease Transmission Laboratory (a biological laboratory in the sublevel of Building 1), the Atmospheric Chemistry and Composition Modeling Laboratory in Building 48, and the Biopolymer Laboratory in Building 1 have all been built with ergonomic and state-of-the-art capabilities representative of the future-oriented thinking of the occupants.

The Marelli Biopolymer Laboratory continues to grow, and in response we have expanded the biological and fluids laboratory in the sublevel of Building 1, which now includes a plant growth chamber.

The newest members of our faculty include Dave Des Marais and Desiree Plata. Dave, who is working on environmental studies, brings opportunities to update spaces to facilitate his state-of-the-art growth chambers, adding to our expansive menu of technical abilities. Desiree also brings a modern spin by adding new and different gases and techniques to her field of environmental chemistry, pushing our labs to an operational level beyond what we could have imagined.

Office improvements for Tal Cohen, Ali Jadbabaie, and Serguei Saavedra are taking our building into the modern era with smart building technologies that are not just visually appealing but offer better functionality for today's professionals.

Each new space project, whether it involves a laboratory, computational space, multi-purpose space, or office, is thoughtfully designed to accommodate what is happening now as well as what could happen in the future, and this is truly exciting.

Objective 3

Using the momentum of the visiting committee recommendations, CEE embarked on aggressive faculty searches over the past three years. There was an unprecedentedly large pool of candidates and, as a result, the department was able to add three new faculty members during AY2018, including one with a dual appointment in IMES.

Our future success depends in large part on internalizing our new vision across our two research labs (Pierce and Parsons), developing our junior faculty, and attracting top new faculty. The following are associated highlights and accomplishments in these critical areas. Our strategic priorities also include fueling emerging frontiers of innovation and creative design and empowering our students and faculty to lead Institute-wide cross-cutting initiatives. Hiring excellent faculty is arguably the most critical component in supporting these activities.

The faculty search process has been changed to focus on several necessary criteria that differ from those of searches conducted in past years:

- Identify the highest-caliber candidates in compelling intellectual frontiers.
- Look for relevance to the vision and domains of CEE, especially those identified as critical needs.
- Build on CEE's strengths in areas where it can lead. Candidates should be dedicated to educating our students in such a way as to equip them to work as scholars and academic leaders, professionals, and entrepreneurs.
- Find candidates who support and are supported by intellectual communities.

New Faculty Hires

Dave Des Marais, Tami Lieberman, and Desiree Plata joined the faculty during AY2018.

Dave Des Marais joined the department as an assistant professor in October 2018. He received his BA in integrative biology from the University of California, Berkeley, in 2000, studying plant diversity and evolution, and a PhD in biology from Duke University. His dissertation addressed how multifunctional proteins evolve within and between species. Des Marais did postdoctoral research at the University of Texas at Austin, where he was awarded a fellowship from the US Department of Agriculture's National Institute of Food and Agriculture to investigate plant responses to environmental stresses. Most recently, he was a principal investigator (PI) in the Department of Organismic and Evolutionary Biology at Harvard and a senior fellow at the Arnold Arboretum. Des Marais's research interests are in plant ecophysiology, evolutionary biology, and functional genomics. He is particularly interested in plant interactions with the abiotic environment—water, temperature, nutrients, and light—and how plants respond when these factors impose stress. He studies natural diversity within and between plant species both in the field and in controlled environments, and he hopes to develop a mechanistic understanding of plant performance to conserve natural plant populations and improve agricultural productivity and sustainability.

Tami Lieberman joined the MIT faculty as the Hermann L.F. von Helmholtz Career Development Professor with dual appointments in CEE and IMES. Lieberman earned a BA in molecular biology and genetics at Northwestern University, where she was awarded a Barry M. Goldwater Scholarship. She earned a PhD in systems biology from Harvard, where she developed new genomic approaches for understanding how bacteria evolve during infections. Lieberman was previously a postdoc in Eric J. Alm's lab at MIT, where she further developed and applied genomic approaches to understand the microbes that colonize the human body. She will lead a computational and experimental research group focused on uncovering the principles governing colonization and personalization in the human microbiome. Lieberman has also made contributions to our understanding of antibiotic resistance, including the co-invention of a new platform for visualizing evolution in real time.

Desiree Plata will join the department as an assistant professor in July 2018. She earned her bachelor's degree in chemistry from Union College in 2003 and her PhD in chemical oceanography and environmental chemistry from the MIT/Woods Hole Joint

Program in Oceanography and Applied Ocean Science and Engineering in 2009. Plata was most recently the John J. Lee Assistant Professor of Chemical and Environmental Engineering at Yale University. Plata's work is in the area of environmental chemistry, with applications in minimizing the environmental impact of emerging industries. She has made fundamental contributions to the field of heterogeneous catalysis with respect to the bond-building mechanisms in carbon nanotube synthesis, which can be leveraged to lessen environmental impacts. Plata is a National Academy of Engineers Frontiers of Engineering Fellow and was recently recognized for excellence by the California Institute of Technology's Resnick Sustainability Institute.

Faculty Promotions

Colette Heald was promoted to full professor effective July 1, 2018. Heald is an atmospheric chemist who aims to understand the key chemical and physical processes that control the composition of the atmosphere and the impacts of gases and particles in the atmosphere, as well as the global-scale influences of the changing climate and biosphere.

Ruben Juanes was also promoted to full professor effective July 1. Juanes's research focuses on understanding and modeling the physical processes associated with multiphase flows in porous geological media.

In June 2018, Professor Jesse Kroll was appointed the new director of the Parsons Laboratory for Environmental Science and Engineering. Kroll is an associate professor and a world-leading atmospheric chemist whose research focuses on organic aerosol, colloidal suspension of particles dispersed in the atmosphere, and, especially, how these particles evolve over time under varying conditions. Professor Kroll is a dedicated teacher and mentor both inside and outside the classroom. He regularly teaches 1.84J, an introductory graduate-level atmospheric chemistry subject. At the undergraduate level, he has taught 1.107/1.080 Environmental Chemistry, and he has led the CEE 1.091/1.092 Traveling Research Environmental Experience (TREX) field subject for several years. As part of TREX, Jesse has worked with students to measure the air quality associated with a plume of volcanic smog downwind of the Kilauea volcano in Hawaii.

Faculty Professorships

Professor Tal Cohen was named the Robert N. Noyce Assistant Professor effective July 1, 2018. The Noyce chair, established in 1991, is an Institute-wide professorship presented in recognition of a faculty member's outstanding accomplishments and future promise. Cohen works in mechanics, especially the mechanics of structures subjected to extreme loading conditions and shock wave propagation. Her work on the mechanics of stretchable materials that can undergo extreme deformations up to loss of stability, and on the mechanics of growth in both biology and engineering, exploits analogies with related fields.

Faculty Deaths

Professor Joseph Sussman, an expert in complex engineering systems and revered mentor, died at 79. Professor Sussman retired in January 2017 after 50 years in CEE. He joined the Institute faculty in 1967 after earning a PhD in civil engineering systems at MIT. During his tenure as a faculty member, Sussman served as head of the Department

of Civil and Environmental Engineering and as director of the Center for Transportation Studies. In his research, where he applied a systems approach to transportation, he worked in rail freight transportation operations, intelligent transportation systems, regional strategic transportation planning, and passenger rail, emphasizing high-speed rail. In 1991, Sussman was named MIT's first JR East Professor and played an instrumental role in building a strong relationship between MIT and the East Japan Railway. A memorial was held on campus and attended by many.

Annual Research Event

After seven years of hosting the CEE Research Speed Dating event, the department decided to try a different approach—a more casual digital research poster event complete with networking on April 24. The change of format attracted over 30 different participants, and faculty, graduate and undergraduate students, postdocs, research scientists, and staff attended to learn about the research being conducted across the department. At the conclusion of the night, three top prizes, determined by students and faculty at the event, were awarded to graduate student Murat Uzun ("Learning Full-scale structures"), graduate student Jane Chui ("Impact of Motile Bacteria on Viscous Fingering"), and postdoc Diego Lopez Barreiro ("Multiscale Modeling and Manufacture of Biomass-derived Materials").

Cross-Disciplinary Seed Funding for New Faculty Research

In October 2017, the Department of Civil and Environmental Engineering awarded funds to two cross-disciplinary projects intended to promote collaboration between different domains. H.M. King Bhumibol Professor Dennis McLaughlin and Mitsui Chair Professor Serguei Saavedra were given funding toward their research examining the impact of resource allocation and community ecology on crop productivity and resilience. Tal Cohen and Otto X. Cordero were awarded funds for their research project that is seeking to determine the relationship between the physical and biological processes that underlie how biopolymers are consumed by bacteria.

In April 2018, the MIT Tata Center for Technology and Design announced funding for eight new projects for the 2018–2019 academic year. Nearly 70 proposals were submitted, and eight projects were designated to receive funding; a pair of CEE professors were among those whose projects were funded. Associate Professor Jesse Kroll received funding to conduct research on modeling and deployment strategies for low-cost air quality sensors in urban India. Kroll will work with Professors David Hsu (Department of Urban Studies and Planning) and Youssef Marzouk (Department of Aeronautics and Astronautics). Professor Colette Heald was awarded funding to further her research on understanding the sources contributing to the air pollution crisis in India.

Objective 4

Over the 2017–2018 year, the department invested in reinvigorating CEE's online presence. In fall 2016, CEE launched a new website that better aligned with the department's vision. During the past year, additional changes were made to improve the site, and efforts were made to maintain active social media platforms and curate a popular student blog initiative. The latter initiative invites current CEE undergraduate and graduate students

to write about their experiences in the department, including studies abroad, internships, and innovative classes. Online as well as offline, we are empowering the department to share new research and happenings and start new conversations.

CEE Communications and the Academic Programs Office collaborated to recruit undergraduate students to write about their experiences being a Course 1 major. The blogs share the undergraduate experience in a casual setting and encourage students to share how they use civil and environmental engineering principles around the world. Topics ranged from an inside look into a capstone project to a student's perspective on fieldwork experiences such as TREX and ONE-MA[3]. Through this new initiative, Communications and APO have strengthened their connection with undergraduate students.

These investments in CEE's online presence enhance our ability to connect with alumni, potential students, industry leaders, and news media outlets.

Social Media Outreach and Statistics

The following statistics reflect continued growth in awareness and engagement of CEE online. Note that the statistics do not include any staff or faculty online accounts. For example, Department Head Markus Buehler also has significant growth in followers of his professional LinkedIn and Twitter accounts.

Departmental Facebook Page

In June 2017, our Facebook page had 11,903 "likes" (people who subscribe to CEE posts). This increased in June 2018 by 5% to 12,444 page "likes."

Department Instagram Page

CEE has a strong presence on Instagram, a social media platform primarily used for sharing photos and videos. CEE had 1,122 followers in June 2017 and reached 1,340 followers in June 2018, a 19% increase. From 2016 to 2017, we averaged 74 "likes" per photo, and this rose during 2017–2018 to an average of 87 "likes" per photo, an 18% increase. CEE hosts two photo competitions, one in winter and one in summer, that encourage CEE community members to interact with the department and share their adventures using #CEESummer or #CEE_IAP with the chance to win prizes. The competitions are always well received and attract a vast number of submissions.

Twitter Activities

Between June 2016 and June 2017, we tweeted an average of 52 times a month. This increased by 8%, to an average of 56 tweets per month (not including retweets), in June 2018. In 2016–2017, we received an average of 231 "likes" per month on our tweets, a figure that increased by 9% in 2017–2018 to an average of 252. As of June 2017, we had 2,394 followers, and by June 2018 we had reached 3,300 followers (a 38% increase). We primarily share research news on Twitter, which means that the number of clicks our links receive is an important and valuable metric. In 2016–2017, we received an average of 209 clicks each month on our tweeted links. This increased by 30% in 2017–2018, to an average of 271 clicks.

LinkedIn Page

As of June 2017, the CEE LinkedIn page had attracted 742 followers. In June 2018, our number of followers rose to 1,123, a 51% increase.

Objective 5

CEE Resource Development changed the format of the New Research Alumni Breakfast, hosting the New Research Reception on October 26, 2017. Professors Oral Buyukozturk, Penny Chisholm, Tal Cohen, and Dennis McLaughlin presented their current research to an audience of more than 50 alumni and community members.

CEE continues to produce its seasonal newsletter for alumni and friends. CEE recently redesigned the newsletter into a digital format and produced a limited run of print publications. The newsletter was renamed *Course One*, and the changes were well received. Analytics show that open rates for the newsletter exceed the average education industry standards.

In partnership with Resource Development, the Alumni Association, and friends of MIT, the department continues to expand its efforts to increase philanthropic support for CEE. Department fundraising efforts helped support our mission of providing faculty and students with innovative education and research programs to develop real-world applications that have a large-scale impact on people and sustainability.

Alyssa Feit, who joined the department in December 2016, leads the resource development effort with alumni, CEE friends, and the central MIT Office of Resource Development. Her addition to the department represents a renewed investment in resource development; Feit joined the staff in a full-time position (the position was previously part time).

School Development has worked to increase the visibility of the department's central themes in order to inform and engage both alumni and friends of CEE. In partnership with central resource development, CEE has benefited from several seven-figure commitments to the department. Furthermore, Feit has engaged the department faculty through a variety of speaking engagements.

Accomplishments

Faculty Activities and Initiatives

In June 2017, Assistant Professor Caitlin Mueller, rising sophomore Zoe Lallas, and postdoc Valentina Sumini were part of a team that had the winning project in the NASA Revolutionary Aerospace Systems Concepts-Academic Linkage Design Competition Forum. The project, Managed, Reconfigurable, In-space Nodal Assembly (MARINA), was designed as a commercially owned and operated space station. Mueller served as a faculty advisor, Lallas was a member of the design group, and Sumini contributed to the architectural concept.

In July 2017, Professors Lydia Bourouiba, Markus Buehler, Daniel Cziczo, Benjamin Kocar, Chandra Madramootoo, Benedetto Marelli, and Dennis McLaughlin each

presented on their research and fielded questions from industry practitioners as part of an MIT Professional Education short program, Innovation and Technology in Agriculture and the Environment. The program highlighted the connections between CEE research and industry applications.

Also in July, Professor Oral Buyukozturk and members of his research group (postdocs Hao Sun and Justin Chen and graduate students Steven Palkovic, James Long, and Murat Uzun) traveled to Turkey to participate in a workshop, "Energy Based Structural Analysis and Sensing," designed to advance research into the energy-based design paradigm. The event was part of a newly established collaboration among MIT, Boğaziçi University, and Istanbul Technical University.

Throughout summer 2017, members of the Concrete Sustainability Hub (CSHub) traveled to New Brunswick, Canada, to get a firsthand look at concrete durability issues at the Mactaquac Dam. CSHub is collaborating with researchers from the University of New Brunswick and Oregon State University to pursue a multifaceted research project exploring the multiple durability issues that affect concrete, including an issue that affects the dam. The group is studying an alkali-silica chemical reaction known to cause the cracking and structural problems that are slowly expanding the dam.

In September 2017, Professor Buyukozturk was invited to participate in a meeting of the National Academies of Sciences, Engineering, and Medicine that addressed the role of advanced technologies in structural engineering for more resilient communities. Buyukozturk was one of five speakers taking part in the session focusing on innovative technologies, specifically advanced structural and material technologies for smart infrastructure in building more resilient and sustainable communities.

Also in September, Assistant Professor Otto Cordero and Visiting Associate Professor Roman Stocker hosted a group of researchers at MIT for the first meeting of the Simons Foundation Theory of Microbial Ecosystems (THE-ME) collaboration. THE-ME aims to understand basic principles and laws of microbial ecosystems.

On October 4, Professor John Williams taught a class on computational thinking to a group of seniors at Concord-Carlisle High School. Williams was invited by principal Michael Mastrullo and head of computer science Anthony Beckwith. The class covered how to write a chat application similar to WhatsApp and how to apply data science to Boston city data.

To provide insight into careers in academia, the department hosted 20 distinguished women in October for the second CEE Rising Stars Workshop. The event, organized by Professor Heald, featured faculty panels, research presentations, networking sessions, and campus tours.

On October 23, Breene M. Kerr Professor Elfatih Eltahir spoke on a panel assessing the impact of climate change on malaria. During the panel, held at Harvard's T.H. Chan School of Public Health, Eltahir discussed his research into the various factors involved in the spread of malaria and the creation of models for predicting future transmission of the disease.

Professor Mueller, postdoctoral fellow Valentina Sumini, and undergraduate student Zoe Lallas are taking part in a Mars City Design project that was featured on MIT News in October. The project, Redwood Forest, uses the local Mars environment to create dwellings for humans. Sumini and Lallas are members of the interdisciplinary team of MIT students working on the project, and Mueller is leading the group.

In November, Class of 1942 Professor and Professor of Architecture John A. Ochsendorf donated an exhibition he created on renowned vault builders Rafael Guastavino and his son to organizers establishing a museum featuring the work of the Guastavinos. The exhibit, *Palaces for the People: Guastavino and America's Great Public Spaces*, supplements Ochsendorf's 2010 book *Guastavino Vaulting: The Art of Structural Tile*. The exhibit launched at the Boston Public Library in 2012 and was subsequently donated to the Christmount Conference Center in Black Mountain, NC, where Guastavino's estate is located.

In December, Esther and Harold E. Edgerton Career Development Professor Admir Masic participated in the "Protecting the Rights of Individuals Fleeing Conflict: The Role of Scientists, Engineers, and Health Professionals" symposium in Washington, DC. Masic spoke on a panel addressing the right to education. The symposium was hosted by the Committee on Human Rights of the National Academies of Sciences, Engineering, and Medicine.

In January the MIT Refugee Action (ReACT) Certificate Program, created by Professor Masic, launched its first cohort of participants in Jordan. The participants will complete a yearlong blended learning program focused on computer and data science with an emphasis on innovation and entrepreneurship. In addition to online courses, they will take part in mentored industry internships. The ReACT program aims to increase access to education and professional opportunities for highly talented refugees.

Professor Ruben Juanes was named the principal investigator and director of the newly established Center of Excellence in Multiscale Reservoir Science, a partnership between MIT and the College of Petroleum Engineering and Geosciences at King Fahd University of Petroleum and Minerals (KFUPM) in Saudi Arabia. The collaboration, initially funded by KFUPM at $2.5 million over three years, will focus on the development of technologies for improved characterization of the subsurface via combined active/passive seismic imaging, simulation of coupled flow and geomechanics, and pore-scale modeling of multiphase flow. The MIT team also includes Professor Youssef Marzouk (Department of Aeronautics and Astronautics), Professor Nafi Toksoz (Department of Earth, Atmospheric and Planetary Sciences [EAPS]), and Senior Research Scientist Michael Fehler (EAPS).

Professor Williams presented the keynote address ("Leveraging Big Data in the Oil Industry") at a meeting of the Saudi Arabia Society of Petroleum Engineers (SPE) on January 2. The event was attended by around 300 high-level executives and engineers. Williams was hosted by CEE alumnus Zeid Alghareeb, chairman of Saudi Arabia SPE, and was presented a magnificent trophy depicting the first oil rig to strike oil in the kingdom.

On February 2, Professor Eltahir presented a talk titled "From Charney's Hypothesis to Multiple Climate Equilibria in the Sahel" at the MIT "Chaos and Climate" symposium,

which celebrated the diverse and enduring scientific legacies of former MIT professors Jule Charney and Ed Lorenz. Using examples from research in his group explaining the expansion of the Sahara Desert 6,000 years ago, Eltahir discussed how feedback in the coupled land-atmosphere system may lead to meta-stabilities in the regional climate system. Professor Bourouiba also presented at the symposium, speaking on how the legacies of Lorenz and Charney influenced her path from research on turbulence to her current work in fluid dynamics.

Professor Heald participated in the Global Food+ symposium on February 16. Heald spoke about the impact of particulate matter on crops, particularly maize, wheat, and rice. The symposium, hosted by Tufts University, featured lectures on food, agriculture, environment, and health.

In March 2018, Professor Charlie Harvey was featured in a documentary titled *HAZE, It's Complicated*…. The film, created by the Earth Observatory of Singapore, discusses the burning of peat forests in Southeast Asia from the points of view of local and regional stakeholders. More information and a preview are available at the observatory's website.

Professor Bourouiba was featured in a Storied Women of MIT video during Women's History Month in March. The video highlighted Bourouiba's contributions to the field of fluid mechanics as applied to disease transmission. Institute Professor Penny Chisholm was also featured in the series in a video that highlighted her role in discovering *Prochlorococcus*, the world's smallest, most abundant photosynthetic organism. The Storied Women of MIT video series is produced by MIT Video Productions.

Also in March, Professor Bourouiba was featured in the Howard Hughes Medical Institute's Breakthrough: Portraits of Women in Science series as part of a mini-series that will be screened in theaters across the country. The aim of the series is to increase the public's access to science and inspire and increase the number of minorities involved in science, technology, engineering, and mathematics. The episode "Breakthrough: Connecting the Drops" highlights Bourouiba's research and her path to MIT.

In March, Professor David Simchi-Levi announced that he is leading a multiyear collaboration between MIT and JDA Software to advance intelligent supply chains. The collaboration aims to leverage machine learning and optimization to improve supply chain performance.

In April Yossi Sheffi, the Elisha Gray II Professor of Engineering Systems and director of the Center for Transportation & Logistics, was featured in an MIT News article for his new book *Balancing Green: When to Embrace Sustainability in a Business (and When Not To)*. The article describes case studies of large companies grappling with their impact on the environment and how Sheffi suggests companies pursue sustainability measures in their business models.

Professor Herbert Einstein was interviewed in an April *Forbes* article about Elon Musk's proposed high-speed underground tunnels in Los Angeles. In the article, Einstein provided expert insight into tunnel engineering and Musk's design. The article also discussed the Decision Aids for Tunneling tool developed in Einstein's lab, which estimates cost and construction time.

Student Outreach

On August 15, 2017, the department hosted its second annual CEE Kids Camp, inviting children, friends, and neighbors of CEE community members of all ages and abilities to visit the campus for a day to experience what it is like to be a civil and environmental engineer at MIT. Students, faculty, postdocs, and researchers came together to host activities in which children learned about the wide range of research in the department. About 20 visitors attended the camp, and many of the hosts noted how much fun it was to share their work with students. CEE is planning to host another Kids Camp in August 2018.

Also in August 2017, the week before freshman orientation, CEE hosted 20 incoming freshmen for a pre-orientation program called Discover Course 1. Led by civil and environmental engineering seniors Amber VanHemel and Florence Lo, Discover Course 1 allowed students to participate in hands-on modules focusing on the three CEE cores: systems, mechanics and materials, and environmental engineering science. The modules included creating transportation maps of Boston, conducting strength tests of 3D printed materials, and learning about water diversion for urban planning. The week closed with a presentation of projects from the students in which they used their newly acquired knowledge to propose a solution to a hypothetical dam rebuilding.

CEE hosted "grilled cheese study breaks" during both the fall and spring semesters, encouraging students to take some time to relax amid stressful exam periods. Professors volunteered a few hours to cook grilled cheese for students and members of the community. Tal Cohen, Ali Jadbabaie, and Benedetto Marelli participated in the fall event, and Cohen, Dave Des Marais, and Tami Lieberman attended during the spring.

New this year, the Academic Programs Office hosted the Course 1 Carnival in Lobby 10 on November 16, 2017. The event had great attendance, and prospective students were able to learn about the various opportunities available in CEE, including ONE-MA^3, TREX, and the flexibility and customization that the Course 1 undergraduate degree offers.

The department hosted its annual holiday party on December 8, bringing together faculty, researchers, and students. The event featured ornament decorating and a canned food drive.

On March 7, spring-boarding on the Institute's "Random Acts of Kindness" initiative, the department hosted a Random Act of Kindness luncheon for members of the CEE community. The luncheon was held in the Parsons kitchen, and CEE students, faculty, postdocs, and researchers were invited to enjoy pizza, make their own "dirt cups" (pudding, Oreos, and gummy worms), and create a happy gram—a handmade card meant to thank someone or show appreciation.

On April 6, admitted graduate students visited the campus to learn about the department. The day concluded with a reception at the Stata Center with faculty, staff, and current graduate students. Current students were encouraged to attend and to share their experiences with prospective students.

On April 9, the Academic Programs Office and CEE hosted an open house targeted at prospective Course 1 majors. The event was attended by freshmen, current CEE

students, and faculty including Professor Admir Masic. The room was divided by research topic, ranging from civil engineering to environmental engineering.

APO and members of CEESA hosted a variety of activities during the spring 2018 Campus Preview Weekend in April. Undergraduate students led prospective students in making columns out of pasta and then stress testing their creations. Also, prospective freshmen were invited to attend 1.011 Project Evaluation as an open class. CEESA hosted a plant night that drew approximately 30 prospective freshmen. In addition, APO hosted a booth for prospective freshmen to learn about the department. The CEE booth was one of the most attended at the event, and the CEE giveaway of blue drawstring bags was extremely popular.

The fifth annual CEE Video Competition, held on April 19, highlighted the wide range of approaches CEE students take to solving the world's most challenging problems and the creative ways they share their research. This year's entries ranged from CEE fieldwork experiences to research projects and highlighted the wide range of opportunities in the department as well as the global impact that CEE students have on the world. Senior Alexa Jaeger won first place for her video *Overcoming Murphy's Law*. The second-place prize went to sophomores Max Kessler, Karen Gu, and Diana Nguyen for their entry *Egyptian Blue;* the video's title refers to the first manmade pigment, prevalent in ancient Egypt. Kessler, Gu, and Nguyen were introduced to Egyptian blue through CEE's ONE-MA^3 program, during which students visit Italy for three weeks of fieldwork. The third-place prize was awarded to sophomores Zoe Lallas and Sierra Rosenzweig; Lallas and Rosenzweig also submitted a video about their 1.057 research project, which was inspired by ancient mosaics they saw in Italy.

The department continues to host photo competitions on social media so that students and members of the CEE community can interact with the department when they are off campus and show how their activities reflect CEE's vision. The department's summer-themed photo contest encourages students to use #CEEsummer on Twitter and Instagram. In the winter, CEE hosts the IAP photo contest with the hashtag #CEE_IAP. Prizes are awarded to the student who submits the most photos and to a student who posts a picture that accurately reflects CEE's mission and vision.

CC Mei Distinguished Speaker Series

Professor Lydia Bourouiba expanded her CC Mei Distinguished Speaker Series to include more speakers, further raising visibility for CEE and its vision beyond MIT audiences. Topics and speakers included:

- "Understanding Nature Holistically (and Without Equations)" by George Sugihara of the University of California, San Diego
- "Speciation and Biogeochemical Cycling of Arsenic in a Minerotrophic Peak Wetland" by Professor Ruben Kretzschmar of ETH Zurich
- "New Ideas for Separation Processes" by Professor Howard Stone of Princeton University
- "Making Mobility Smart Again" by Professor Serge Hoogendoorn of the Delft University of Technology

- "A New Class of Variational Multiscale Methods for Residual-Based Turbulence and Non-Newtonian Bio-Fluid Dynamics" by Professor Arif Masud of the University of Illinois
- "From Reduced Models of Turbulence to Microfluidics" by Professor Nadine Aubry of Northeastern University
- "The Frontiers of Tsunami Hydrodynamics" by Professor Costas Synolakis of the University of Southern California

Research Highlights

The department's research is diverse and crosses many disciplines. Over the past year, CEE had nearly 100 research proposal submissions.

Breene M. Kerr Professor Elfatih Eltahir published research showing that deadly heat waves could harm South Asia, home to one fifth of the world's population. The research suggests that climate change may cause summer heat waves with fatal levels of heat and humidity and that these heat waves may occur in the next few decades. The findings were published in *Science Advances* and reported by MIT News.

McAfee Professor of Engineering Markus Buehler, graduate student Grace Gu, and postdoc Mahdi Takaffoli published research in *Advanced Materials* examining the structure, strength, and toughness of conch shells. They showed how the unique structure could be used for individualized helmets and body armor.

Institute Professor Penny Chisholm and graduate student Andres Cubillos-Ruiz, now a postdoc at IMES, published research showing that *Prochlorococcus* varieties can each produce more than two dozen different peptides belonging to a class of compounds called lanthipeptides. Most bacteria that produce these compounds, often functioning as antibiotics or signaling compounds, make only one or two. The researchers found that the way in which the resulting peptides evolve has never before been observed. The findings were published in the *Proceedings of the National Academy of Sciences*.

Robert N. Noyce Career Development Associate Professor Xuanhe Zhao designed a new soft and slippery yet tough coating that can be applied to plastic and rubber materials such as surgical tubing. The coating makes medical materials more comfortable for patients. This work was recently published in *Advanced Healthcare Materials*.

Professor Buehler, postdoc Shengjie Ling, and research scientist Zhao Qin created reconstituted silk of high strength that can be formed into new shapes and structures that are not feasible with natural silk. This work was published in *Nature Communications*.

Professor Buehler, along with research scientist Zhao Qin and postdoctoral associate Chun-Teh Chen, published research in *Science Advances* on functionalized graphene that folds and unfolds into predetermined 3D structures in response to heat. The research was conducted in collaboration with Johns Hopkins University.

Professor Oral Buyukozturk released research showing that the microscopic properties of cement are key to stronger, more sustainable concrete. Buyukozturk, graduate student Steven Palkovic, and Sidney Yip, professor emeritus in the Department of Nuclear Engineering, created a computer model to simulate the behavior of individual atoms under a variety of conditions and see how strength develops in concrete materials. The research was published in the *Journal of the Mechanics and Physics of Solids*.

Professor David Simchi-Levi developed a new machine learning algorithm that has helped online retailers determine the ideal price for products. This method led to increases in revenue, profit, and market share for retailers such as Rue La La, Groupon, and B2W. It can also be used in other industries, including consumer products, airlines, and banking.

Professor Buyukozturk and research scientist Kunal Kupwade-Patil published research revealing that mixing discarded plastic bottles, in the form of flakes exposed to harmless irradiation, with cement paste can make stronger concrete. This effort began as an undergraduate project and was conducted with researchers from the Department of Nuclear Science and Engineering. The research was published in *Waste Management*.

Professor Charles Harvey and graduate student Brittany Huhmann published research showing that the presence of arsenic in groundwater, deposited through irrigation, damages the rice yield in Bangladesh. The results of their field study, conducted during the 2015 and 2016 growing seasons, were published in the journal *Environmental Science and Technology*.

Professor Buehler and members of the Laboratory for Atomistic and Molecular Mechanics showed that spider silk can help provide an understanding of how bones regenerate. The researchers modeled how a cell membrane protein receptor, integrin, folds and activates the intracellular pathways that lead to bone formation. This research was conducted in collaboration with Tufts University and Nottingham Trent University.

Associate Professor Colette Heald, research scientist David Ridley, and Professor Jesse Kroll produced research showing that the Clean Air Act saved more lives than initially estimated by the US Environmental Protection Agency. The researchers studied observations of organic aerosol across the United States and found that there had been a significant decrease between 1990 and 2012. The study was published in the *Proceedings of the National Academy of Sciences*.

Professor Martin Polz, in collaboration with Professor Eric Alm, published research revealing that microbial communities in the ocean are able to form despite rapidly varying conditions in a coastal environment but that these communities demonstrate high turnover. The research group, including graduate student Brian Cleary of the Broad Institute, former CEE postdoc Antonio Martin-Platero, current postdoc Kathryn Kauffman, and former CEE graduate student and biological engineering postdoc Sarah Preheim, used a time series method and an algorithm to understand the patterns and behaviors of the communities over time. The study was published in *Nature Communications*.

Professor Polz and postdoctoral associate Kathryn Kauffman have discovered a new type of virus that is representative of the uncharacterized majority of viruses in the ocean. Named *Autolykiviridae* after a character from Greek mythology who was storied for being difficult to catch, these viruses were previously undetected because of their unusual properties that are not revealed in common laboratory techniques. Their study was published in *Nature*.

Professor Buyukozturk, research scientist Kunal Kupwade-Patil, and junior Stephanie Chin published research showing that using volcanic ash in place of traditional cement can reduce the embodied energy that goes into manufacturing concrete. The research was conducted in collaboration with researchers in Kuwait. The findings were published in the *Journal of Cleaner Production*.

Professor Eltahir and former postdoc Ross Alter published research indicating that intensive agriculture has an impact on the summer climate in the midwestern United States. Eltahir and Alter demonstrated that there was a significant empirical association and physical connection among the intensification of agriculture in the Midwest, the decrease in observed average daytime temperatures in the summer, and an increase in observed local rainfall. This work shows that intensive agriculture is no less important than greenhouse gas emissions in shaping regional and local climates. The research was published in *Geophysical Research Letters*.

Professor Franz-Josef Ulm and research scientist Roland Pellenq produced research showing that city arrangement impacts the heat buildup of cities, a phenomenon referred to as the "heat island effect." The researchers found that cities with more grid-like designs have more heat buildup than cities with more chaotic layouts, making these cities hotter than their surrounding areas. The research was published in *Physical Review Letters*.

Professor Kroll and former postdoc Gabriel Isaacman-VanWertz, now an assistant professor of civil and environmental engineering at Virginia Tech, tracked organic molecules as they react in the air. This research is the first to offer a comprehensive understanding of the process and could help in the study of pollutants, smog, and emissions in the atmosphere in the future. Graduate students Chris Lim, Jon Franklin, and Josh Moss, as well as former Kroll lab members Rachel O'Brien and James Hunter, also contributed to the work. The study was published in *Nature Chemistry*.

Professor Simchi-Levi published research showing that the Thompson sampling method, developed in the 1930s, can be combined with a linear algorithm to address revenue management problems. Simchi-Levi demonstrates that Thompson sampling can be naturally combined with a classical linear program formulation to include inventory constraints and can be applied in the airline, Internet advertising, and online retail industries.

Researchers from CSHub published a study that shows that using life-cycle methodologies before beginning infrastructure projects has both environmental and financial benefits in the long term. The researchers suggest that engineers and policymakers complete life-cycle assessments and cost analyses in the planning stages of projects so that they can have a better understanding of the underlying environmental and financial costs and benefits.

Graduate student Tianli Zhou of the Interdepartmental Transportation Program was profiled on MIT News for his research into vehicle sharing services. Zhou and Evan Fields, a PhD candidate in MIT's Operations Research Center, used data from Zipcar to infer demand for vehicles and develop algorithms to inform best practices for car-sharing services. Zhou and Fields are advised by Associate Professor Carolina Osorio.

The Herman Project, a citizen science sourdough project from Assistant Professor Otto Cordero's lab, was featured on MIT News. The Herman Project digitizes the tradition of peer-to-peer sharing of sourdough starters by asking users to document their location and type of flour used and to share samples of their starter with Cordero's lab. Postdoc Gabriel Leventhal, creator of the Herman Project, is working with undergraduates Sarah Weidman and Lindsey McAllister to analyze the samples to study how microbial communities change in different conditions and environments.

Research from Professor Buehler and the Laboratory for Atomistic and Molecular Mechanics on subnanometer-scale channels was featured on the cover of the February issue of *Nature Materials*. The research modeled the mechanisms of molybdenum disulfide, a two-dimensional material that could inform the creation of flexible, transparent electronics.

A review by Professor Buehler, former postdoc Shengjie Ling, and David Kaplan of Tufts University was featured on the cover of the April edition of *Nature Reviews: Materials*. The review, titled "Nanofibrils in Nature and Materials Engineering," summarizes the hierarchical design strategies of cellulose, silk, and chitin, focusing on nanoconfinement, fibrillar orientation, and alignment in 2D and 3D structures.

Awards and Recognition

In March, QS World University Rankings released its 2018 rankings, and CEE was ranked among the top. The department was named first overall for civil and structural engineering and third overall for environmental science. The QS rankings are intended to educate prospective students about the leading schools in their preferred field.

Faculty Awards and Recognition

The faculty in CEE have received numerous significant awards, reflecting their excellence and impact within the Institute and beyond.

Professor Oral Buyukozturk recently received a $1.3 million research grant from Shell to develop innovative technologies to detect and characterize earthquakes induced by oil operations in areas near urban populations and to study the effects in neighborhood buildings. These operations and their locations are of significant concern and are challenging to characterize from both social and scientific perspectives. Buyukozturk is the principal investigator for the project, with Nafi Toksöz of EAPS as co-PI.

Edmund K. Turner Professor of Civil and Environmental Engineering Moshe Ben-Akiva was presented with the 2017 Robert Herman Lifetime Achievement Award in Transportation Science by the Institute for Operations Research and the Management Sciences (INFORMS) Transportation Science and Logistics (TSL) Society. The award

recognized Ben-Akiva's fundamental and sustained contributions to transportation science and logistics and his influence on the field through writings, teaching, service, and nurturing of young professionals. Ben-Akiva was presented with the award at the 2017 INFORMS annual meeting in Houston. In addition, he gave the TSL plenary session, where he presented his work on preference estimation and personalization for smart mobility.

Visiting Professor Pedro Reis was named an American Physical Society (APS) Fellow. He also received a 2017 APS Early Career Award. Reis is one of 12 members of the MIT community to recently receive honors and awards from APS.

Professor Charles Harvey and his lab were awarded a $3.7 million grant to continue their research on tropical peatlands. With the grant, the researchers will combine field and laboratory data with satellite data to predict and prevent fires, better manage tropical peatlands, and characterize the chemistry and transport of regional haze.

Ruben Juanes, the ARCO Associate Professor in Energy Studies, and Xiaojing (Ruby) Fu, a postdoctoral associate, were recognized with the *Physical Review Letters* Editors' Suggestion for their paper "Nonequilibrium Thermodynamics of Hydrate Growth on a Gas-Liquid Interface." Editor's Suggestion awards acknowledge a paper's importance, innovation, and broad appeal.

Paul M. Cook Career Development Professor Benedetto Marelli received the 2018 Young Investigator Award from the Office of Naval Research (ONR). The award can be used to support laboratory equipment, stipends, and scholarships, as well as other expenses for ongoing and planned studies. Marelli is one of five MIT professors to receive the award. Also, Professor Marelli was presented with the ONR Director of Research Early Career Grant, an award of $1 million over five years to cover research expenses.

In April 2018, Professor Desirée Plata's startup company, Nth Cycle LLC, was presented with the Department of Energy's Innovation Crossroads Award, a $500,000 entrepreneurial traineeship. The award was granted to Megan O'Connor, co-founder of Nth Cycle LLC and current postdoc in Plata's lab. Nth Cycle aims to help transition the United States away from its reliance on primary mining and refining of metals overseas toward recycling of rare earth and specialty metals domestically.

Student Awards and Recognition

In September 2017, graduate student Justin Montgomery was named the winner of the Student Research Competition at the annual conference of the International Association for Mathematical Geosciences for his research on hierarchical Bayesian modeling of shale gas production.

In October 2017, graduate student Grace Gu of the Laboratory for Atomistic and Molecular Mechanics received the Graduate Excellence in Materials Science Award for her presentation at the MS&T (Materials Science & Technology) conference. The conference, held in Pittsburgh, was hosted by the American Ceramic Society.

Graduate student Maitham Makki Alhubail received the Shoji Award in October. This award, established by Mikio Shoji in 2011, is given to a student for innovation in civil engineering information technology.

Abdullah Almaatouq, a graduate student in the computational science and engineering program and a research assistant in the Media Laboratory's Human Dynamics Lab, led a team of MIT students who won first place in three of six categories in the 2017 Fragile Families Challenge.

In November CEE research affiliate Hao Sun, also a former postdoctoral associate in the department, was named one of *Forbes* magazine's 30 Under 30 in Science for his work on detecting vibrations in buildings and modeling their structural health. Sun is currently an assistant professor of civil and environmental engineering at the University of Pittsburgh.

In January, Grace Gu was selected as one of the California Institute of Technology's 2018 Young Investigator Lecturers in Engineering and Applied Science. This lecture series, hosted by Caltech's Division of Engineering and Applied Science, provides research exposure and networking opportunities for selected female and underrepresented minority PhD students and postdoctoral scholars with Caltech faculty.

Also in January, Justin Montgomery was invited to speak at the Energy Forecasting Forum, a monthly lecture series hosted by the US Energy Information Administration. Montgomery and Francis O'Sullivan, director of research for the MIT Energy Initiative, discussed their paper "Spatial Variability of Tight Oil Well Productivity and the Impact of Technology."

Postdoctoral associate Arun Prakash and his coauthors, including Edmund K. Turner Professor of Civil and Environmental Engineering Moshe Ben-Akiva, were presented the Best Simulation Application Paper Award for "Improving Scalability of Generic Online Calibration for Real-Time Dynamic Traffic Assignment Systems." The award was presented by the Transportation Research Board's Joint Traffic Simulation Subcommittee (SimSub) at the board's annual meeting in January. SimSub is a joint committee that focuses on coordinating advancements in traffic simulation and promoting and endorsing the use of simulation tools in transportation systems analysis.

Graduate student Joanna Moody presented her research at the Transforming Transportation Conference, held in January at the World Bank's headquarters in Washington, DC. Moody discussed her work on "car pride" and its impact on car usage and ownership in two Latin American cities. The project was funded by the Lee Schipper Memorial Scholarship for Sustainable Transport and Energy Efficiency, which Moody received in August 2017. This scholarship recognizes innovative young researchers who challenge existing paradigms and expand research and policy dialogues on sustainable transportation.

In February, graduate student Judy Yang, a member of Professor Heidi Nepf's Environmental Fluid Mechanics Lab, was selected as one of Caltech's Young Investigator Lecturers in Engineering and Applied Science. Yang spoke on how vegetation such as wetlands mitigates coastal erosion.

Graduate student Kyle Delwiche of Harold Hemond's lab received the Outstanding Student Paper Award from the American Geophysical Union. Delwiche won the award for her paper showing that rising methane bubbles in Massachusetts's Upper Mystic Lake transport arsenic-containing particles from contaminated sediments to the water surface. Her work was supported by the Singapore-MIT Alliance for Research and Technology and the National Science Foundation.

In March, research scientist Francisco Martin-Martinez was named president of the Association of Spanish Scientists in the United States, an organization that aims to disseminate and expose the high-impact work of the community of Spanish science and technology professionals in the United States and to educate and inspire new generations of scientists and innovators. Martin-Martinez was previously the association's vice president.

2018 Annual Awards: Faculty, Staff, and Students

These awards celebrate all that is CEE. This past year the department added several new awards to stimulate the local community to identify and further the excellence within the department. The awards were presented at the Senior Celebration and Awards Banquet in May.

First-year student Rayna Higuchi received the CEE Best Undergraduate Research Award for her exceptional academic record, significant contributions to research projects, and mature intellectual and communication skills.

Juniors Amber VanHemel and Meghan Reisenauer, co-presidents of the CEE Student Association, received the CEE Leadership and Community Award for their positivity and proactive nature in leading CEESA.

The Juan Hermosilla (1957) Prize, given to a student demonstrating exceptional talent and potential for future contributions at the intersection of mechanics, materials, structures, and design, was awarded to junior Stephanie Chin. Chin was lauded for her exceptional research record; as part of her structures and materials UROP project with Professor Buyukozturk, Chin published three peer-reviewed papers this year.

The Leo (Class of 1924) and Mary Grossman Award, given annually to an undergraduate student with a strong interest in transportation and a strong academic record, was presented to junior David Wu. Wu was recognized for taking a new big data approach to a traditional transportation problem and for asking and answering challenging questions in the classroom.

Mikayla Murphy received the Paul L. Busch (1958) Prize, which is awarded to undergraduate students in environmental science and engineering for academic achievement and contributions to the CEE community. Murphy was honored for her unique research interests at the intersection of environmental science and engineering, biology, and computer science and, specifically, for her contributions during CEE's TREX program in 2017.

MEng candidate Jackson-Lee Jewett was the recipient of the Tucker-Voss Award, presented to an undergraduate or graduate student who shows particular promise in the field of building construction. Jewett was commended for his dedication to building more efficient structures and for his exceptional performance during the MEng program. The Tucker-Voss Award was created when the Department of Building Construction merged with the Department of Civil Engineering in the 1950s. The award is named in memory of Professor Ross F. Tucker and Professor Walter C. Voss, who were the first two heads of the Department of Building Construction.

The Trond Kaalstad (Class of 1957) Fellowship, presented annually to a graduate student who has displayed leadership and contributed significantly to the well-being of the CEE community, was awarded to Sidhant Pai. Pai was an instrumental leader of the 2018 mini-UROP program, serves on GradCom, and was recognized for being an active advocate for graduate students.

The Maseeh Award for Excellence as a Teaching Assistant went to Adam Bockelie for his role in 1.010 Uncertainty in Engineering. Bockelie was lauded for his development of course materials and for thinking of new ways to teach material.

Alison Hoyt PhD ’17 was given the CEE Best Doctoral Thesis Award for her project “Carbon Fluxes from Tropical Peatlands: Methane, Carbon Dioxide and Peatland Subsidence.” The award honors scholarly and academic excellence and a high level of distinction among CEE graduate students.

The CEE Postdoctoral Scholar Mentoring, Teaching, and Excellence Award was presented to Katie Travis. This award is given in recognition of mentoring, teaching, and other exceptional contributions by a postdoc. Travis was extolled for her willingness to help others, for her investment in the community, and for giving advice to others about her academic experience.

Donald and Martha Harleman Professor Heidi Nepf was presented the Maseeh Excellence in Teaching Award, given annually to the most outstanding faculty instructor in the past year. Nepf was acknowledged for her use of various learning materials and for drawing from examples from nature and engineering to clarify concepts in fluid mechanics.

The CEE Distinguished Service and Leadership Award was presented to Professor Oral Buyukozturk for his contributions to the department over many decades. Buyukozturk was central to the creation of the revised civil engineering education program in the department, which launched in 2014. He also leads the Henry L. Pierce Seminar Series, which brings distinguished faculty from areas of civil, structural, and infrastructure science and engineering to campus.

Professor Herbert Einstein received a standing ovation as he was presented the Ole Madsen Mentoring Award, which honors a faculty member for his or her contributions to mentoring and educating CEE students outside the classroom and for inspiring them to pursue a career in the field of civil and environmental engineering. Einstein was commended for his mantra “to change the world, you need to be truly involved

with it" and for his dedication to his students and their overall well-being. He was also honored for sharing his enthusiasm for geotechnical engineering and being a source of inspiration for his students and lab members.

Two staff members received CEE Excellence Awards for their outstanding contributions to the CEE community, including their commitment to professionalism, dedication, and best practices and their fostering of a culture of diversity, inclusiveness, and innovation. The awards were presented to Roberta Pizzinato, a financial coordinator of sponsored activity, and to program manager Donna Hudson.

Angela Odoari Mickunas, CEE's administrative officer, received the Ellen G. Mandigo Award for Outstanding Service from the School of Engineering. Angela retired from MIT in June 2018.

Markus J. Buehler
Department Head
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