

Center for Environmental Health Sciences

Human health depends on our relationship with the environment. The [Center for Environmental Health Sciences \(CEHS\)](#) predicts and elucidates the ways that chemical and biological agents in the environment affect human health and the health of the ecosystem that supports all life. In addition to identifying toxic chemicals and hazardous organisms in the environment, CEHS research develops methods to detect such chemicals and organisms, shows how these agents affect health at the cell, tissue, individual, or population levels, and helps to create new technologies that allow humans to live longer and healthier lives. As a federally funded center, CEHS does this in a manner that responds to its mandate to interact with the local community.

The center acts as a nexus for a diverse group of environmental scientists, engineers, historians, and policy experts from nine departments across the Institute. It brings their collective expertise to bear on both domestic and global environmental threats that range from industrial pollution to the emergence of new infectious agents. CEHS complements its talented human resource pool with a toolbox of state-of-the-art technologies to make quick headway on high-impact problems—problems that are larger than those that could be realistically tackled by any individual laboratory. In this way, CEHS enables synergistic partnerships of people and technologies, leading to the solution of important environmental problems. Approximately 40 laboratories within CEHS have many areas of expertise. The areas most in alignment with the CEHS mission are:

- Knowledge of the chemistry and transport of pollutants in the atmosphere, water, and soil;
- Knowledge of the pathways by which cells and organisms respond to toxic agents in the environment (reflected by CEHS expertise in DNA damage, DNA repair, genomic instability, proteomics, metabolomics, and gene expression analysis);
- Knowledge of the ways that microbes as individual agents, or collectively as microbiomes, affect health and disease;
- Knowledge of the roles that the immune system and inflammation play as promoters of many environmental diseases;
- Knowledge of bioengineered cellular, tissue, and whole-organism systems that enable next-generation testing of environmental hazards and development of disease-prevention strategies; and
- Creation of technologies that enable physical detection of contaminants and analysis of biological processes relevant to environmental health.

Organization

CEHS is funded primarily by the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health as one of the 22 core centers (Center Core Grants; Activity P30) focusing on environmental health. Fulfilling the requirements of the NIEHS grant program, the CEHS is composed of an Administrative Core, a Community Outreach Education and Engagement Core (COE2C), a Career Development Program, a Pilot Project Program (including both basic and translational pilot projects),

and a Global Environmental Health Sciences Program. In addition, CEHS also has four research facilities cores, including a mandated Integrative Health Sciences Facilities Core, which provides an interface with the local medical community.

The CEHS membership currently consists of 36 science and engineering faculty, five emeritus faculty, and four professional full-time senior research members. Forty-four members are from MIT and one is from the Broad Institute of MIT and Harvard (Professor Paul Blainey). Of the MIT members, the center has one senior research scientist emeritus and one principal research scientist. The members of the administrative core, which is charged with the center's overall operation, include John M. Essigmann, William R. (1956) and Betsy P. Leitch Professor in Residence Professor of Chemistry, Toxicology, and Biological Engineering, director; Bevin P. Engelward, Professor of Toxicology and Biological Engineering, deputy director; Amanda Tat, administrative officer; Gabrielle Stump Ceriales, fiscal officer; Kerry Forristall, administrative assistant; Gianna Hernandez-Figueroa, event coordinator; and a financial assistant. COE2C helps communities understand and, where possible, avoid exposures to environmental hazards that can adversely affect public health. In a broad mission to environmental justice communities located in the urban Boston area, COE2C partners with the Mystic River Watershed Association and the Friends of the Malden River. COE2C also works with five tribes in northern Maine, collaborating directly with tribal educational and environmental departments. Within MIT, COE2C partners with the MIT Edgerton Center and the MIT Clinical Research Center to reach out nationally to science teachers and healthcare professionals with instructional environmental health materials. Kathleen Vandiver, director, and Professor Engelward, co-director, lead COE2C with support from Amy Fitzgerald and Amanda Mayer, outreach coordinators. Director Essigmann has a strong interest in these programs and actively participates in them.

CEHS continues a long tradition of providing its membership with excellent research facilities that reflect, nurture, and support the center's research directions. The CEHS researchers use four facilities cores; each core contributes to the research efforts of at least 10 center members. The cores include the Bioimaging and Chemical Analysis Facilities Core, the Genomics and Informatics Facilities Core, the Animal Models Facilities Core, and the Integrative Health Sciences Facilities Core.

The CEHS Internal Advisory Committee decided last year to consolidate the important but financially challenged Bioanalytical Core with the Imaging Core and to reach out to other facets of MIT that could share costs, help jointly manage the combined cores, and expand the user base. This reorganization resulted in a new core, the Bioimaging and Chemical Analysis Facilities Core. More recently, CEHS partnered with the Department of Chemistry's instrumentation facility to hire Mohanraja Kumar, an analytical chemistry expert, as a permanent addition to the management of the new core. This was a significant revision to the CEHS structure, but it resulted in collaborations with other departments and ultimately addressed many financial challenges. The Bioimaging and Chemical Analysis Facilities Core provides center members with the latest tools, techniques, and expertise in the characterization and quantification of almost any molecule in a biological system—including modifications of cellular molecules such as DNA, RNA, and proteins—as well as state-of-the-art proteomics and metabolomics research capabilities. This core offers a variety of sophisticated quantitative imaging

technologies. It operates as a resource for the center, as well as for all of MIT, and provides invaluable training for students and postdoctoral associates to become proficient in biological mass spectrometry, other modern analytical methods, and sophisticated imaging tools. The new Orbitrap Exactive Q mass spectrometer added a proteomics functionality to the CEHS portfolio. This instrument gives researchers the ability to analyze how protein networks change over time in response to foreign agents (toxicants, infectious agents, and drugs), and also permits researchers to see real-time changes of conventional small-molecule metabolites of cells treated with the same agents. One junior faculty member, Matthew Shoulders, uses it to study the evolution of viruses in real time. To get maximum utility from this novel technology, CEHS partnered with the Departments of Biological Engineering and Chemistry recently to purchase a refurbished the EASY-nLC 1000 system, which provides effortless nano-flow ultra-high-performance liquid chromatography. This proteomics capability is now fully functional and is changing the way that both CEHS and non-CEHS laboratories that use the facility do high-impact science. In addition, as a cost-control measure for the entire facility, CEHS purchased a liquid nitrogen generator; this device will significantly reduce the amount of liquid nitrogen needed to run the instruments in this core.

Because genomics and informatics have been growing rapidly at MIT and elsewhere, the Bioimaging and Chemical Analysis Facilities Core has been renamed to the Genomics and Informatics Facilities Core. This core provides center members with an integrated facility for transcriptomics, next-generation sequencing capabilities, data storage, database management, and data mining and modeling. It overlaps with the Animal Models Facilities Core and the Integrative Health Sciences Facilities Core (IHSFC) in providing biostatistics support unit for CEHS. These physical, computational, and statistical tools are critical to the goal of moving the center's research efforts to higher levels of sophistication in the attempt to understand the response of the whole organism to environmental agents. In late 2017, the center added a Pacific BioSciences Sequel to the core; it is now being test driven to probe the assets of this technology. Using a novel technique for DNA sequencing, the principal advantage of this equipment is the ability to sequence enormously long pieces of DNA. It has a high error frequency compared with normal next-generation sequencing; however, Stuart Levine is working with a CEHS technology development research scientist who developed a way to do DNA sequencing at three to four orders of magnitude higher accuracy than next-generation sequencing. They expect to bring the equipment's sequencing fidelity to a level that will allow fast, high-fidelity sequencing of entire genomes. This example shows how service facilities work with the science community to develop advanced technology that will benefit a broad community of scientists at MIT and elsewhere.

The Animal Models Facilities Core, directed by Professor James G. Fox, provides center members with materials and services needed for the application of animal models to environmental health research, including the generation of genetically engineered mice, embryo rederivation of imported mice, colony management, and preparation and interpretation of murine tissues by histological and image analysis. The Animal Models Facilities Core maintains cutting-edge technology, including the rapid production of mouse mutants using clustered regularly interspaced short palindromic repeats (CRISPR) and CRISPR-associated protein 9. This core also does state-of-the-art research on the role that microbes play in accelerating the development of diseases such as cancer.

Professors Michael Yaffe and Fox lead IHSFC, with the support of Catherine Ricciardi, Hospital Liaison Program director, and a number of clinical and translational consultants. Ricciardi has day-to-day management responsibility for IHSFC, but Yaffe (a practicing physician-scientist) and Fox (a veterinarian and the director of the Division of Comparative Medicine) have faculty-level responsibility for human and animal translational studies, respectively. Ricciardi is an expert in the preparation of institutional review board proposals for the use of human subjects in experimentation. She is also the center's liaison to the Harvard Catalyst network of clinical experts at Harvard University and the Harvard-MIT Program in Health Sciences and Technology. This connection with the MIT Catalyst Clinical Research Center provides access to services to CEHS members involved in human health research, particularly studies with human clinical samples, clinical trials, and statistics for human population-based studies and other activities. IHSFC was developed to help CEHS members translate their research activities for the clinical and epidemiological realms.

Another major program in CEHS is the Global Environmental Health Sciences Program, led by co-directors Essigmann and Peter Dedon. This program focuses on developing collaborative relationships between CEHS members and international researchers in environmental health, as well as on developing research training and education exchange programs for graduate students and postdoctoral associates. The program's global efforts focus on Thailand, Singapore, and South America. One example of the impact of this work is the recent discoveries on the mechanism by which paraquat, a herbicide still used in the developing world, causes oxidative stress that can lead to neurological diseases such as Parkinson's disease. Another global effort is in Singapore; this program helped with the development of a therapy for dengue fever that was recently approved by Singapore's Health Sciences Authority.

CEHS has a long-standing commitment to fostering the careers of its young scientists and junior faculty members. The Career Development Program, directed by Professor Engelward, provides opportunities for the advancement of its members at all stages of their careers. From research resources to career coaching to global opportunities for outreach, CEHS provides resources that promote success and enable community engagement in environmental health. These opportunities and resources include:

- Mentoring
- Financial and research administration support
- Research resources
- Speaking opportunities for junior faculty
- New Frontiers Transition Seminar Series for postdoctoral associates
- Translational research support
- Engagement opportunities
- Global program in public health
- Responsible conduct of research training

The center continues its successful and popular Pilot Project Program, funded by both National Institutes of Health (NIH) and private sources; it is overseen by the center

deputy director and director, along with the Internal Advisory Committee. This program provides initial support for early-stage investigators and support for senior investigators who wish to establish new lines of research in environmental health sciences and toxicology. The program also motivates investigators from other fields of research to apply their expertise to environmental health research and promotes the development of novel COE2C activities that arise directly from the research of CEHS members.

Finally, the Translational Pilot Project Program was created to encourage CEHS members and others to pursue translational research in which fundamental research activities are moved progressively from cell-based systems to animal models and ultimately into human epidemiological and clinical application. The importance of this type of research warrants special funding. A joint partnership established in 2015, the Translational Pilot Project Program partnered with the Theron G. Randolph Translational Pilot Project gift to encourage investigators to take basic environmental health research to the translational level, especially in areas that connect environmental exposures to allergy and immunity. The current Theron G. Randolph Translational Pilot Project was awarded in 2017 to Principal Research Scientist Susan Erdman, and in 2018 to Professor Katharina Ribbeck. Erdman studies how probiotics influence the health status of children and their offspring. Such multigenerational studies have been determined to be exceptionally relevant in the field of toxicology. Professor Ribbeck studies how mucus can act as a barrier to environmental toxicants and bacteria. She collaborates with a Superfund program based in Puerto Rico to study how mucus affects human populations. This work is especially relevant as the island continues its recovery from Hurricane Maria.

Accomplishments

Many of the center's accomplishments this past year stem from its instrumentation stock in the facilities cores. Matthew Shoulders is providing new insights into protein evolution during viral attacks and Professor Elizabeth Nolan is providing new insights into how infectious agents acquire metals needed for their normal biology (and pathobiology). Shoulders's work explains how viruses such as HIV evolve rapidly to resist drugs and Nolan's work is a guide toward new drugs that could limit metal nutrients needed for pathogen growth. The Orbitrap proteomics instrumentation is critical to Shoulders's work and the inductively coupled plasma mass spectrometer (ICP-MS) is critical to the work done by Nolan. These are both new pieces of CEHS equipment that have enabled many ground-breaking discoveries in a short period of time. More than 70 investigators in several dozen laboratories at MIT use the ICP-MS.

CEHS has maintained an extremely strong volume of research support, totaling more than \$12.6 million in FY2018 and resulting in at least 270 publications. These research projects are funded through a variety of sources, including the National Institutes of Health (the National Cancer Institute, National Institute of Allergy and Infectious Diseases, National Institute of Biomedical Imaging and Bioengineering, National Center for Advancing Translational Sciences, and NIEHS); the National Science Foundation; the US Department of Defense; the Food and Drug Administration; the Singapore-MIT Alliance for Research and Technology, and various foundations and industries. The center's institutional training grant in toxicology, now in its 44th year, reflects the broadening of CEHS to include many faculty members, mainly engineers, from outside the Department of Biological Engineering. The training grant now supports

PhD candidates and postdoctoral associates in many disciplines and has fostered interdisciplinary research. To keep the training grant grounded in the field of toxicology, Professors Essigmann and John Groopman (of Johns Hopkins University) teach an intensive subject, 20.S949 Fundamentals of Environmental Toxicology, that is required of CEHS trainees and all trainees in the center's Superfund Research Program, and offered to other interested parties at MIT.

A CEHS strength is its ability to integrate with other organizations on campus, including departments with shared interests. As noted, CEHS has been awarded a center grant under the Superfund Research Program (the P42 program—multiproject center grants). The leaders of this program are Professors Engelward (director) and Essigmann (co-director). Additionally, Vandiver (director of CEHS COE2C) plays a critical role by making connections to stakeholders in nearby communities in Massachusetts and Maine. An important strength of the funded Superfund Research Program is its focus on DNA alkylating agents and polycyclic aromatic hydrocarbons—chemicals in the environment that can cause mutations and cancer. Within the program, there are five research projects, each with multiple investigators from seven departments (Earth, Atmospheric, and Planetary Sciences; Institute for Data Systems and Society; Civil and Environmental Engineering; Chemical Engineering; Chemistry; Biological Engineering; and Biology). The projects focus on water pollution, air pollution, genetic susceptibility factors for disease, mutational spectrometry, and complex systems-level responses to exposures. Further, four cores support key aspects that are shared by all of the projects. The foci of these four cores are administrative, research translation, community engagement, and training. The preparation of the proposal brought 11 CEHS members together and thus fostered new collaborations and research aimed at problems in environmental health. A key aspect of the program that was critical to its funding was the coming together of research leaders to focus on specific contaminants and to develop strong synergies with each other. All of the research projects benefit from all of the cores, making this a highly cohesive program. All members of the Superfund Research Program are also CEHS members, making this new program a great asset to CEHS.

Community Outreach Education and Engagement Core

The center's primary funding agency, the National Institutes of Environmental Health Sciences, mandates that all of its extramural research centers across the country engage in community-based programs to improve environmental health. COE2C chose four engagement efforts to match the center's strength: outreach to underserved communities as well as to environmental justice communities; innovative pedagogy and technology for conveying key concepts relevant to environmental health to the public, including children; workshops to serve members in MIT's educational communities by teaching them about environmental health; and, for some of the center's community partners, advice and boots-on-the-ground help in addressing local environmental health problems.

COE2C selected two communities and regions in New England to serve. One is the urban Mystic River watershed. COE2C has for several years had partnerships with the Mystic River Watershed Association and the Friends of the Malden River. The Mystic River flows through 22 Boston-area communities that include immigrant populations and environmental justice populations (e.g., the towns Malden, Chelsea, and Everett) along the Malden River.

The other community is that of Native Americans who live on tribal lands in rural northern Maine. The challenge is how to find the best way to inform, advise, listen, and work with partner organizations in these communities to mitigate the human health effects of industrial pollution and unhealthy lifestyles.

Three major community accomplishments from the past year: a highly successful Citizen Science drinking water project in Maine; a finalized human health risk study for the Malden River communities; and a completed curriculum project for Boston Public Schools.

- During academic year 2018, Vandiver and two Civil and Environmental Engineering master's degree students (Abby Harvey and Tchelet Segev), whose mentor was Professor Harry Hemond, partnered with the Passamaquoddy Environmental Department to carry out a Citizen Science drinking water study in the remote townships of Eastport, Pleasant Point (the tribal reservation), and Perry, Maine. After holding public meetings where residents voiced concerns about the water quality, people joined in collecting water samples from their homes. Residents' samples included locally sourced water from the municipal facility at Boyden Lake and from private wells scattered around the area. This study was highly successful, with 22% of the region's population participating. This outstanding participation rate can be attributed to a six-year sustained relationship that Vandiver developed with the Passamaquoddy people. More than 300 sampling kits were returned, producing more than 600 water samples for ICP-MS analysis of concentrations of 12 metals, including arsenic and lead. The final number of samples was just less than 1,000. The study reached 145 private wells, double the number of wells tested in an earlier US Geological Survey project (2005–2009). Maine has naturally high levels of arsenic and many well owners do not regularly test for arsenic because of the expense. The results were returned individually to each resident by mail. The results were also reported at two community meetings, one of which was covered by a reporter from the Eastport newspaper, the *Quoddy Tides*. Through this effort, residents in this low-income community were informed whether or not their drinking water had concentrations of metals that were above US Environmental Protection Agency (EPA) guidelines, and CEHS worked with the Maine Department of Public Health and EPA to point those families to ways to mitigate the problem. CEHS brought several tribal members to MIT about five times to teach them how to use the ICP-MS; the spectrometer was used to measure, in one run, 13 different metals relevant to health. Vandiver gave a very well-received plenary talk on this program at the meeting of the NIEHS Core Center directors in July 2018.
- In Massachusetts, COE2C has provided timely leadership to the communities of Malden, Everett, and Medford via the Mystic River Watershed Association and its sister organization, Friends of the Malden River. COE2C recognized the need for public access to clean water and open green spaces to promote a healthy lifestyle for all. The banks of the Malden River have been inaccessible to the public for decades—the river is fenced off to protect people from the river's legacy of industrial waste. To understand the current risks to using the river for recreation, COE2C, along with two other community partners (the Mystic River Watershed Association and Gradient Corporation), participated in sampling river water and sediments from the Malden River and produced a human health risk study on the use of the river for recreational boating. COE2C is currently contributing to events that are being planned to will report back to the communities. The human health

risk study revealed that the health risk is minimal for recreational purposes, such as rowing and kayaking on the river. The findings will be reported at several different public functions in partnership with the Mystic River Watershed Association and municipal and state officers. COE2C is pleased to have played a key role in promoting a healthy public use of the Malden River.

- In education, COE2C has continued to make strides in disseminating innovative teaching tools for molecular biology, funded by a generous grant from the J. M. R. Barker Foundation. Last year, working with the Edgerton Center, COE2C began to deliver DNA and protein classroom sets to each high school in Boston Public Schools and to provide workshops for teacher training. In November 2017, COE2C trained several additional teachers and completed delivery for a total of 30 classroom sets, each costing \$2,400. Overall, educators find the DNA and protein hands-on models help students learn the key concepts better in science, technology, engineering, and mathematics (STEM) curricula. COE2C continues to lead workshops to support local teachers and international teachers through Abdul Latif Jameel World Education Lab programs. COE2C continues to participate in the Cambridge Science Festival.

Annual CEHS Poster Session

For the 14th consecutive year, the center offered its popular Poster Session in April 2018, in partnership with the newly minted Superfund Research Program. This event attracted more than 100 participants, including CEHS members, Superfund Research Program members, faculty members, students, postdoctoral associates, scientists, and staff. The Myriam Marcelle Znaty Research Fund, administered by Professor Steven Tannenbaum, sponsored the cash prizes for the best poster presentations in both graduate student and postdoctoral associate categories. The CEHS Poster Session received overwhelmingly positive feedback in terms of promoting scientific exchange and collaborations, as well as introducing CEHS to the broader MIT community.

CEHS-Sponsored and Co-sponsored Lecture Series

In the past year, the center hosted seven Friday Forum lectures and two Superfund Friday Forum lectures. This long-standing series of informal research seminars is one of the most popular CEHS-sponsored events and has stimulated significant collaboration in environmental health research. New center members, potential members, Pilot Project award recipients, and Superfund Research Program members and centers, gave presentations. The format of the seminar series included opportunities for socializing both before and after the seminar. These opportunities for mingling have been a steady source of novel scientific collaborations.

The second CEHS-sponsored monthly seminar series is the Boston DNA Repair and Mutagenesis (DRAM) Seminar Series. The DRAM seminars bring together scientists from institutions throughout New England who share an interest in the mechanisms of genome maintenance and the consequences of mutations in humans and model organisms. This evening seminar series draws students, postdoctoral associates, and faculty from the University of Massachusetts Medical School in Worcester, Northeastern University, Harvard University, Boston University, Yale University, Tufts University, and Brown University. The DRAM seminar has become a vibrant part of the CEHS culture.

In addition, the center has continued to offer the New Frontiers: Postdoctoral Transition Seminar Series. The center recognizes the importance of having a great seminar as a credit for job interviews, and this seminar series is specifically aimed at providing postdoctoral associates with the opportunity to give and get feedback on their job talks. Talks are advertised to the entire CEHS community, which allows questions and offers advice to help in preparation for the postdoctoral associate's job interviews. Following the associate's presentation, there is a private meeting between faculty members and the speaker for a detailed discussion of speaking strategy, organization, and clarity. This format provides valuable feedback for postdoctoral associates, enabling them to hone their slides and talks in preparation for a competitive job market.

The center also continues to co-sponsor three named lectureship seminars with the Department of Biological Engineering: the Robert S. Harris, Gerald N. Wogan, and David B. Schauer Lectures. Deputy Director Sindura Ganapathi of the Global Health Program at the Bill and Melinda Gates Foundation presented the Gerald N. Wogan Lecture, "Saving Others and Newborn Lives: How Do We Innovate for SDGs?" in November 2017. Dr. Julie Gerberding, executive vice president for strategic communications, global public policy, and population health, and chief patent officer, at Merck & Co., Inc., presented the David B. Schauer Lecture, "Respect Your Biome: Can Precision Medicines Prevent Antimicrobial Resistance?" in September 2017. Professor Mary Lou Guerinot of Dartmouth College is scheduled to present the Robert S. Harris Lecture in September 2018. She is an expert on heavy metal uptake by plants.

Plans for 2018–2019

In the upcoming year, the CEHS leadership will be actively engaged in strategic planning discussions to reflect the evolution of the center's leadership and membership as well as the CEHS organizational chart. The CEHS center director and the deputy director will focus on the goals for AY2019, which are:

- To reassess the center membership, with the specific goals of attracting additional junior faculty and fostering relationships, where possible, between scientists and engineers;
- To stimulate center members' participation in the Global Environmental Health Sciences Program, because environmental pollution ignores geopolitical boundaries and the diseases of the developing world indirectly affect the United States;
- To reexamine the Career Development Program and the IHSFC, to make sure they are fully in concert with best practices in the field;
- To continue the center's dialog with members of the External Advisory Committee;
- To continue to make use of the Community Outreach Education and Engagement Core to showcase some of the exceptional research performed by center members to the community; and
- To continue to assess the temporary management of the Bioimaging and Chemical Analysis Facilities Core to develop a permanent management plan for financial sustainability. As always, the CEHS leadership will continue efforts to engage the broader MIT community, including the Environmental Solutions Initiative and the MIT Energy Initiative, in research activities related to environmental health sciences.

With the newly funded NIEHS Superfund Research Program, CEHS plans to expand the activities and seminars to incorporate a separate focus specifically for this program. This program also includes community work with Native American tribes in northern Maine and community work with populations in the Boston area.

The COE2C plans for AY2019 include two new initiatives: the Hawaii Vog Sensor Network and the development and production of an additional molecular biology teaching tool, the chromosome set.

- The Hawaii Vog Sensor Network, funded by an EPA grant awarded to Professor Jesse Kroll, a CEHS and Superfund Research Program member, is currently underway with additional urgency because of the recent eruptions on Hawaii Island. Vandiver will travel to Hawaii in September 2018 to provide teacher training workshops for the science kits designed to teach basic chemistry principles, including chemical reactions that produce that, a particulate pollutant created from volcanic sulfur dioxide gases. CEHS will be working with Hawaiian Pacific Islanders along with local partner organizations, including the Kohala Center, with about 15 different schools, and several health centers on the island.
- Additional molecular biology teaching tools for STEM classes for students in kindergarten through 12th grade are in development and will be put into production in the coming year. The goal is to teach about genetic variation in cells with colorful, hands-on models.

The COE2C team has successfully reached out to hundreds of people with educational activities this past year. The team used innovative CEHS-supported technologies to teach about the impact of the environment on health, including examples from air pollution and climate change as well as DNA damage.

With regard to global research efforts, CEHS will continue its ongoing collaboration with the Chulabhorn Research Institute in Bangkok, Thailand, which has been a developing world hub for environmental health research and training for many years. At any time, one to three students from the Chulabhorn network participate in internships at MIT in CEHS laboratories; some of that research is relevant to CEHS's Superfund efforts. The center's global program is now formally connected to its new Superfund Training Core. In addition, several center members have laboratories and strong commitments in Singapore, which is the locus of much CEHS research in the infectious disease arena. International partnerships give CEHS access to populations, which is critical to its translational mission.

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