Abdul Latif Jameel Water and Food Systems Lab

Climate change, urbanization, and a growing and evolving global population put tremendous stresses on the world's water and food supplies. MIT is pursuing a growing portfolio of research addressing these most basic human needs. The Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) is at the center of these efforts. J-WAFS stimulates, coordinates, and funds MIT research and student engagement across the entire Institute.

J-WAFS focuses on water and food systems to meet human needs through a portfolio of early-stage research grants, commercialization efforts, student funding and mentorship, and events that convene local and global experts. J-WAFS programs advance knowledge and innovation in support of resilient systems that can deliver safe and sufficient supplies of water and food for our changing world.

J-WAFS is the major funder of water- and food-related research on campus. This year, J-WAFS distributed $2.15 million to the MIT community through its annual funding initiatives and other programs, including research grants, graduate student fellowships, and various grants and awards for research, entrepreneurship, and career development activities. J-WAFS also manages ongoing sponsored research awards made through its research affiliate program, which connects corporate partners to MIT researchers working in the water and food sector.

In FY2019, J-WAFS-funded researchers achieved many successes:

- A major discovery in the basic science of microbiology as it relates to marine food production—a new family of viruses
- Over $4.1 million in follow-on funding secured by early-stage research projects supported by J-WAFS grants (over $12.5 million secured since the start of the grant program)
- New cross-institutional collaborations to address complex research challenges, among them: Université Cheikh Anta Diop de Dakar; University of São Paulo; Princeton University; University of California, Berkeley; and the Technical University of Madrid
- Relationships with policy makers and stakeholders with whom funded researchers have shared their findings, among them the Senegalese Institute for Agricultural Research, the Consultative Group for International Agricultural Research, the Confederation of Indian Industries, the Abdul Latif Jameel Poverty Action Lab South Asia, and others
- One spinout company, Xibus, launched through commercialization projects

This year, J-WAFS funded the third cohort of graduate student fellows, continued two student grant programs, launched a new collaborative research grant with the Indian Institute of Technology in Ropar (IIT Ropar), and produced and co-sponsored numerous events that helped disseminate our research results to industry professionals, other academics, and policy makers. In addition, the production of a 2018 workshop, "Climate

Change, Agriculture, Water and Food Security: What We Know and Don't Know," funded through MIT's Office of the Vice President for Research, has led to the launch, in June 2019, of an 18-month research study. This study will expand upon the workshop outcomes and craft a research agenda supporting solutions at the nexus of climate change adaptation, food, and water.

J-WAFS' leadership and other members of its research community have also received international recognition in FY2019 for their work, receiving various honors and awards.

Finally, in early FY2019 the lab's name changed from "the Abdul Latif Jameel World Water and Food Security Lab," to "the Abdul Latif Jameel Water and Food Systems Lab," partnered with a tagline that captures its mission and goals: "Securing humankind's vital resources." The terms "food system" or "water system" refer to the broad array of activities, resources, and technologies—as well as related policies and economics—involved in the production, processing, transport, and consumption or use of food and water. These terms encompass issues as diverse as food and water safety, access to fertilizer, water purification, climate change, and the sustainability of water supplies and food production systems.

Highlights and Accomplishments

J-WAFS–Supported Researchers

With the addition of FY2019 grants, the MIT research community funded by J-WAFS since 2015 will include:

- 69 principal investigators (PIs) representing 21 MIT departments, labs, and centers, spanning all five schools
- 76 students (including PhD candidates, master degree candidates, visiting students, and undergraduates)
- 49 postdoctoral researchers
- 16 additional research staff

Seed and Solutions Grant Programs

Following a competitive review process, seven new seed grants—totaling more than $1 million—were awarded to nine MIT PIs in 2019. Three new 2018 J-WAFS Solutions commercialization grants and one renewal grant were awarded early in FY2019 following a rigorous proposal and review process conducted in FY2018. Another round of proposal submission and review was initiated in FY2019, with the announcement of new awards and renewal grants still pending at the close of the fiscal year.

Research Affiliate Program

J-WAFS' three-year research affiliate agreement with Xylem, Inc., which began in 2016, is supporting three sponsored research projects based in the Laboratory for Information and Decision Systems and the Department of Mechanical Engineering. Additional support from this research affiliate relationship included continued financial sponsorship

of the MIT Water Club, a J-WAFS graduate student fellowship (one semester), two J-WAFS Water Leader Travel Grants, and mentorship of MIT teams competing for the Water Innovation Prize. Xylem, Inc. has committed to renew funding for another three-year cycle. Their fourth sponsored research project is under review. Two additional projects will be determined in consultation with J-WAFS in the coming years, and support for graduate student fellowships and other student activities will continue.

Other Fundraising and External Engagement

J-WAFS received funding from the Indian Institute of Technology Ropar to launch a seed fund supporting new collaborative research addressing food, water, and agriculture in India. The agreement between IIT-Ropar and MIT was signed in April 2019, and the first call for proposals was announced in June. The grants will be offered as part of the MIT International Science and Technology Initiatives Global Seed Funds and administered in partnership with the MIT India program.

A gift from MIT alumnus Kishore Mariwala SM '59 has funded a second round of the J-WAFS Grant for Water and Food Projects in India. Grants were awarded in June 2019. Mariwala has committed funds for a third round of grants for FY2020.

Rabobank continues to support MIT students and student-led innovations in the food sector through the Rabobank-MIT Food and Agribusiness Innovation Prize. Rabobank increased the awards for the 2019 Prize to a total of $30,000 distributed to the first and second place winning teams.

Throughout FY2019, Professor John Lienhard has been involved in a cross-institutional effort with the Desalination Research and Innovation Consortium (DRINC) to put forward a proposal for a national grant from the US Department of Energy. DRINC is led by three US National Laboratories, including Lawrence Livermore, Argonne, and Idaho, and also involves desalination experts from MIT; Arizona State University; Northwestern University; University of California, Los Angeles; and industrial partners including Toray, Suez, and Evoqua. This spring, the proposal was selected as one of three finalists for this $120-million grant.

The creation of a part-time position of director of external relations has allowed JWAFS to increase its outreach and fundraising efforts. Two notable outreach events were day-long workshops featuring MIT research that J-WAFS organized for FoodShot Global (a collaborative platform of innovators, funders, and industry leaders), and the Vyla Alliance (a joint venture focusing on bringing technology to the dairy industry, including Land O'Lakes and Nestle, among others).

Student Engagement and Support

J-WAFS awards the Rasikbhai L. Meswani Fellowship for Water Solutions from an endowed gift that provides one semester of funding to advanced MIT PhD students. In FY2019, J-WAFS supported two doctoral students with these fellowships. In spring 2019, the two recipients of the FY2020 fellows were announced. This year, J-WAFS made awards under two additional grant programs that are open to MIT students and other researchers: the Grant for Water and Food Projects in India and the J-WAFS Water

Leader Travel Grant. FY2019 is the second year that each grant has been offered. J-WAFS both co-sponsors and provides mentorship to the leaders of the MIT Water Club and the MIT Food and Agriculture Club.

Events

J-WAFS events expose audiences both on and off campus to the innovative water and food systems research that J-WAFS supports across the Institute. FY2019 events produced by or co-sponsored by J-WAFS included the Seed Grant Research Workshop (September 2018), an IAP workshop on strategies for sustainability and resilience for smallholder farming, the Water Innovation Prize, the Rabobank-MIT Food and Agribusiness Innovation Prize, and outreach events mentioned above.

J-WAFS Grant Making and Research Support

Fueling water and food systems research is the core of J-WAFS' mission and forms the base of its programming and other activities. Principal funding mechanisms are the J-WAFS seed grant program and the JWAFS solutions program. The J-WAFS seed grant program provides grants to support new research initiatives that have the potential to have significant impact on issues and challenges related to the world's water and food supply. J-WAFS solutions grants support translational water and food systems research with the intent of moving technology from the laboratory to market. Both grant programs are run annually, with FY2019 being their fifth year.

Several additional J-WAFS funding streams continued in FY2019, including graduate student fellowships, sponsored research projects funded by the research affiliate program, the J-WAFS Grant for Water and Food Projects in India, and the JWAFS Water Leader Travel Grant. The MIT-IIT Ropar Fund agreement was finalized in FY2019, and the first call for proposals was distributed in June 2019.

J-WAFS Seed Grants

FY2019 Seed Grants Process and Awards

In spring 2019, J-WAFS awarded seven new J-WAFS seed grants. These competitive grants provide two years of research support, free of overhead, to MIT faculty and other principal investigators.

Seed grants serve as important catalysts for new research, and also have a profound impact on the research trajectories and careers of the funded PIs, students, and researchers. The grants have been particularly transformative for the junior faculty and for the MIT PIs who are new to water and food as a research subject. In addition, over the last four grant cycles, this program has catalyzed important research collaborations and partnerships both within and outside of the Institute, prompted novel cross-disciplinary research discoveries, and informed new research practices and teaching methodologies.

The FY2019 seed grant request for proposals attracted submissions from 34 principal investigators, nearly one-third of whom were proposing to J-WAFS for the first time. A peer review process involving more than 50 faculty and research associates from across the Institute resulted in the selection of seven new projects led by nine PIs,

representing all five schools. The nine funded faculty members collectively represent eight departments and labs, including the Departments of Civil and Environmental Engineering, Mechanical Engineering, Chemical Engineering, Chemistry, and Economics—as well as the Media Lab (School of Architecture and Planning), MIT D-Lab (Office of the Vice Chancellor), and the Sloan School of Management.

The projects, which will begin on September 1, 2019, will explore new approaches to ensure safe drinking water, develop support tools for smallholder farmers, and combat food safety challenges.

Approaches to Ensure Safe Drinking Water

Understanding Effects of Intermittent Flow on Drinking Water Quality

PI: Andrew J. Whittle, Edmund K. Turner Professor in Civil Engineering, Department of Civil and Environmental Engineering

Nearly one billion people worldwide receive their drinking water through underground pipes that only operate intermittently. In contrast to continuous water supplies, pipes like these that are only filled with water during limited supply periods are vulnerable to contamination. However, it is challenging to quantify the quality of water that comes out of these pipes because of the vast differences in how the pipe networks are arranged and where they are located, especially in dense urban settings. Andrew J. Whittle addresses this problem by gathering and making available more precise data on how water quality is affected by how the pipe is used—i.e., during periods of filling, flushing, or stagnation. Supported by a seed grant, he and his research team will perform tests in a section of abandoned pipe in Singapore, one that is still connected to the urban water pipe network. By controlling flushing rates, monitoring stagnation, and measuring contamination, the study will analyze how variances in flow affect water quality, and evaluate how these data might be able to inform future water quality studies in cities with similar piped water challenges.

Microparticle Systems for the Removal of Organic Micropollutants

PI: Patrick Doyle, Robert T. Haslam (1911) Professor of Chemical Engineering, Department of Chemical Engineering

Wastewater from industrial and agricultural processes often contains solvents, petrochemicals, lubricants, pharmaceuticals, hormones, and pesticides, which can enter natural water systems. While these micropollutants may be present at low concentrations, they can still have a significant negative impact on aquatic ecosystems, as well as on human health. Because of the low concentrations in which they occur, the challenge is in detecting and removing these micropollutants. For this project, Patrick Doyle will develop a system to remove a variety of micropollutants at even the smallest concentrations using a special hydrogel particle that can be "tuned" to fit the size and shape of particular particles. Leveraging the flexibility of these hydrogels, this technology can improve the speed, precision, efficiency, and environmental sustainability of industrial water purification systems. It can also improve the health of the natural water systems upon which humans and our surrounding ecosystems rely.

Support Tools for Small-holder Farmers

Designing Supply Chain Platforms for Smallholders in Indonesia

PI: Joann de Zegher, Maurice F. Strong Career Development Professor, Sloan School of Management

More than half of food calories consumed globally—and 70% of food calories consumed in developing countries—are supplied by approximately 475 million small-holder households in developing and emerging economies. These farmers typically operate through informal contracts and processes, which can lead to large economic inefficiencies and lack of traceability in supply chains. Joann de Zegher seeks to address these challenges by developing a mobile-based trading platform that links small-holder farmers, middlemen, and mills in the palm oil supply chain in Indonesia. Rapid growth in demand in this industry has led to high environmental costs, and recently, pressure from consumers and nongovernmental organizations (NGOs) is motivating producers to employ more sustainable practices. However, these pressures deepen market access challenges for small-holder palm oil farmers. Her project seeks to improve the efficiency and effectiveness of the current supply chain, and create transparency as a byproduct.

Designing Purely Weather-Contingent Crop Insurance with Personalized Coverage to Improve Farmers' Investments in Their Crops for Higher Yields

PI: Robert M. Townsend, Elizabeth and James Killian Professor of Economics, Department of Economics

Robert M. Townsend is leading a research effort to improve access to crop insurance for small-holder farmers, who are particularly vulnerable to weather-related crop failures. Crop cultivation worldwide is highly vulnerable to unfavorable weather. In developing countries, farmers bear the financial burden of their crops' exposure to weather ravages, the extent of which will only increase due to the effects of climate change. As a result, they rely on low-risk, low-yield cultivation practices that do not allow for the food and financial gains that can be possible when favorable weather supports higher yields. While crop insurance can help, it is often prohibitively expensive for these small-scale producers. Townsend and his research team seek to make crop insurance more accessible and affordable for farmers in developing regions by developing a new system of insurance pricing and payoff schedules that takes into account the widely varying ways through which weather affects crops' development and yield throughout the growth cycle. Their goal is to provide a new, personalized insurance tool that improves farmers' ability to protect their yields, invest in their crops, and adapt to climate change in order to stabilize food supply and farmer livelihoods worldwide.

Electrocatalytic Ammonia Synthesis for Distributed Agriculture

PI: Yogesh Surendranath, Paul M Cook Career Development Assistant Professor, Department of Chemistry

Access to affordable fertilizer is another challenge that smallholder farmers face. Ammonia is the key ingredient in fertilizers; however, most of the world's supply is produced by the Haber-Bosch process, which directly converts nitrogen and hydrogen gas to ammonia in a highly capital- and energy-intensive process that is difficult to

downscale. Finding an alternative way to synthesize ammonia could transform access to fertilizer and improve food security, particularly in the developing world where current fertilizers are prohibitively expensive. For this seed grant project, Yogesh Surendranath will develop an electrochemical process to synthesize ammonia, one that can be powered using renewable energy sources such as solar or wind. Designed to be implemented in a decentralized way, this technology could enable fertilizer production directly in the fields where it is needed, and would be especially beneficial in developing regions without access to existing ammonia production infrastructure.

Evaporative Cooling Technologies for Vegetable Preservation in Kenya

PIs: Daniel Frey, professor, Department of Mechanical Engineering, and faculty research director, MIT D-Lab; Leon Glicksman, professor of building technology and mechanical engineering, Department of Mechanical Engineering; Eric Verploegen, research engineer, MIT D-Lab

Even when crops produce high yields, post-harvest preservation is a challenge, especially to fruit and vegetable farmers on small plots of land in developing regions. The lack of affordable and effective post-harvest vegetable cooling and storage poses a significant challenge for them, and can lead to vegetable spoilage, reduced income, and lost time. Most techniques for cooling and storing vegetables rely on electricity, which is either unaffordable or unavailable for many small-holder farmers, especially those living on less than $3 per day in remote areas. The solution posed by an interdisciplinary team led by Daniel Frey, Leon Glicksman, and Eric Verploegen is a storage technology that uses the natural evaporation of water to create a cool and humid environment that prevents spoilage and dehydration, all without the need for electricity. This system is particularly suited for hot, dry regions such as Kenya, where the research team will be focusing their efforts. The research will be conducted in partnership with researchers from the University of Nairobi's Department of Plant Science and Crop Protection, who have extensive experience working with low-income rural communities on issues related to horticulture and improving livelihoods. The team will build and test evaporative cooling chambers in rural Kenya to optimize the design for performance, practical construction, and user preferences, and will build evidence for funders and implementing organizations to support the dissemination of these systems to improve post-harvest storage challenges.

Sensor to Detect Food Adulteration and Contaminants

Learning Food and Water Contaminants Using Wireless Signals

PI: Fadel Adib, assistant professor, MIT Media Lab

Food safety is a matter of global concern, and a subject that several J-WAFS-funded researchers seek to tackle with innovative technologies. Food contamination and foodborne pathogens cause sickness and even death, as well as significant economic costs, including the wasted labor and resources that occur when a contaminated product is disposed of, the lost profit to affected companies, and the lost food products that could have nourished people. Fadel Adib, will receive a seed grant to develop a new tool that quickly and accurately assesses whether a given food product is contaminated. This food safety sensor uses wireless signals to determine the quality and safety of packaged food using a radio-frequency identification (RFID) sticker placed on the product's container.

The system turns off-the-shelf RFID tags into spectroscopes which, when read, can measure the material contents of a product without the need to open its package. The sensor can also identify the presence of contaminants—pathogens, as well as adulterants, that affect the nutritional quality of the food product. If successful, this research, and the technology that results, will pave the way for wireless sensing technologies that can inform their users about the health and safety of their food and drink.

FY2019: Concluding Seed Grant Projects and Milestones

Most of the funded projects supported by the 2016 round of two-year seed grants ended in September 2018, successfully meeting their research objectives. Several have exceeded expectations with new discoveries, publications in influential journals, and substantial awards of follow-on funding. A small number of projects are continuing with no-cost extensions of their grants.

Active Materials for Heavy Metal Extraction from Water

PI: Timothy Swager, John D. MacArthur Professor of Chemistry, Department of Chemistry

Over the last two years, a research team led by Professor Timothy Swager has been developing scalable designs for polymer-based membranes that can remove toxins such as lead and mercury from water at the molecular level. These membranes work by manipulating electrical charges to catch and release toxic metal ions. To date, the team has built and validated a prototype filter that can successfully remove both of these heavy metals, and has shown how it could be used at an industrial scale. The team has already secured financial support to build on its successful research results. A grant from the MIT Energy Initiative will support the application of the membrane production process toward the creation of high-performance fuel cells. Additionally, Professor Swager is now leading a new effort—with JWAFS-funded faculty members Jeffrey Grossman and T. Alan Hatton—that applies the filtration strategy developed as a result of this grant to the extraction of specific molecules from plants.

Bacterial viruses as pathogen control agents in aquaculture systems

PI: Martin Polz, professor, Department of Civil and Environmental Engineering

One of the many challenges that aquaculture farms face is population decline due to bacterial infection. Oysters and shellfish are particularly vulnerable to infection, and are often treated with large doses of antibiotics, which is not always effective at controlling disease. A J-WAFS seed grant supported Martin Polz and his research team to explore how engineered viruses might serve as an effective control to the bacteria responsible for disease and population loss. The team is working toward the creation of "virus cocktails" that suppress the growth of harmful bacteria. Because the use of antibiotics in aquaculture is so widespread, and is becoming less effective over time, viruses that are able to target specific harmful bacteria could serve as a sustainable alternative. Over the two-year grant period, the team has characterized and mapped virus/bacteria interactions to identify combinations of viruses that can stay ahead of bacteria's ability to evolve resistance. The resulting map is the largest assay of bacteria/virus interactions that has ever been achieved.

The mapping efforts undertaken during this research project resulted in a major breakthrough in the basic science of microbiology: the discovery of a new family of viruses, *autolykiviridae*. These viruses, found to be very common in the ocean in particular, look and behave very differently compared to other viruses, which is why they have previously gone undetected. While the research team is excited by the avenues for further exploration that this discovery has opened up, the development of bacteria-fighting virus cocktails is complicated. The team reports that more research is needed into cells' responses to virus infections, in particular how cells resist infection. This means that the development of a virus-based solution to aquaculture disease is farther off than they originally thought. However, they are continuing to explore this possibility. The virus discovery remains a major achievement all the same. In recognition of this research success, the Simons Foundation has provided approximately $3 million in follow-on funding to support further research into bacteria/virus interactions in order to move closer to the goal of producing an antibiotic-free solution to bacterial infection in aquaculture systems.

Real-time, On-site Detection of Foodborne Pathogens by Engineered Bacteriophage Integrated with Microfluidic Sample Preparation Platforms

PIs: Jongyoon Han, professor, Department of Electrical Engineering and Computer Science and Department of Biological Engineering; Timothy Lu, associate professor, Department of Electrical Engineering and Computer Science and Department of Biological Engineering

In food production and processing facilities, there is a large, unmet need for technologies that can quickly and precisely detect foodborne pathogens. Early detection allows companies and facilities to more effectively control outbreaks of foodborne disease, which reduces cost as well as the adverse health impacts that occur when contaminated food reaches the marketplace. A JWAFS seed grant supported the development of a platform that can quickly and effectively perform food safety testing. Using their expertise in microfluidics, they have built a high-throughput device that separates and concentrates cells in food samples (milk, meat, or vegetable juices). This is combined with a virus detection system that uses viruses engineered to specifically infect bacteria such as *Salmonella* and *Listeria*, and cause them to light up. By measuring the amount of light a sample gives off, one can determine the level of contamination. Based on the promising results of their first two years of work, Jongyoon Han's research group is now exploring how the technology might be used for water safety testing as well. He has currently issued a non-disclosure agreement with a company interested in bacterial detection for water-based heavy metals.

Estimating the Benefits to Strengthening Water Markets

PI: Christopher Knittel, George P. Schultz Professor, Sloan School of Management

How can economic policy promote more efficient water use in urban and agricultural contexts to adapt to rising water scarcity? This question guides a research effort led by Christopher Knittel. By compiling the first known complete data set capturing surface water allocations in California from 1980 to the present, the research team is painting a more accurate picture of water use in order to understand and quantify the economic and environmental benefits of water markets (i.e., selling, purchasing, and trading

water resources). These simulations have allowed the team to better understand and quantify how farm revenues change based on a wide range of surface water allocations, including where the water (and revenue) might flow if these water allocations were to be traded among farmers and with California cities. Among the successful outcomes of the work are the relationships Knittel and his doctoral student have built with state and independent agencies that are invested in future research results, such as the Department of Water Resources, the State Water Resources Control Board, and several brokerage and consulting firms that are involved in water pricing. In the next several months, the research team will be working with MIT's International Policy Lab to develop a policy brief aimed at these and other stakeholders. This work will be followed by a new research project, to be directed by Nick Hagerty (PhD '18), who worked closely with Knittel on this project. Hagerty is evaluating the impact of one of the first formal, local groundwater markets created in California. He will continue this research at the University of California, Berkeley—where he has accepted the position of the S.V. Ciriacy-Wantrup Postdoctoral Fellow in Natural Resource Economics and Political Economy in the College of Natural Resources.

Air Pollution Impacts on Global Crop Yields

PI: Colette Heald, professor, Department of Civil and Environmental Engineering, and Department of Earth, Atmospheric and Planetary Sciences

How does air pollution affect crop production? While much research has been done on the effect of ozone on crop health and yield, little research exists on the effect of particulate matter. Colette Heald noticed this research gap, and used a 2016 JWAFS seed grant to examine the effects of airborne particulate matter on crop yield. Combining crop production and atmospheric chemical transport models, her team created the first comprehensive estimate of the food production impacts of air pollution (both ozone and particulate matter). The team modeled current as well as potential air pollution scenarios for the year 2050, and incorporated data on possible future resource restrictions such as lack of nitrogen and water stress with future air pollution effects. The models demonstrated that, while ozone damages plants' leaves, particulate matter can diffuse solar radiation and thereby increase the sunlight available to plants, offsetting some projected ozone damage. However, the research results also revealed a great degree of variability, demonstrating the uncertainty of the overall impact of particulate matter on global crop yields.

Completed Projects with No-cost Extensions for Continuation

Leverage Points: Opportunities for Increasing Food Production in Developing Countries

PIs: Dennis McLaughlin, professor, Department of Civil and Environmental Engineering; Erica James, associate professor of medical anthropology and urban studies, and director, MIT Global Health and Medical Humanities Initiative, Department of Urban Studies and Planning

In this 2015-funded seed grant project, Dennis McLaughlin and Erica James led a team combining ethnography with quantitative modeling and optimization methods to explore ways that food production might be increased in specific regions in India and Haiti. They assessed the benefits and drawbacks to switching from subsistence farming to cash crops, such as rice (in India) and cacao (in Haiti)—and, in the process,

transformed each other's approach to research and problem definition in important ways. In the case of Professor James, considerations such as groundwater use data are now factored into her analyses, along with interviews and the cultural factors she assesses as an ethnographer. In the case of Professor McLaughlin and his doctoral student Anjuli Figueroa, their analyses of water use and agriculture data are now accompanied by a new sensitivity to how social elements like family organization and gender roles play into farmers' crop and technology choices and farm productivity. The team has established important ties with institutions and policymakers involved with agricultural and natural resource development in both Haiti and India as a result of their work, and these connections are providing the foundation for follow-up efforts and further outreach.

A Bioassay-based Approach to Food Safety in China

PIs: Anthony Sinskey, professor, Department of Biology; Stacy Springs, director, MIT Center for Biomedical Innovation; Vishal Valdya, associate professor, Harvard Medical School

In countries with weak food safety regulations, where antibiotics and other drugs can be overused or misused in farming contexts, how can food quality be most effectively tested and assured? This question drives a research team from MIT's Biology Department, the Center for Biomedical Innovation, and the Harvard Medical School. Since the start of their grant in 2015, the team has built on prior work by systematically evaluating the toxicity of previously unstudied poultry medicines. The researchers' aim is to develop and validate a state-of-the-art in vitro toxicology assay that could be used in a proactive manner to evaluate the safety of chicken and other foods. To do this, they investigated an FDA food safety case involving a specific brand of dog jerky treats that was actually poisoning some dogs.

The resulting disease, Fanconi syndrome, is tied to chemical food contaminants from antibiotics, but the specific chemical compounds (or combination or number of compounds) that cause illness and death are yet unknown. The test that the team has developed uses a cell bioassay—in this case the kidney cells of dogs affected by Fanconi syndrome—to determine the precise array of chemicals present in the toxic dog treats they consumed. Ultimately, the team hopes to develop this into a testing methodology that can measure the presence, as well as the specific toxicity levels, of the particular food contaminants that are tied to use of antibiotics and other drugs by chicken- and other meat-producing farms.

Following the period of J-WAFS-funded research, the team will continue to work with the US Food and Drug Administration (FDA) to obtain more food samples from the Fanconi food safety case in order to test their bioassay strategy further. Five million dollars in follow-on funding from the Walmart Foundation, as well as $2.5 million in follow-on funds Hainan Airlines, will support MIT research on poultry supply chains in China, which will in turn guide the research team's efforts to determine the chemical adulterants they are looking for in the jerky treat samples. These funds are also supporting continued research into food safety and supply chains by another 2015-funded MIT research team comprising Retsef Levi, J. Spencer Standish (1945) Professor of Management, and Yanchong (Karen) Zheng, Sloan School Career Development Professor and KDD Career Development Professor in Communications and Technology.

FY2019: Continuing Seed Grant Projects

Purifying Water from Boron Contamination with Highly Selective Metal-Organic Framework (MOF) Membranes

PI: Zachary Smith, Joseph R. Mares Career Development Professor, Department of Chemical Engineering

Anthropogenic Soils of the Amazon: Origins, Extent, and Implications for Sustainable Tropical Agriculture

PIs: Dorothy Hosler, professor of archaeology and ancient technology, Department of Materials Science and Engineering; Heather Lechtman, professor of archaeology and ancient technology, Department of Materials Science and Engineering; J. Taylor Perron, associate professor of geology, Department of Earth, Atmospheric, and Planetary Sciences

Supermolecular Nanostructure Gels for Chelation of Arsenic from Drinking Water

PI: Julia Ortony, Finmeccanica Career Development Professor, Department of Materials Science and Engineering

What Controls Arsenic Contamination in South Asia? Making Sense of Two Decades of Disjointed Data

PI: Charles Harvey, professor, Department of Civil and Environmental Engineering

Printed Silk-based Colorimetric Sensors for Food Spoilage Prevention and Supply Chain Authentication

PI: A. John Hart, associate professor, Department of Mechanical Engineering; Benedetto Marelli, Paul M. Cook Career Development Professor, Department of Civil and Environmental Engineering

Novel Systems Biology Tools for Improving Crop Tolerance to Abiotic Stressors

PIs: David Des Marais, assistant professor, Department of Civil and Environmental Engineering; Caroline Uhler, Henry L. and Grace Doherty Assistant Professor, Department of Electrical Engineering and Computer Science and Institute for Data, Systems and Society

Assessing Climate Vulnerability of West African Food Security Using Remote Sensing Observations

PI: Dara Entekhabi, Bacardi and Stockholm Water Foundations Professor, Department of Civil and Environmental Engineering and Department of Earth, Atmospheric, and Planetary Sciences

2016 Seed Grants with No-cost Extensions

The original abstracts for these projects were reported in the 2016 Report to the President. Due to the no-cost extensions granted to each, the final outcomes will be reported in the FY2020 report.

Gravity Fingering during Water Infiltration in Soil: Impact on the Resilience of Crops and Vegetation in Water-stressed Ecosystems

PI: Ruben Juanes, associate professor, Department of Civil and Environmental Engineering

Waste to Food: Yarrowia Lipolytica as Protein and Lipid Production Platform

PI: Gregory Stephanopoulos, Willard Henry Dow Professor of Biotechnology and Chemical Engineering, Department of Chemical Engineering

J-WAFS Solutions Grants

The J-WAFS Solutions program provides one-year, renewable grants aimed to support the commercialization of early-stage MIT technologies. The program is currently supported by Community Jameel and administered in partnership with the MIT Deshpande Center for Technological Innovation. Through the program, annual grants of up to $150,000 are available to MIT research teams that meet the program's requirements for commercialization readiness.

In FY2019, one project has launched an open-sourced technology for a low-cost home water filter, and commercialization efforts are under way, supported by a social enterprise organization based in New Delhi, India. This organization, Development Alternatives, will establish a local manufacturing facility in Delhi and set up a supply chain and distribution strategy that supports the local economy.

2019 Solutions Projects

Decentralized Torrefaction for Producing High-yield, Irrigation-saving Fertilizer

PI: Ahmed Ghoniem, Ronald C. Crane (1972) Professor, Department of Mechanical Engineering

Currently, most of the world's fertilizers are produced in capital- and energy-intensive centralized facilities in North America, Europe, and China. As a result, rural farmers in the Global South often pay two to three times the cost of fertilizer than elsewhere. To meet this challenge, Ahmed Ghoniem is developing a technology that downsizes and decentralizes the production of organic fertilizer to make it easily available in rural villages through small-scale production. The process, biomass torrefaction, uses small-scale reactor units developed in Ghoniem's lab to heat agricultural residues (husks, stalks, and other organic materials that are otherwise considered waste) using conditions that turn this biomass into an alkaline, carbon-rich substance. When added to soils, plant growth is promoted and soil retention of nutrients and moisture is improved. The portable reactors can be latched onto the back of tractors or inside standard shipping containers and can perform the biomass processing in the field rather than at a centralized plant, reducing the cost of fertilizer and enabling rural, small-scale farmers to increase both their yield and their net income.

QuantiSoil: Commercialization of an On-site Soil Analysis System for Small-holding farmers

PIs: A. John Hart, associate professor, Department of Mechanical Engineering; Chintan Vaishnav, senior lecturer, Sloan School of Management, and academic director, MIT Tata Center for Technology and Design

Soil nutrient deficiency is one of the primary drivers of yield gaps. Fertilizers can help to reduce these gaps, but can be prohibitively expensive for some farmers in the

Global South and can, if misapplied, have a negative environmental impact. The use of sensors that accurately detect soil nutrient needs can help. When soil sensors provide accurate information to farmers, they can use expensive fertilizer more efficiently and reduce unnecessary applications, saving money and reducing the environmental impact of runoff. The research team of A. John Hart and Chintan Vaishnav has developed QuantiSoil, a soil sensor aimed at providing small-holder farmers with an accessible, affordable way to measure soil nutrients. This on-site soil analysis system uses printed ion-selective electrodes, combined with an electrochemical reader, to obtain actionable soil health information. J-WAFS Solutions funding is supporting the scale-up of this technology as well as field trials.

Manufacturing and Marketing E. coli *Test Kits to Promote Safely Managed Drinking Water and Improved Public Health in Nepal*

PIs: Jeffrey S. Ravel, professor, Department of History, and faculty lead, MIT-Nepal Initiative

In spring 2016, the MIT-Nepal Initiative funded the production and shipping of 2,000 low-cost, easy-to-use, and highly accurate water testing kits to Nepal. The wearable kits, designed by MIT D-Lab lecturer Susan Murcott, who is a researcher leading the FY2019 Solutions-funded work, provide a simple, accessible way to test the presence of *E. coli* in drinking water. The prototypes were used by the Environment and Public Health Organization (ENPHO), a Nepali non-governmental organization, to test water found in food trucks and mobile water tanks in the Kathmandu Valley in the wake of the April 2015 earthquake. Building on that success, a J-WAFS Solutions grant is supporting a collaboration of the MIT-Nepal Initiative, led by Murcott and Jeffrey Ravel, with ENPHO and its business subsidiary EcoConcern. The goal is to refine the design of these kits based on feedback from users in Kathmandu in 2016, as well as Murcott's subsequent kit design and implementation in Ghana, the Philippines, and Puerto Rico (after Hurricane Maria). The redesigned kits will be producible directly in Nepal, and the process should be transferrable to other developing-world settings.

FY2018 Project Receiving Renewal Grant in FY2019

Reducing Runoff and Environmental Impact of Agricultural Sprays

PI: Kripa Varanasi, associate professor, Department of Mechanical Engineering

2017 Solutions Grant Project that Concluded in August 2018

Detection of Pathogens Using Dynamically Reconfigurable Liquid Colloid Particles

PI: Timothy Swager, John D. MacArthur Professor, Department of Chemistry; Alexander M. Klibanov, Novartis Professor of Chemistry and Bioengineering, Department of Chemistry

This project received grants in both 2016 and 2017 to support the development of a handheld food safety sensor that uses specialized droplets—called Janus emulsions—to test for bacterial contamination in food. The droplets behave like a dynamic lens, changing in the presence of specific bacteria. These optical systems can indicate the presence or absence of bacteria, including *Salmonella* and *Listeria*, by analyzing the light

either transmitted through or emanating from these dynamic lenses. In addition to serving as a potential food safety sensor for the consumer market, the team is exploring how the product might be relevant to food processing equipment and HVAC systems as well. The research team launched a startup in September 2018 called Xibus Systems. That group is currently working on product development, and is focusing on *Listeria* detection as their first target market.

Development of Low-cost Water Filter Using Sapwood Xylem

PI: Rohit Karnik, associate professor, Department of Mechanical Engineering; Amy Smith, senior lecturer, Department of Mechanical Engineering, and founding director, MIT D-Lab

This project aims to address the largely unmet need to provide safe and affordable drinking water to low-income groups in India. The resulting technology, developed through a collaboration between researchers in MIT's Department of Mechanical Engineering and MIT D-Lab, is a low-cost water filter made of xylem tissue in wood that is capable of bacteria filtration. The product design was created in collaboration with an NGO and communities in the Uttarakhand region of India. The research team also produced standardized procedures that local entrepreneurs can use to manufacture and sell the filters. The team is currently working with a social enterprise organization based in New Dehli to commercialize the filter. Follow-on funding has included a Rasikbhai L. Meswani Fellowship for Water Solutions, which supported mechanical engineering PhD candidate Krithika Ramchander for one semester in FY2019 while she worked on the project. The research team has also received a J-WAFS Grant for Water and Food Projects in India to support the development of marketing and teaching materials to support dissemination.

In-situ Particle Characterization in Emulsions for Field-scale Quality Assurance in the Dairy Industry

PI: Sanjay Sarma, Vice President for Open Learning and Fred Fort Flowers (1941) and Daniel Fort Flowers (1941) Professor of Mechanical Engineering

In the dairy industry in India, milk procurement is challenging. The supply chain involves millions of small-holding farmers spread across the country. There are severe quality and safety concerns among consumers. The technology that was supported with a J-WAFS Solutions grant used optical methods to rapidly measure milkfat and protein through a portable, low-cost device designed to enable real-time analysis of and control over milk quality. The project team developed a prototype design, gathered feedback from potential users via a field-scale evaluation, and used these findings to refine their product design. As a result of this research and market testing, the team discovered that although the technology has some merits over existing state-of-the-art milk testing devices, it still was not able to adequately meet the needs of the target customers. Therefore, team members are now exploring ways the technology can be used for medical imaging in dermatological diagnosis.

Proposals and renewal requests submitted in response to the 2019 J-WAFS Solutions call for proposals were still under review as of the beginning of July 2019.

Developing Intelligent Selective Electrodialysis for 21st-Century Agriculture

PI: John H. Lienhard V, Abdul Latif Jameel Professor of Water and Food, and director, Abdul Latif Jameel Water and Food Systems Lab

While desalination technologies have been widely adopted for meeting industrial and municipal water demand, desalination has not yet been widely adopted in the agriculture sector. This is because conventional desalination technologies are costly. For this project, the research team intended to upgrade existing desalination technology in order to selectively remove minerals and salts in order to more efficiently meet the water needs of hydroponic agriculture, saving costs for fertilizers. As a result of more than 100 user interviews in the greenhouse sector in the US and Mexico, the research team assessed customer needs; the value of the savings in fertilizer, water and energy; the requirements for technology adoption; and market size. The team determined that the projected market in the agriculture sector was too small to be profitable.

Other MIT Research Funding

J-WAFS Research Affiliates Program

In FY2019, Xylem, Inc. continued as an active and engaged member of the J-WAFS Research Affiliate program. Now in its third year, this agreement is funding projects led by three MIT faculty members selected by Xylem to conduct sponsored research projects that address specific water sector technology challenges. In FY2019, Xylem made a commitment to renew its agreement for an additional three-year term. Xylem is also committed to student support, which entails providing financial sponsorship of the MIT Water Club, funding an annual one-semester J-WAFS Graduate Student Fellowship (offered each year of the three-year the agreement), sponsorship of the J-WAFS Water Leader Travel Grant, and mentorship of individual MIT students as well as MIT teams competing for the Water Innovation Prize. For the second year in a row, Xylem chose to host its annual gathering of top executives at MIT. J-WAFS collaborated in curating a series of presentations by MIT researchers about innovative water systems concepts being developed here.

J-WAFS Graduate Student Fellowships

In FY2019, two graduate students were funded for one semester each by the second round of fellowships: the Rasikbhai L. Meswani Fellowship for Water Solutions and the J-WAFS Graduate Student Fellowship (funded by Xylem, Inc., through the Research Affiliates program). In June, J-WAFS announced the awarding of the 2019–2020 fellowships.

2018–2019 J-WAFS Fellows

Two selected students were supported during FY2019: Krithika Ramchander, PhD candidate in the Department of Mechanical Engineering, and Andrea Karin Beck, PhD candidate in the Department of Urban Studies and Planning.

2019–2020 Fellowship Selection and Awards

During FY2019, two new students were selected for 2018–2019 fellowship awards; one "honorable mention" recipient was also selected. The three students receiving recognition are Sahil Shah, Peter Godart, and Mark Brennan.

2019–2020 Rasikbhai L. Meswani Fellow for Water Solutions

Sahil Shah is a PhD candidate in the Department of Mechanical Engineering. Currently, he is exploring the use of electrodialysis, which is a membrane-based desalination process. He seeks to decrease the cost and increase the energy efficiency of these systems. His solutions will be piloted in both on-grid and off-grid applications in India, supported through a collaboration with consumer goods maker Eureka Forbes and infrastructure company Tata Projects.

2019–2020 J-WAFS Graduate Student Fellow

Peter Godart is a PhD candidate in the Department of Mechanical Engineering. His current research at MIT focuses on improving global sustainability by using aluminum waste to power desalination and produce energy. The process enables recycled aluminum to react with water in order to produce hydrogen gas, which could be used in fuel cells or internal combustion engines to generate electricity, heat, and power for desalination systems.

Honorable Mention

Mark Brennan is a PhD candidate in the Department of Urban Studies and Planning. He is currently collaborating with a team of researchers at the MIT Sloan School of Management, MIT D-Lab, and the Department of Urban Studies and Planning on a J-WAFS-funded project that is investigating ways to increase the accessibility of irrigation systems to small, rural, sub-Saharan African farmers, with a specific focus on Senegal.

J-WAFS Grant for Water and Food Projects in India

In fall 2017, J-WAFS announced a new grant opportunity that provides $15,000 to MIT research teams for pilot-stage MIT projects that focus on water and food challenges in India that could benefit from the opportunity for on-the-ground research and testing. This grant opportunity, made possible by a donation from MIT alumnus Kishore Mariwala (SM ’59), now in its second year, is open to anyone in the MIT community (including faculty, students, and staff).

2017-funded Projects that Concluded in FY2019

Scaling a Decentralized Biomass Torrefaction Reactor for Localized Fertilizer Production that Improves Farmers’ Yields and Reduces Irrigation Needs

Project team: Kevin Kung, postdoc, Department of Mechanical Engineering; Alex Slocum, professor, Department of Mechanical Engineering; Ahmed Ghoniem, professor, Department of Mechanical Engineering

Access to affordable fertilizer is a challenge for rural farmers in the Global South. This JWAFS grant supported the launch of a pilot in Maharashtra, India, which brings portable, low-cost reactor units that convert post-harvest agricultural residues into organic fertilizer using torrefaction. Funding from this grant enabled the project team to interview more than 100 rural farmers in India to better understand their soil nutrient and water challenges, resulting in the development of a pre-commercial prototype and published papers. The grant has enabled the team to build relationships with local

research groups and secure follow-on funding. Additionally, the spinout company, Takachar, is seeking to scale up the prototype in India, as well as in Kenya. A grant of $350,000 was recently approved by the state of California to the team, including UC Berkeley collaborators, for further scale-up and testing. The project lead, Kevin Kung, also received a fellowship from Echoing Green in 2019 to continue his work with Takachar.

Conservation Credits for Groundwater Management

Project Team: Ariel Zucker, PhD candidate, Department of Economics; Nick Hagerty, PhD candidate, Department of Economics

In India, groundwater is the source of 85% of drinking water and more than 60% of water for irrigation. However, this has resulted in over-extraction that poses a challenge to current and future agricultural production. New strategies for water management are needed to conserve these scarce resources while also increasing food production. This JWAFS grant supported an experimental study being conducted in partnership with J-PAL (Abdul Latif Jameel Poverty Action Lab) South Asia to compare the use of conservation credits to the existing practice of providing micro-irrigation investment subsidies. The grant funded a pilot study to evaluate the feasibility and effectiveness of using conservation credits to manage groundwater, which produced promising results for using conservation credits to reduce water consumption. Funding for further scale-up to 2,000 farmers has been secured from the International Growth Center and the Weiss Family Fund.

2019-funded India Grant projects that will launch in FY2020

Piloting Evaporative Cooling Technologies to Improve Vegetable Shelf-life and Farmer Income in Western India

Project team: Eric Verploegen, research engineer, MIT D-Lab; Anish Paul Antony, postdoctoral researcher, MIT D-Lab

In India, 30% of the fruits and vegetables cultivated annually are lost due to insufficient post-harvest storage options. The lack of affordable and effective post-harvest vegetable cooling and storage poses a significant challenge for smallholder farmers that can lead to vegetable spoilage, reduced income, and lost time. This grant is supporting a research team to pilot a design for a novel, brick-based evaporative cooling chamber that is intended to limit the deterioration of fruit and vegetable harvest quality due to post-harvest wilting and ripening and to elongate shelf-life.

Development of Communication Materials for the Dissemination and Commercialization of an Open-sourced Xylem Water Filter

Project team: Rohit Karnik, associate professor, Department of Mechanical Engineering; Krithika Ramchander, PhD candidate, Department of Mechanical Engineering; Amy Smith, founding director, MIT D-Lab; Kendra Leith, associate director for research, MIT D-Lab; Megha Hegde, research associate, MIT D-Lab; Anish Paul Antony, postdoctoral associate, MIT D-Lab

Microbial contamination of drinking water is a major cause of health concerns for communities without access to sources of clean water. This MIT team has produced a water filter that uses the natural filtration capabilities of xylem tissue in wood. This

grant will fund the research team to prepare a suite of communications materials to accompany the filter, as well as to develop an outreach strategy that will support the commercialization of the technology in India. In collaboration with local NGOs, the team will create a website and develop additional supporting and educational materials,

J-WAFS Water Leader Travel Grant

In the spring of FY2018, with support from Xylem, Inc., J-WAFS introduced the J-WAFS Water Leader Travel Grant, offering travel grants to MIT graduate students to attend a major water sector conference. Two students—Tiziana Smith, then a PhD candidate in the Department of Civil and Environmental Engineering, and Haleemah Quireshi, a 2018 graduate of the Department of Urban Studies and Planning—were selected to receive funding to attend Stockholm World Water Week in August 2018. J-WAFS' Research Affiliate Xylem, Inc. is a sponsor with a strong presence at the conference. They were joined by two other MIT students who were supported with other funds from Xylem.

In June 2019, three students were selected to receive travel grants to Stockholm World Water Week in August 2019. They are Nadia Christidi, a PhD candidate in the Program in History, Anthropology, and Science, Technology, and Society (HASTS); Dai Lin, a master's student in the Program in Systems Design and Management through the School of Engineering and the Sloan School of Management; and Sophia Wu, a master's student in the Technology and Policy Program at MIT.

Engagement of the MIT Community

In addition to providing funding for research support across all schools at MIT, J-WAFS is invested in cultivating the water and food systems research community at the Institute. This involves producing, co-producing, and co-sponsoring on-campus events as well as providing mentorship to students and student groups.

J-WAFS Events

J-WAFS Research Workshop—September 14 and September 28, 2018

J-WAFS PIs presented updates on their work at this annual research workshop. Split over two days, the event gathered students, postdocs, and professors for presentations on 26 funded research projects across the Seed and Solutions grant programs, including six that had recently concluded.

The research workshop's goals are to nurture the water and food research community on campus and to provide a venue for PIs to present their research goals and progress and get feedback from faculty peers. Nearly 85 professors, researchers, MIT staff, and students attended the two-day event.

J-WAFS Research Seminars

- Toward sustainable seafood: The limits and possibilities of aquaculture certification (J-WAFS Visiting Scholar Mohammed Saidul Islam, associate professor in the Department of Sociology at Nanyang Technological University in Singapore)

- Urban food security in the age of vulnerability: The Singapore story (J-WAFS Visiting Scholar Mohammed Saidul Islam, associate professor in the Department of Sociology at Nanyang Technological University in Singapore)
- Climate change and food security in the Asia-Pacific: Response and resilience (J-WAFS Visiting Scholar Mohammed Saidul Islam, associate professor in the Department of Sociology at Nanyang Technological University in Singapore)
- Smallholder Farming: Strategies for Sustainability and Resilience (graduate student research panel)

Events for Corporate Outreach

J-WAFS Workshop for FoodShot Global—March 4, 2019

This workshop was for FoodShot Global, a collaborative platform of innovators, funders, and industry leaders. FoodShot is a relatively new initiative that brings together a few major companies in the food and agriculture sectors, including Mars and Rabobank—a J-WAFS funder—along with a number of large and small foundations and agriculture organizations. The workshop featured a multidisciplinary agenda showcasing MIT research, spinouts, and innovation programs for over a dozen FoodShot participants.

J-WAFS Workshop for the Vyla Alliance—June 14, 2019

This workshop was hosted for Vyla, a joint venture focusing on bringing technology to the dairy industry. Five corporate members representing Nestle, Land O'Lakes, and VAS, as well as the Vyla CEO, participated in a day-long workshop that showcased MIT research and spinouts involved in various aspects of food supply chains, food safety, and sensor technologies for the dairy sector—and food and agriculture more broadly.

Xylem Day at MIT—March 20, 2019

In FY2019, Xylem, Inc. hosted their annual senior leadership team meeting at MIT for the second year in a row. The company used this year's event as an opportunity to learn more about MIT research that could inform innovation in the various water technologies they deploy across the world. J-WAFS worked with MIT's Industrial Liaison Program to develop the agenda, and invited a number of J-WAFS–affiliated MIT students and faculty to present on their research. The event ended with a reception and banquet attended by MIT students, faculty, and J-WAFS staff. Xylem presented its Excellence in Innovation Award, and Gregory Norris from the MIT Materials Research Laboratory delivered a keynote lecture on sustainable supply chain assessment and "carbon handprints."

Co-sponsored and Collaboratively Produced Events

MIT Water Summit: Thirsty Cities—November 15 and 16, 2018

Event producer: The Water Club
J-WAFS Role: Co-Sponsor and Mentor

Participants from academia, non-profits, industry, and government gathered at MIT for the annual Water Summit. This event is organized by the MIT Water Club, a student group. It was supported by J-WAFS both financially through co-sponsorship and via the ongoing mentorship of the student organizing team by Renee Robins. The mission of this event is to explore current problems and potential solutions surrounding key water issues. A theme is selected each year and used as a lens through which to look at water sector challenges; this year's theme was "Thirsty Cities." Panels of experts spoke on topics such as water rights and negotiation, urban design, water management, and water sharing. More than 200 people attended from within and outside of MIT.

MIT Water Night—February 26, 2019

This event, also organized by MIT Water Club, celebrated water research of all kinds with an art- and science-filled event in Walker Memorial. The event included hands-on demonstrations, multimedia art and film, a poster session, and a keynote lecture by Richard Hyman, former member of Jacques Cousteau's diving team. Posters and projects were submitted by Boston-area students as well other members of the community, with research projects and creative work devoted to water.

2019 Water Innovation Prize—April 18, 2019

The MIT Water Innovation Prize—now in its fifth year—is yet another annual event organized by the MIT Water Club, and co-sponsored by J-WAFS and Xylem, Inc., among others. An entrepreneurship competition that awards up to $35,000 in prizes to student-led startup companies tackling water issues, it attracted 60 first-round proposals (twice the number as in 2017). Eleven student teams were selected to compete for $30,000 in cash awards. Finalist teams worked with mentors who supported their idea development and helped them formulate a final business plan and presentation.

The judges split the first-place award between SiPure, a startup that targets the Indian textile market with a silicone water filter, developed by MIT researchers, that can reclaim more than 98% of the water from the original textile wastewater stream, and Symbrosia, a startup that plans to pair methane reduction in cattle with sustainable shrimp farming. The second-place winner was Volta Irrigation, a startup from Rwanda that is developing a pedal-powered irrigation machine that uses smart water sensors to efficiently distribute water across farmland. In addition to co-sponsorship, members of the J-WAFS community were involved in the judging, including John Lienhard, Susan Murcott, and Karen Golmer of the MIT Deshpande Center.

2019 Rabobank-MIT Food and Agribusiness Innovation Prize—May 1, 2019

The Rabobank-MIT Food and Agribusiness Innovation Prize—now in its fourth year—is co-sponsored by J-WAFS. Renee Robins served as a mentor to the student organizers of the prize throughout the year. This event, modeled after the Water Club's Water Innovation Prize, is the premier innovation prize for student-developed food and agribusiness start-ups. It is sponsored by Rabobank—the largest bank in the world serving food and agribusiness clients—who provides the cash awards, as well as mentorship and opportunities for exposure. In 2019, Rabobank increased the total awarded to $30,000.

The event included a kick-off "generator dinner" to support the formation of student teams. Fifty first-round proposals were submitted in the winter, up from 30 submitted in the previous year. Seven finalist teams were selected to develop business plans and compete at the May pitch night. The judges awarded first place and $20,000 to Gramhal, an end-to-end digital and mobile-enabled solution for storage, credit, and sales to smallholder farmers in India. The second-place title and $10,000 award went to Velaron, a startup that seeks to create a first-ever marketplace for commercially farmed and traded seafood, helping to promote and achieve more sustainable aquaculture globally by enabling risk-hedging and trading.

Funded Project Outreach and Notable Relationships

In addition to the papers published in academic journals, PIs distribute their knowledge and research results through presentations at conferences and invited lectures. Countries where J-WAFS-funded researchers presented their work in FY2019 include Brazil, China, Costa Rica, Germany, South Korea, Norway, Spain, Taiwan, and the United Kingdom. They also presented in eight different American states.

PIs and research teams also initiated important new relationships with international stakeholders this year. In one example, the research team led by Professors Stephen Graves (Sloan School of Management) and Bishwapriya Sanyal (Department of Urban Studies and Planning) secured official research status and an affiliation with the West African Research Center. This partnership has played an important supportive role for their research on irrigation extension service policies in Senegal, including the facilitation of a collaboration with institutional partners in Dakar. These partners are helping to build a network of relevant researchers, institutions, and policymakers in the area. The team also involved students from the Université Cheikh Anta Diop de Dakar (UCAD) in their research trips and served in a mentorship role. UCAD is the country's primary public university. Additionally, the team developed relationships with three organizations in Senegal and is considering which among the three they will formally partner with as the research unfolds. They are: the Senegalese Institute for Agricultural Research, AfricaRice, and Prospective Agricultural and Rural Initiatives.

In another example, stakeholder engagement has been critical to the dissemination of research results. PI Christopher Knittel's project involving water markets in California built relationships with the California Department of Water Resources, the consulting firm and brokerage WestWater Research, the consulting firm ERA Economics, and the law firm Bolen Fransen Sawyers—with whom the team has shared results. The researchers have also discussed aspects of the project with the State Water Resources Control Board, the California Institute for Water Resources, and Atkinson Consulting Services.

Several other projects have developed external relationships. Ruben Juanes, who is leading a 2016-funded project on the behavior of water drainage in different soil types, has established a collaboration with Corina Tarnita and Simon Levin, professors in the Department of Ecology and Evolutionary Biology at Princeton University, and is working with them to incorporate the dynamics predicted by the MIT-developed models into field observations of grasses, trees, and termite mounds in semi-arid environments in Africa. Also, the research team led by Professor Gregory Stephanopoulos has discussed their project, engineered yeast that can convert food waste into Omega-3-

rich animal feed, with various dairy farmers and feed companies both in the US and internationally. These interactions have supported a better understanding of the market for livestock feed. Lastly, a cross-institutional partnership supported Antoine Allanore, a 2017-funded PI and assistant professor in the Department of Materials Science and Engineering, who is facilitating the testing of a new fertilizer that his team had developed by providing access to greenhouse space as well as agronomy expertise that are not available at the Institute. The J-WAFS grant gave them the freedom to partner with Allen Barker, a professor of plant and soil sciences at the Stockbridge School of Agriculture at the University of Massachusetts, Amherst. Professor Barker and his students tested the fertilizer in his greenhouse and the cross-institutional team published the results in January 2019.

Media Coverage and Communications Initiatives

J-WAFS emphasizes communications and outreach activities in support of our fundraising efforts as well as our overall visibility within and outside of MIT. Central to these efforts was a decision to change our name from the Abdul Latif Jameel World Water and Food Security Lab to the Abdul Latif Jameel Water and Food Systems Lab partnered with a tagline that captures our mission and goals: Securing humankind's vital resources. The new name and tagline was made public in September 2018.

J-WAFS' communications efforts were further amplified by media coverage from within and outside of MIT. In FY2019, 53 articles and blog posts were written about J-WAFS' work and funded research community members.

A communications priority for FY2019 has been a website redesign project that is slated for completion in September 2019. The new site will facilitate expanded content and search functions, providing better coverage and visibility of funded research and the J-WAFS community.

In collaboration with Abdul Latif Jameel and Community Jameel, J-WAFS continues to develop significant worldwide press coverage, especially in the Middle East and North Africa, including numerous articles in *Opening Doors Magazine* and social media amplification of our news content. Community Jameel also supported the production of a short video (and a version for social media) about J-WAFS, that accompanied the announcement of the name change.

In FY2019, J-WAFS expanded its staff with a new communications and project assistant. This full-time position is filled by a Northeastern University student for six-month appointments, which is part of the Northeastern co-op program.

J-WAFS continues to distribute its monthly email newsletter to nearly 1,700 contacts and to publish monthly articles about J-WAFS research and initiatives on the MIT News website.

Honors and Awards

- John H. Lienhard was elected as a fellow of the American Association for the Advancement of Science in recognition of his distinguished contributions to thermal science and engineering.

- Stephen Graves, the Abraham J. Siegel Professor of Management at the Sloan School of Management, was appointed to the National Academy of Engineering.
- Susan Solomon, the Lee and Geraldine Martin Professor of Environmental Studies, received Sweden's Crafoord Prize in Geosciences for her discoveries of the role of atmospheric trace gasses in Earth's climate system.
- Lienhard and Susan Murcott received MIT's Committed to Caring Award, honoring their commitment to teaching, student support, and student mentorship.
- Jonars Spielberg, a J-WAFS-funded PhD candidate in the Department of Urban Studies and Planning, received a 2019 Fulbright fellowship to study agricultural policy in Senegal.
- Sarah Fletcher, PhD '18 and current postdoc in the Department of Civil and Environmental Engineering, received first place in the PhD category for the American Water Works Association's Academic Achievement Award.
- J-WAFS-funded students and faculty have been recognized in:
    - *Forbes Magazine*'s "30 under 30" lists for 2019—You Wu PhD '18 and Kishor Nayar SM '14
    - *MIT Technology Review*'s "35 Innovators Under 35"—Shreya Dave '09, SM '12, PhD '16

Personnel

Core Team

The core J-WAFS leadership team consists of Professor John Lienhard, director and Abdul Latif Jameel Professor from the Department of Mechanical Engineering, and Renee J. Robins '83, executive director. Andi Sutton continues in the position of communications and program manager and Jasmine Edo continues in the position of financial and project coordinator.

To extend communications and outreach capacity, J-WAFS added a full-time, term-limited position of communications working with Northeastern University's co-op program for staffing. The position has been filled by Elia Knieriemen (July-December 2018) and Archana Apte (January-June 2019). Lisa Miller was hired in the spring to start at the beginning of July 2019.

In August 2018, J-WAFS hired Maren Cattonar to a part-time position as director of external engagement. The addition of this position has helped expand J-WAFS' capacity to engage with potential corporate and foundation sponsors, ensuring the visibility of MIT water and food research in these sectors.

To oversee the 2019–2020 research study on the future of climate and agriculture, J-WAFS hired Gregory Sixt in May 2019. Sixt holds a PhD in agriculture, food, and environment and water diplomacy from Tufts University.

Visiting Scholars

In fall 2018, Mohammad Saidul Islam, an associate professor of sociology in the School of Sciences and Asian School of the Environment at Nanyang Technological University Singapore joined J-WAFS as a visiting scholar. Professor Islam's research applies international development and environmental sociology to food systems, with a particular focus on industrial aquaculture, the global agro-food system, climate change, food security, and environmental sustainability.

Professor Chandra Madramootoo has been a visiting scholar with J-WAFS since 2016. In FY2019, he served as contributing editor of the culminating report on the J-WAFS 2018 expert workshop, "Climate Change, Agriculture, Water, and Food Security: What We Know and Don't Know," which will be released in fall 2019. Prior to 2018, Madramootoo was dean of the School of Agricultural and Environmental Sciences at McGill University in Montreal, a professor in the Department of Bioresource Engineering, and director of the Water Innovation Lab.

John H. Lienhard
Director
Abdul Latif Jameel Professor of Water and Food

Renee J. Robins
Executive Director