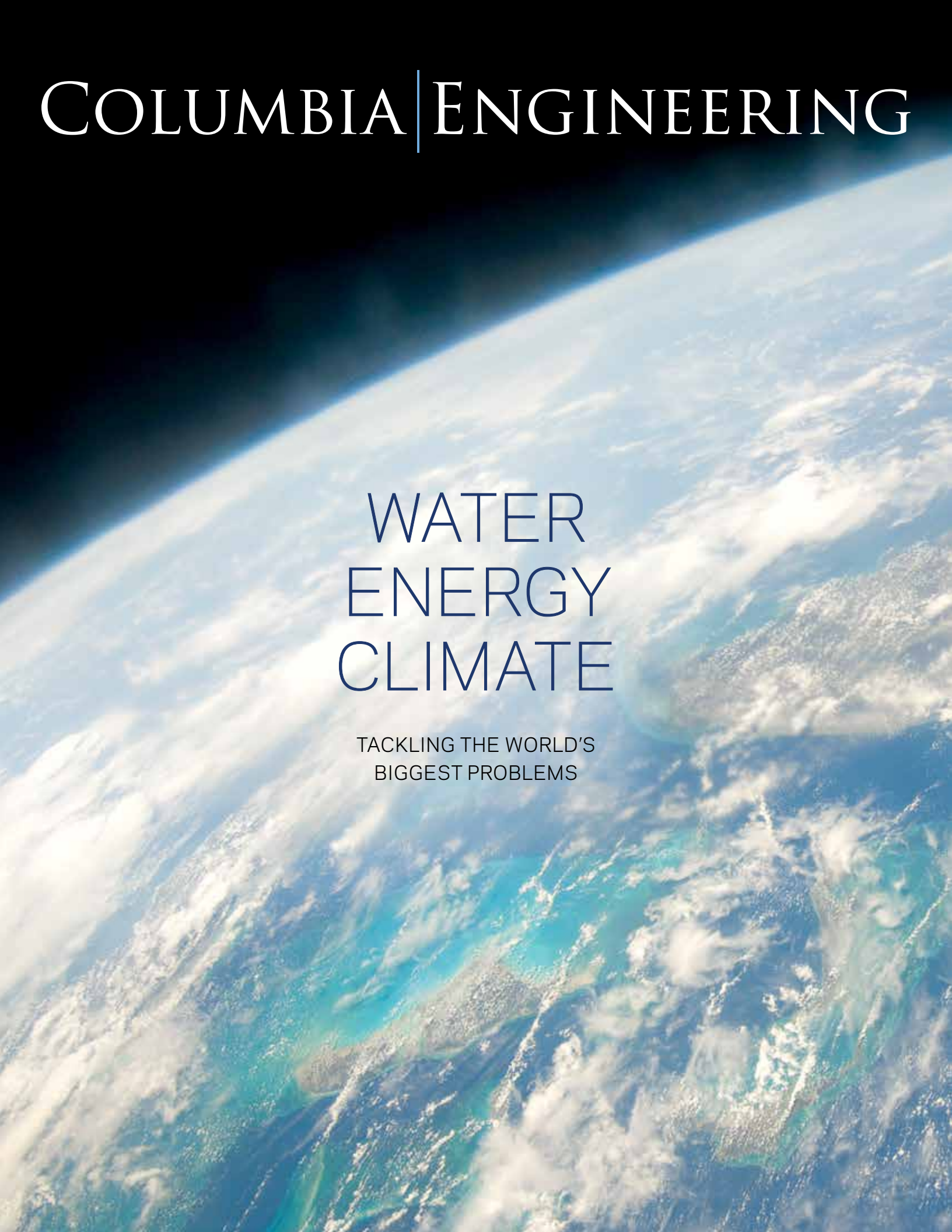
COLUMBIA | ENGINEERING



WATER
ENERGY
CLIMATE

TACKLING THE WORLD'S
BIGGEST PROBLEMS

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Our shared engineering mission today could never be more palpable or more important. We are inspired to confront the many challenges facing humanity, defining new frontiers and transcending disciplinary boundaries to bring novel solutions to these problems, and preparing the next generation to lead the future. Sustaining Earth while meeting the needs of an expanding population is one of the most daunting challenges of today.

In this issue, we highlight the research efforts of faculty who are tackling the complex global issues of water, energy, climate, and food production. They are leaders in Columbia's interdisciplinary Earth Institute and Data Science Institute and are conducting research critical to the health of the planet and its inhabitants.

You will read about four faculty members whose innovative approaches are helping to ensure water sustainability and about a life-changing rainwater harvesting project in Uganda by students in Columbia's chapter of Engineers Without Borders (see articles beginning on page 6).

This issue also gives a glimpse into the research of professors and their students who are advancing our understanding of energy. From providing microgrids in developing areas, to creating new materials for advanced batteries, to developing systems that combine photovoltaics and thermal technology to simultaneously produce electricity and hot water, our researchers explore unique approaches that will lead to energy sustainability (page 12).

Learn also about how faculty are deconstructing extreme weather and working to better understand the impact of water and carbon cycles on atmospheric dynamics and climate (page 20), including how seasonal cycles in the Amazon rain forest affect us all, no matter where we live.

An in-depth look at the research of Peter Schlosser (page 25) and V. Faye McNeill (page 26), coupled with highlights of work by faculty whose research interests initially may appear to have little connection to the environment, shows how their collective endeavors contribute to the resilience of the earth (page 29).

Other articles in this issue showcase our students, including the contributions of women engineers, who now make up a significant part of the student body; new courses that foster entrepreneurship and introduce data science; alumni whose work has an environmental footprint; and an introduction to new faculty who are taking their place among the best and brightest of their generation as they pursue their academic careers at Columbia Engineering.

Earth Day, which has been marked annually on April 22 since 1970, is a good time to reflect on what it will take to build a sustainable future and how we, as engineers, have an important role to play by inventing the technological tools to understand and solve the challenges that are critical to the future of life on Earth.

Mary Cunningham Boyce
Dean of Engineering
Morris A. and Alma Schapiro Professor

Pictured above: Dean Mary C. Boyce; *opposite page*: photoelectrochemical test cell in Daniel Esposito's lab (page 13). (Photos by Jeffrey Schifman)
Cover: A view of Earth from the STS-125 crew, which included Michael Massimino BS'84, professor of professional practice. (Image courtesy of NASA)

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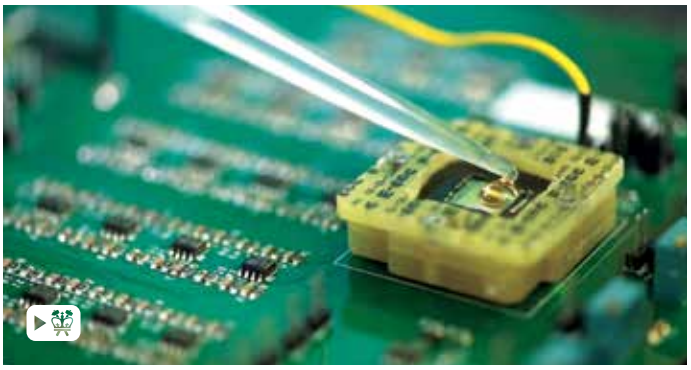
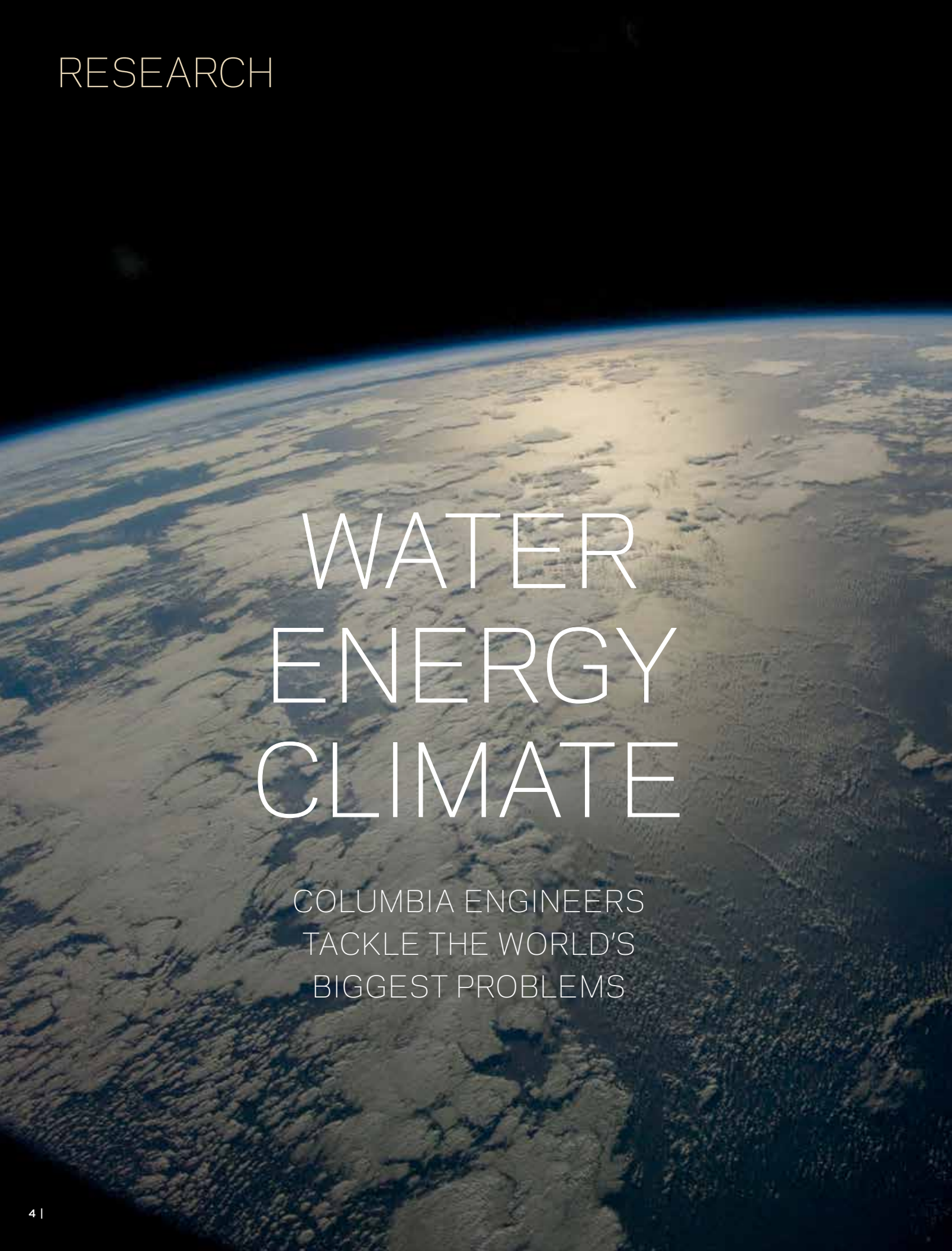
Tour Brookhaven National Laboratory with Professor Simon Billinge, who harnesses the world's newest and brightest synchrotron light source to predict the nanomaterials of the future. (Videos by Jane Nisselson)



Take a look at Professor Ken Shepard's Bioelectronics Systems Lab as researchers build the man-machine—interfacing biological materials directly with custom-designed chips.

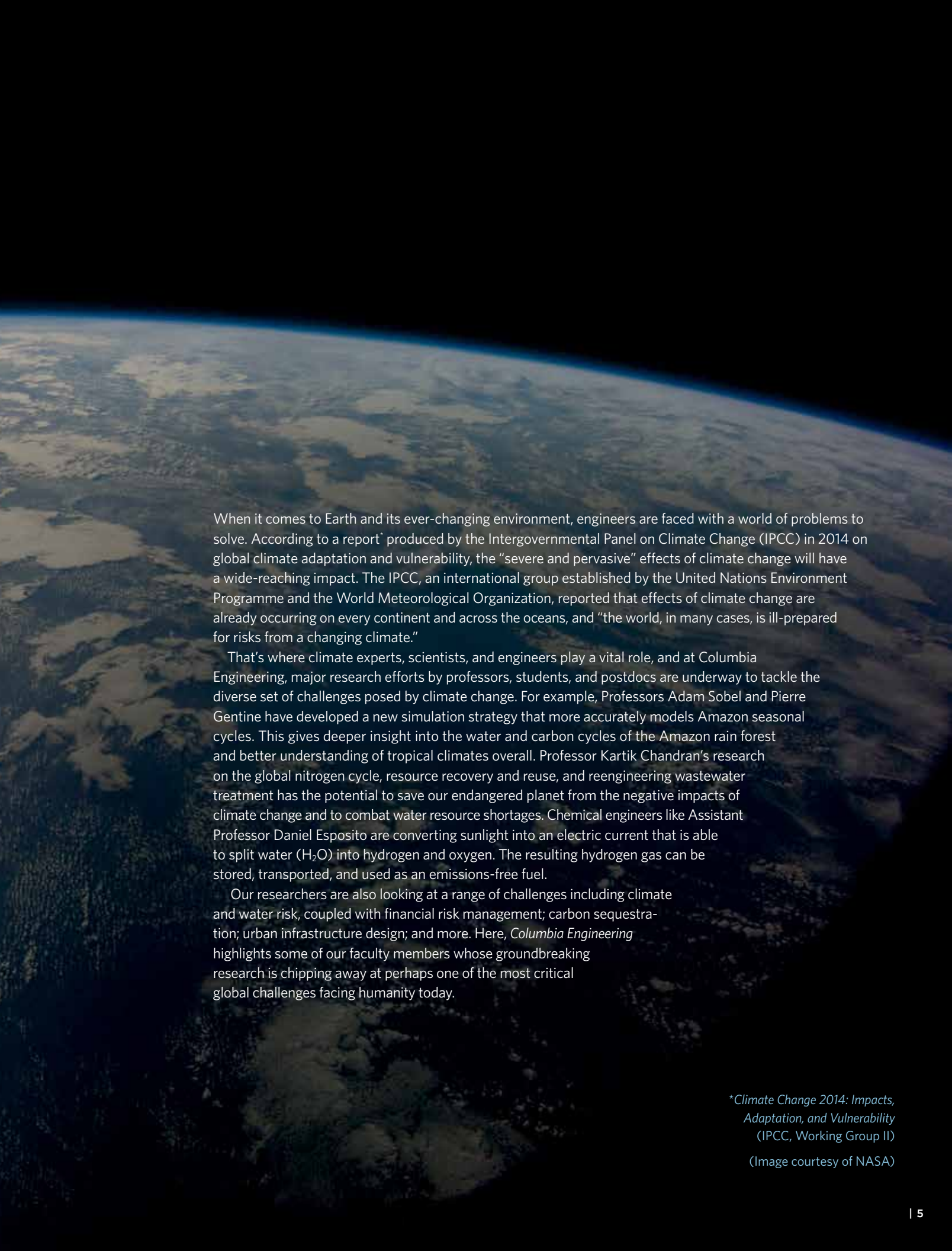
Materials science pioneer Katayun Barmak takes you behind the scenes at Columbia Nano Initiative's new Electron Microscopy lab where researchers probe the nature of materials at the nanoscale.

Find out how bacteria disrupt how we approach waste in a one-on-one with Professor Kartik Chandran and Professor Mike Massimino, former NASA astronaut. The second installment in our Extreme Engineering series.



WATER ENERGY CLIMATE

COLUMBIA ENGINEERS TACKLE THE WORLD'S BIGGEST PROBLEMS



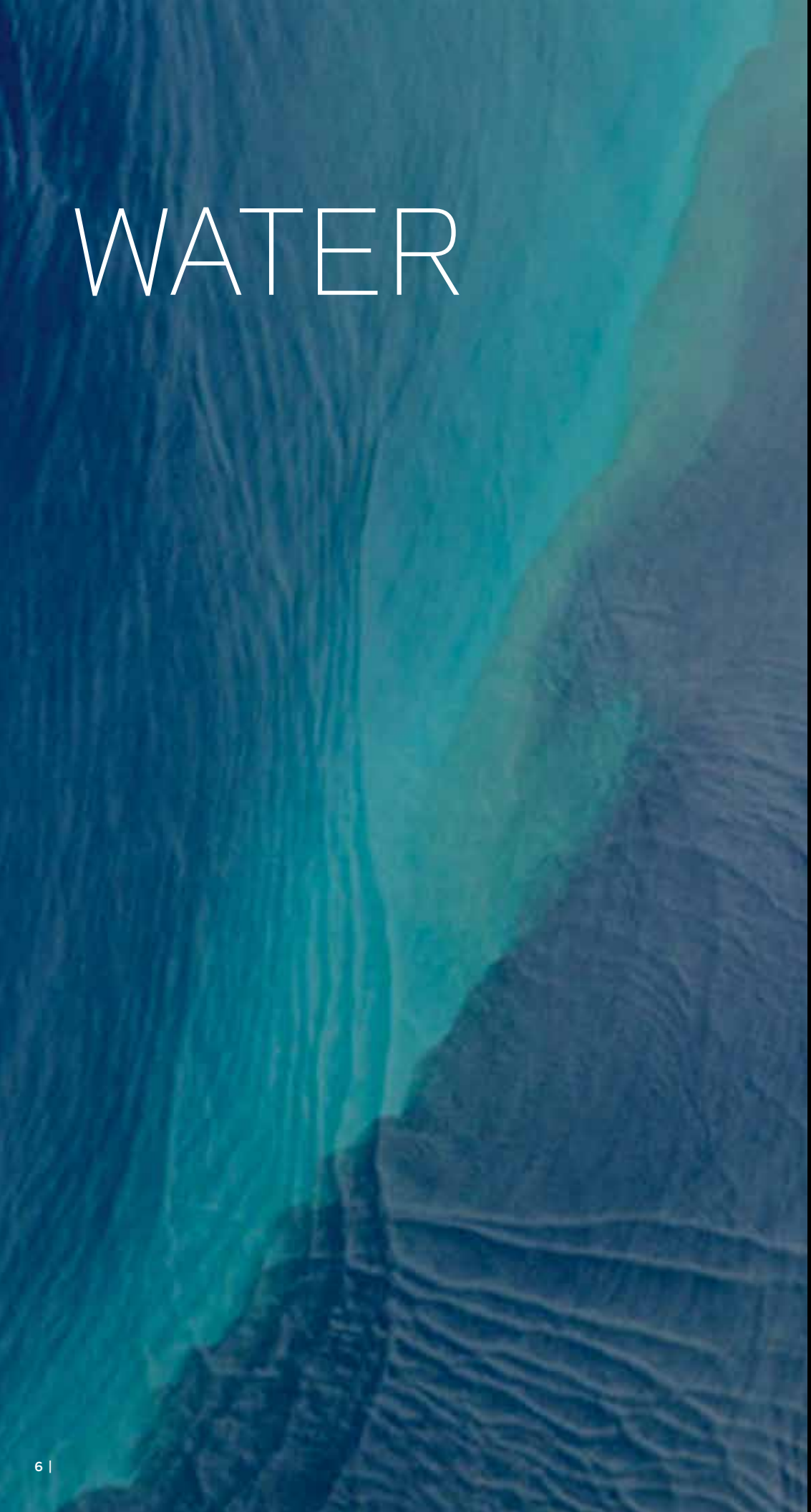
When it comes to Earth and its ever-changing environment, engineers are faced with a world of problems to solve. According to a report* produced by the Intergovernmental Panel on Climate Change (IPCC) in 2014 on global climate adaptation and vulnerability, the "severe and pervasive" effects of climate change will have a wide-reaching impact. The IPCC, an international group established by the United Nations Environment Programme and the World Meteorological Organization, reported that effects of climate change are already occurring on every continent and across the oceans, and "the world, in many cases, is ill-prepared for risks from a changing climate."

That's where climate experts, scientists, and engineers play a vital role, and at Columbia Engineering, major research efforts by professors, students, and postdocs are underway to tackle the diverse set of challenges posed by climate change. For example, Professors Adam Sobel and Pierre Gentine have developed a new simulation strategy that more accurately models Amazon seasonal cycles. This gives deeper insight into the water and carbon cycles of the Amazon rain forest and better understanding of tropical climates overall. Professor Kartik Chandran's research on the global nitrogen cycle, resource recovery and reuse, and reengineering wastewater treatment has the potential to save our endangered planet from the negative impacts of climate change and to combat water resource shortages. Chemical engineers like Assistant Professor Daniel Esposito are converting sunlight into an electric current that is able to split water (H_2O) into hydrogen and oxygen. The resulting hydrogen gas can be stored, transported, and used as an emissions-free fuel.

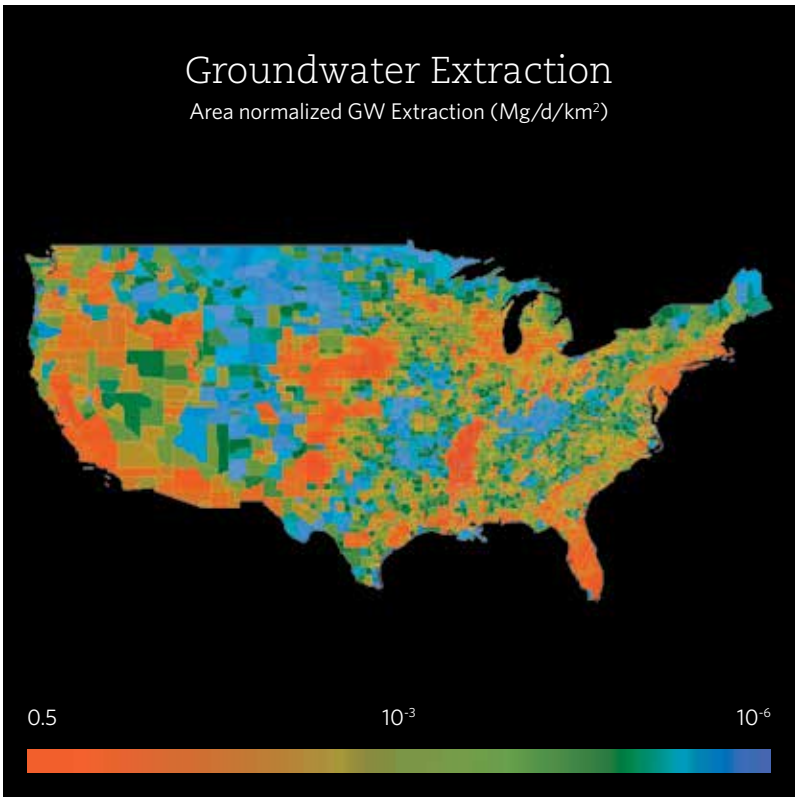
Our researchers are also looking at a range of challenges including climate and water risk, coupled with financial risk management; carbon sequestration; urban infrastructure design; and more. Here, *Columbia Engineering* highlights some of our faculty members whose groundbreaking research is chipping away at perhaps one of the most critical global challenges facing humanity today.

**Climate Change 2014: Impacts, Adaptation, and Vulnerability* (IPCC, Working Group II)

(Image courtesy of NASA)



WATER



H_2O Innovations: A Steady Flow of Solutions to Tackle the Global Water Crisis

Global water scenarios in the current and coming decades certainly sound dire, but then so do food and energy forecasts. More than 750 million people in the world today lack access to clean drinking water. That figure could triple as our population grows to more than 9 billion people by 2050, which is estimated to translate into a 55 percent increase in water demand. To feed everyone, food production must double and crop irrigation demands will rise. Energy production will also have to expand, but freshwater access is key to energy production. At the same time, water treatment and delivery require energy. Clearly, water sits at the intersection of all the critical issues facing humanity, which themselves are interdependent and currently out of sync.

Above: Increasing groundwater extraction from the deep aquifers in the US is leading to a significant decline of groundwater stocks that are used to buffer droughts. Upmanu Lall and his group are working on solutions for overall water management that can reverse this trend. (Image courtesy of Columbia Water Center)

Upmanu Lall is calling for a coordinated plan to ensure a reliable supply of water, energy, and food of appropriate quality for all life around the world by 2050. Policy makers have yet to launch a successful plan of action to this end. Despite the preceding figures, Lall, the Alan and Carol Silberstein Professor of Engineering and director of the Columbia Water Center, and his colleagues are still optimistic about the world's future water prospects—a future that simultaneously can address growing food and energy shortages.

To be sure, the deeper one digs, the more daunting these contemporary water challenges can seem, especially when viewed as part of the so-called water-food-energy-climate nexus. Under a business-as-usual scenario, global water demand will outstrip available supply by 40 percent by 2030, according to a 2015 report by the United Nations. Water infrastructure in much of the Western world has reached the end of its intended design-life, the replacement of which in the United States alone could cost $1.7 trillion by 2050 if it is to keep up with population growth. In the developing world, much infrastructure is in a state of disrepair, if it exists at all.

INNOVATION IN WATER SUSTAINABILITY

Clearly, it's time for a paradigm shift, and several Columbia Engineering researchers are at the forefront of efforts to design for sustainable water. "Suppose we were going to start at zero," Lall said, "and we're going to spend all this money [to address inadequate water systems]. What would you rather do? What would your infrastructure be? We seem ready to spend over a trillion dollars to replace our water infrastructure without a serious effort to design systems to address 21st century needs using innovative technologies." Patricia Culligan, professor of civil engineering and engineering mechanics, has headed up several projects that ask similar fundamental questions. For instance, would it make sense to combine distributed infrastructure elements with new and extant centralized infrastructure elements?

In most urban areas in the developed world, utilities rely on massive and centralized collection,

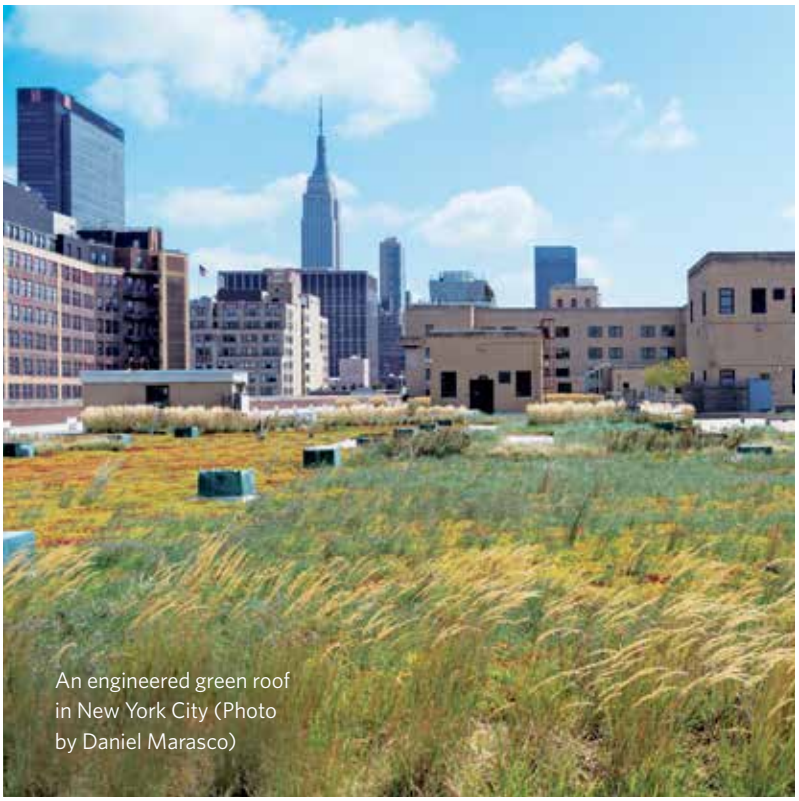
delivery, treatment, and sewage systems. Rather than replacing today's cracked and corroded pipes and other elements of these systems at high expense, water collection and treatment could be performed more locally, in a more distributed fashion. Utilities could also integrate rainwater harvesting, local groundwater usage, point-of-use treatment, and water reclamation and reuse.

Wastewater treatment, in particular, begs for rethinking and redesign. For instance, during extreme weather events, sewage pipes overflow with added storm water runoff, resulting in wastewater dumping into local bodies of water or the ocean. In cities in developing countries, and in other areas lacking such infrastructure, dumping of wastewater occurs daily, polluting local surface water and groundwater. Some communities have built so-called green infrastructure (GI) to mitigate this pollution, rather than simply expanding treatment plants and laying more pipe. Green roofs, green streets, rainwater gardens, and bioswales can absorb storm water runoff, while also cooling city blocks suffering from the urban heat-island effect during hot summers.

Culligan, who also codirects Columbia's Urban Design Lab and is associate director of Columbia's Data Science Institute, is very interested in the role that distributed infrastructure might play in mankind's future. She is leading a Columbia University team that is part of a $12 million project funded by the National Science Foundation (NSF) aimed at assessing how innovations in infrastructure design, technology, and policy can increase the sustainability, health, and livability of the world's cities. Culligan herself is focusing on the role of GI in preventing urban wastewater overflows, which are responsible for almost half of the pollution that goes into our rivers, lakes, and coastal water bodies. Increased decentralization of wastewater treatment through the widespread adoption of GI solutions could take the pressure off old municipal systems or enable new waterworks on a smaller scale in densely populated regions where a vast system is unattainable.

"A hybrid approach of centralized and decentralized infrastructure is necessary both in cities with aging infrastructure, like New York, and in rapidly growing urban settlements where significant numbers of people live without any infrastructure at all," said Culligan. Hybrid approaches, including solutions involving district energy systems, community solar energy, light rail, and localized urban food systems, offer opportunities for greater

Culligan is focusing on the role of green infrastructure in preventing urban wastewater overflows, which are responsible for almost half of the pollution that goes into our rivers, lakes, and coastal water bodies.

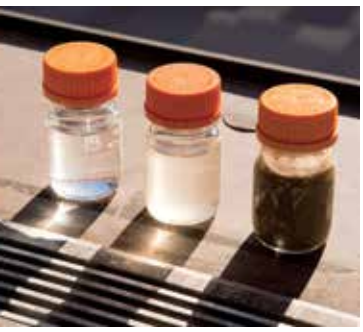


An engineered green roof in New York City (Photo by Daniel Marasco)

A section showing the different layers of an engineered green roof, from the base drainage layer to the upper vegetated layer (Photo by Tyler Carson)

Wastewater treatment, in particular, begs for rethinking and redesign.

Biofilm growth of complex microbial community capable of energy-efficient nutrient removal from nitrogen enriched "waste" streams (Photo by Jeffrey Schifman)



Below: Different wastewater treatment by-products (Photo by Jeffrey Schifman)

resource efficiency, including the better use and protection of our water resources.

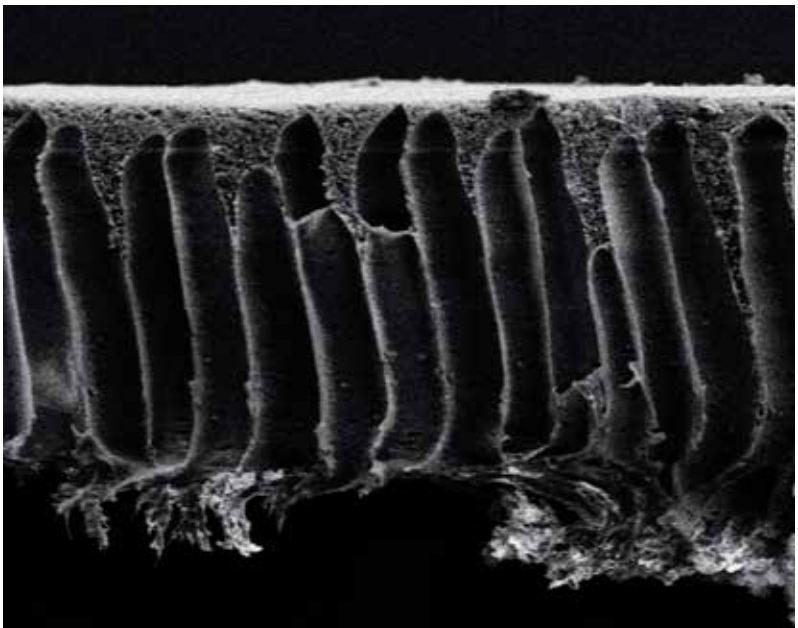
RECYCLE, REUSE

Water reuse systems with broad social impact are the research focus of Kartik Chandran, professor of earth and environmental engineering. He conceives of wastewater, or sewage, as exploitable enriched water rather than a repulsive by-product that requires disposal. At the same time, he questions whether it makes sense to clean wastewater to drinking water quality and then to use it for irrigation and dilution of waste streams. These insights have inspired Chandran and his colleagues to build bioreactors teeming with complex microbial communities that thrive on the waste we flush. The nitrogen cycling within these systems can remove pathogens and harmful chemicals as well as convert sewage into fertilizers, commodity chemicals, and energy sources.

Chandran's systems potentially can serve both the water and sanitation needs of billions of people on Earth who live in sprawling slums and lack access to piped water systems. "Some of our technologies are meant to take that [scarcity] out of the equation but still provide them with clean water, still provide them with sanitation," Chandran said.

Several years ago, Chandran helped New York City officials expand the capacity of five of its existing 14 wastewater treatment plants, in anticipation of the area's burgeoning population. He designed systems including bioreactors that removed from sewage not only carbon but also nitrogen pollution, a highly potent greenhouse gas. He has gone on to devise and optimize systems in locations such as the Chesapeake Bay and Los Angeles, and also in a remote region in Ghana where the only available resource was a continuous supply of truckloads of fecal sludge. Again applying his knowledge of microbial communities' consumption patterns, his system there derived some of the chemicals and energy required for treatment from the sludge itself, thereby offsetting a percentage of the required chemical and energy inputs.

Top: Upmanu Lall; *bottom*: Patricia Culligan (Photos by Jeffrey Schifman)



Cross-sectional scanning electron microscope image of a polymeric membrane. Membranes are at the heart of reverse osmosis technology, allowing only water to pass through while selectively filtering salts and other impurities. (Image courtesy of Ngai Yin Yip)

FROM WATER TO FOOD TO ENERGY AND MORE

That link between water management and improved energy efficiency is no accident. More communities and policy makers in recent years have seen the connections between water treatment, energy use, food production, climate change, and business. Trade-offs that improve one sector at the expense of another no longer make sense.

For instance, one innovation being embraced particularly in arid, highly water-scarce parts of the world is desalination—using reverse osmosis techniques to draw seawater through specialized polymeric membranes to filter out salt, yielding clean freshwater. Half of the world's population lives about 60 kilometers from a coastline, affording access to abundant seawater. However, desalination is energy intensive compared with other water collection and treatment methods.

Ngai Yin Yip, assistant professor in the department of earth and environmental engineering, studies the fundamental mechanism behind the transport of seawater through the membrane material. The goal is to use those insights to develop another material that desalinates more efficiently, likely in the range of a 5 percent to 30 percent improvement in performance. "Because the global desalination market is over tens of billions of dollars, even 5 percent will translate into a huge increase in productivity and cost reduction," Yip said.

All these water collection and treatment innovations certainly are essential, but a sobering fact remains. Consumptive water use, or use of water that is removed from the system and never replaced at the source, is dominated by agricultural and irrigation needs, followed by energy production needs. Yet, the water efficiency opportunities for irrigation and agriculture are seemingly obvious: reduce leaks in irrigation pipes, bank water, install drip irrigation and soil-moisture sensors, develop more water-efficient and drought-tolerant crops through breeding and genetic modification, optimize application of fertilizers, implement plant-growth

regulation techniques. Policy makers have adopted some of these "more crop per drop" solutions, but have not come close to exploiting their full potential.

Why haven't these approaches been put in place? Governance, said Lall, who has worked on myriad water systems all over the world. Whether it's in India or the United States, intelligent incentives, regulations, and enforcement tailored to local conditions typically are not in place. "So, we don't have a water crisis. We have a situation that is solvable," he said.

Like his colleagues, Lall advocates closed loop systems for energy, food, and water infrastructure and more reliance on renewable energy sources, which require dramatically less water to produce and deliver than fossil fuel–sourced energy. Increased free trade, he said, can also give nations and communities in emerging markets the cash necessary to invest in long-term, integrative, and sustainable water solutions, not to mention a higher standard of living.

For Chandran's part, his optimism feeds on many sources, including the success of his team's colorful bioreactors happily feasting on human and food waste in his labs on the ninth and tenth floors of the Mudd Building. It also helps that his graduate students share his drive to address social and environmental challenges. Every member of his introductory wastewater treatment design course last fall came up with novel systems for improving water quality that also used less energy than conventional approaches and recovered nutrients that industrialists and farmers alike desperately need.

By Robin Lloyd

Kartik Chandran (*left*) and Ngai Yin Yip
(Photos by Tim Lee Photographers)

Engineers Without Borders: Building a Global Community

For the students in Columbia's chapter of Engineers Without Borders (EWB), the club is more than just a chance to put their skills to use—it's a way to connect with the whole reason they're becoming engineers.

"One of the great things about Engineers Without Borders is that it's one of the best ways on campus for engineers to actually practice the skills they've been using in class," said copresident Wing-Sum Law '18SEAS.

Law, a mechanical engineering major who has been a member of EWB's Ghana project since her freshman year, has seen the group finish a 10-year project building source-separating latrines in Obodan, a farming village in the western part of the country. "Western aid has a history of failing when we've gone into developing nations. Engineers Without Borders has this model based on community partnership, which is really effective," Law said.

Columbia EWB designed and installed a rainwater harvesting system, which collects and treats precipitation.

EWB copresident Jamie Hall '17SEAS, a mechanical engineering major involved in the Uganda project (the Columbia chapter also runs a project in Morocco), said the group is looking for a new project after completing a rainwater harvesting system. "We've had a long and intimate history with water on the Uganda team," Hall explained. In 2011, Columbia EWB designed and installed a rainwater harvesting system, which collects and treats precipitation and supplies the Beacon of Hope Secondary School in Soroti with clean, potable water, helping reduce their dependence on the unreliable city water line. "When I visited the project in Soroti last summer, the system we installed was still in use."

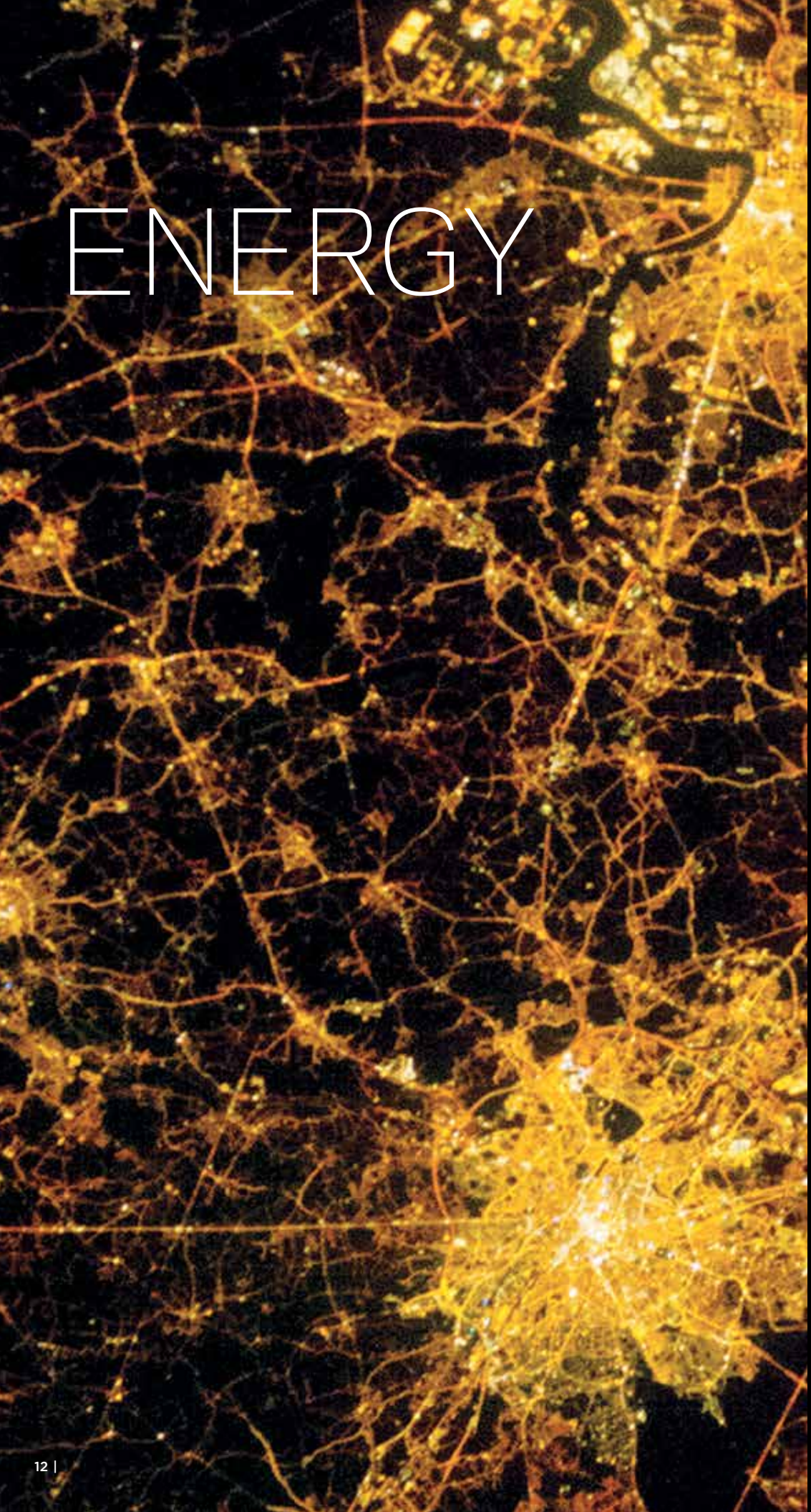
But while the projects are finished, both Hall and Law said their teams are in "constant communication" with their local partners to both monitor the existing projects and develop new goals and new work that will serve the communities.

"We know that what we do affects approximately 1,000 families—every decision we make has to be well thought out," Hall said.

Law agreed. "Engineering has this reputation of being super-technical, and I came to school for that," she said, "but at the end of the day, it's designing for people."

By Jennifer Ernst Beaudry

ENERGY



From All Corners of Engineering, Sustainable Energy Solutions in the Works

The societal imperative to improve the human condition, incomes, and well-being requires energy. Even a fraction of the prodigious amounts we use in the United States goes a long way. But our dependency on seemingly abundant fossil fuels like coal, oil, and natural gas has reached a tipping point. Their continued use and their associated emissions, if unchecked, threaten the health of our environment, with varying degrees of impact across the world. Now we face a complex problem: How do we assure clean, safe, sustainable, and low-cost energy resources for today and well into the future?

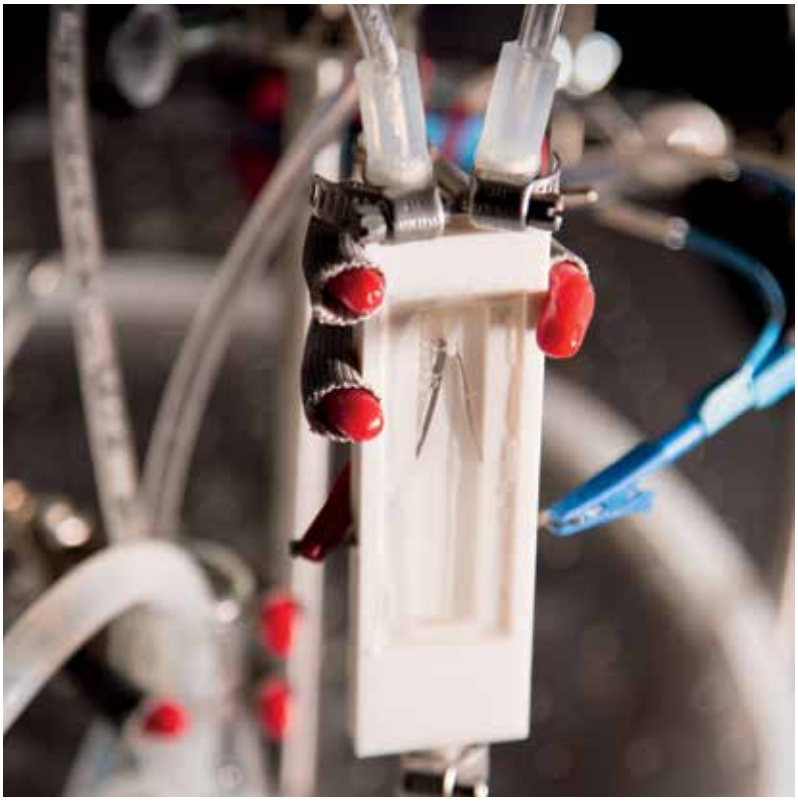
"Developing and deploying affordable, sustainable energy technology at a large scale is one of the grand challenges of our time," says Daniel Esposito, assistant professor of chemical engineering. "Columbia Engineering is strongly positioned to be an important player in the field of sustainable energy for many reasons, chief among them being a collaborative and interdisciplinary environment that leverages expertise across many disciplines for developing next-generation energy conversion technology."

ADVANCING SOLAR FUEL TECHNOLOGY

A growing global population requires a secure and abundant energy supply that is not only safer for the environment, but is also more affordable. One solution lies in two of the earth's most abundant materials: water and sunlight. Scientists like Esposito are converting sunlight into an electric current that is able to split water (H_2O) into hydrogen and oxygen. The resulting hydrogen gas—which can be referred to as solar fuel owing to its production from solar energy—can be stored, transported, and used as an emissions-free fuel.

"Solar fuels are highly attractive for a sustainable energy future because they can be converted into electricity or used directly for transportation, heating, chemical processes, and more," he explains. "Thanks to this versatility, solar fuels such as hydrogen offer an exciting opportunity for society to meet a higher percentage of its energy needs."

In his lab, Esposito focuses on two solar-to-hydrogen processes: photovoltaic electrolysis and photoelectrochemical (PEC) cell technology. In photovoltaic electrolysis, traditional solar panels produce electricity, which then powers an electrochemical device that splits water into hydrogen and oxygen. The PEC cell technology is similar to photovoltaic electrolysis, but combines the solar harvesting and water splitting processes in an all-in-one device.



Above: An electrochemical reactor, or electrolyzer, used for splitting water into oxygen and hydrogen fuel; *bottom*: Daniel Esposito (Photos by Jeffrey Schifman)

"Our goal is to advance these technologies by engineering innovative materials and devices that are more efficient, more durable, and easier to manufacture at a lower cost than existing state-of-the-art technologies," says Esposito. "To achieve that goal, collaboration is imperative. The basic operation of solar fuel technology is underpinned by interdisciplinary research

Side view of a photoelectrochemical test cell used for evaluating the performance of novel materials and electrodes employed for the direct conversion of sunlight into storable fuels such as hydrogen. Inset shows the same test cell from behind. The bright circle in the background is a Xenon Arc lamp that serves as the "artificial sun" for these experiments. (Photos by Jeffrey Schifman)

Below: Members of the Photoelectrochemical Engineering Lab at Columbia

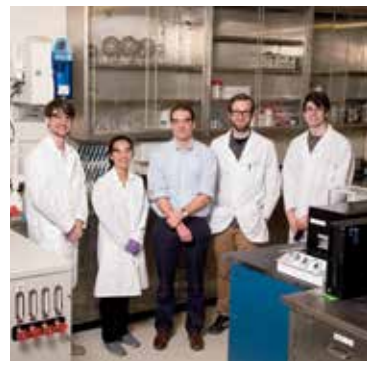
between materials science, physics, chemistry, engineering, and optics."

DEVELOPING MICROGRID TECHNOLOGY TO MEET ELECTRICITY DEMAND

Energy is an essential factor for sustainable development as well as for poverty eradication. But in 2015, the United Nations estimated that about 2.8 billion people still had no access to modern cooking fuels and that more than 1.1 billion did not have electricity.

"We must expand energy access to the poor as an urgent priority in our pursuit of sustainability goals," says Vijay Modi, professor of mechanical engineering. "Science and technology can help meet this challenge."

Modi collaborates with the Earth Institute at Columbia University for an interdisciplinary focus on sustainable development. Five years ago, Modi led a team to deploy 16 microgrid pilot programs to bring electricity to rural villages in Mali and Uganda. Their SharedSolar project



features a small solar power plant with battery storage that serves a local 220V AC microgrid providing battery storage for 20 families or fewer. The grids are regulated by a common smart controller that manages demand, supply, and individual customer accounts. Each customer-side connection is smart metered and users prepay for their electricity either via their cell phones or through a local vendor's phone. The system allows users to purchase electricity when they need it, in the amount they need, and with small payments, which is an important aspect of delivering power to the poor.

The system allows users to purchase electricity when they need it, in the amount they need, and with small payments, which is an important aspect of delivering power to the poor.

Local solar microgrid for rural families in Uganda (Photo courtesy of Vijay Modi)

"This was an opportunity for us to deploy a new technology on the ground in order to understand the customer side; the payment side; the maintenance, sustainability, and long-term viability of the system. We couldn't assume how this solution would be adopted without testing in the field," says Modi.

The microgrid system has proved successful as a reliable solution for early-stage energy needs in poor countries, with the World Bank, the African Development Bank, and others considering them as a potential for first electricity access. The project has also proved that microgrids are an ideal way to integrate renewable resources at a local community level.

"These underdeveloped populations using the microgrid technology are pioneers who are providing the initial market demand for a next-generation power system," says Modi. "This will inevitably lead to demand for more advanced microgrid operating systems that manage time-varying supply and diverse loads, as well as new innovations in wireless communication, low-cost energy storage, and super-efficient appliances."

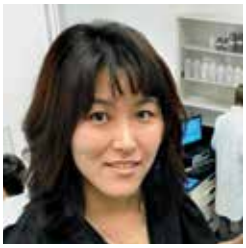
INVESTIGATING INNOVATIVE SOLUTIONS FOR CARBON CAPTURE AND UTILIZATION

Until alternative energy solutions are available for large-scale implementation, fossil fuel use will still predominate. So too will its emissions of carbon and greenhouse gases, which have a grave effect on our lives and environment around the world.

"As a society, we have never faced a more pressing or complex problem than carbon emissions," says Alissa Park, associate professor of earth and environmental engineering and chemical engineering. She is also the director of the Lenfest Center for Sustainable Energy.

Park and her colleagues have worked to develop innovative solutions to capture carbon emissions before they enter into the atmosphere. In the past, reducing carbon dioxide emissions meant three separate, complex—and expensive—processes to

Vijay Modi



Above, top: Alissa Park (Photo by Eileen Barroso); *bottom*: Rethinking waste to complete material cycles for sustainability like the steel slags pictured here, an example of the unconventional resources containing valuables including rare earth elements.

capture, transport, and inject them deep into rock formations at carefully selected safe sites for permanent storage. Park is focusing her research on *ex situ* carbon mineralization, a process of tuning chemical interactions with CO_2 to form solid carbonates.

"By converting CO_2 into solid carbonates, we won't need to monitor it or move it, compared to storing it as a high-pressure gas or liquid," she explains. Park's research has been called "the ultimate backup plan for carbon storage" because it remedies current carbon storage concerns about high-pressure gas underground and subsequent monitoring costs.

Park is using the mineral carbonation concept to treat iron and steel slag waste in China and recycle it for use in other industrial processes, improving the overall sustainability of how we use resources and materials.

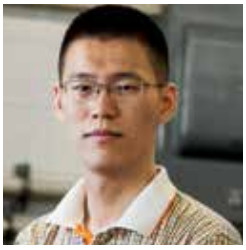
Her work is broadening the knowledge about the fundamental characteristics of the chemical reactions that produce viable *ex situ* carbon mineralization. It has also led her to investigate opportunities to accelerate carbonation of industrial wastes, and how the resulting material can be used for building and construction materials fillers. Park is using the mineral carbonation concept to treat iron and steel slag waste in China and recycle it for use in other industrial processes, improving the overall sustainability of how we use resources and materials.

"Remediating the global impact of carbon emissions requires a comprehensive and interdisciplinary focus," she says. "Developing energy sustainability solutions like carbon sequestration is a big task, but with a collaborative effort we are making progress."

By Amy Biemiller

Nanostructured hollow carbon fibers for high-capacity battery electrode (Reprinted with permission from *Nano Letters* "Hollow Carbon Nanofiber-Encapsulated Sulfur Cathodes for High Specific Capacity Rechargeable Lithium Batteries," coauthors Yuan Yang, Guangyuan Zheng, Judy J. Cha, Seung Sae Hong, and Yi Cui. ©2011 by American Chemical Society. Image by Guangyuan Zheng)

On the Verge of a Battery-Powered Revolution



Yuan Yang is interested in designing materials and devices to address energy and environmental challenges. (Photo by Timothy Lee Photographers)

High-performance energy storage devices will be key to a sustainable future, allowing cell phones to go longer between recharging, increasing mileage for electric vehicles, and stabilizing the power output of solar and wind energy. "Advanced batteries will be a game changer for addressing global challenges of energy sustainability and environmental stewardship," says Yuan Yang, assistant professor of materials science and engineering. "Now is a really exciting time to work in batteries and energy storage."

The world already knows the value of the lithium ion battery, the most common energy source for consumer electronics. It's lightweight and rechargeable. But at the same time, its cycling life and energy density are still not satisfactory for various applications, including electric vehicles. It also comes with safety concerns regarding overheating, which is a problem because lithium ion batteries contain a flammable electrolyte. One promising way to overcome these disadvantages is to develop higher-capacity materials inside the battery that can safely store more energy and then deliver a higher amount of electricity.

"Now a big focus of the battery community is developing high-capacity electrodes, such as metallic lithium negative electrodes," says Yang. "That's one major focus of my research."

Each lithium ion battery has a positive electrode and a negative electrode. The electrodes are surrounded by an organic electrolyte that contains a solution of lithium salt. Although metallic lithium negative electrode has high capacity, it tends to form thin conductive filaments, called dendrites, during the battery charging. These dendrites reduce the life of the batteries and can cause them to catch fire. In addition, lithium is so reactive that it can consume electrolyte through side reactions.

To solve these challenges, Yang plans to observe the nanoscale processes that

happen during lithium dendrite formation and develop solid electrolyte to suppress the growth of dendrites. He expects his research to advance the body of knowledge about the electrochemical reactions that happen inside the battery and to help industry design rechargeable batteries that operate at higher volumes. It could also help further understanding about how nanoscale materials interact.

Yang expects his research to advance the body of knowledge about the electrochemical reactions that happen inside the battery.

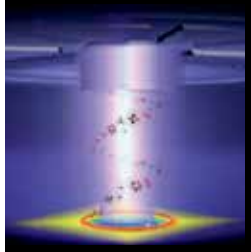
"We will use some novel tools to look inside the battery—something like X-ray imaging but at a much higher resolution, such as several nanometers, which is less than 1/10,000 of a human hair," explains Yang.

Collaboration will drive further advances in Yang's research and be essential to enhancing energy sustainability.

"Nowadays it is hard for a single scientist to grasp all techniques necessary for investigative research, and it is also difficult for one scientist to interpret all the data," he explains. "Collaboration is essential. It brings the expertise of different people together to tackle grand challenges of big problems, like energy sustainability."

By Amy Biemiller

Materials Engineering for a More Sustainably Built Environment



Solar photovoltaics is one of the world's most promising renewable energy technologies. By incorporating solar panels into roofs, skylights, or facades, sunlight can be converted into direct current electricity without harming the environment or depleting resources. Yet typical solar panels can waste a large portion of energy through heat dissipation and efficiency reduction at high temperatures.

But what if solar thermal technology—using that dissipated energy to heat water—could be combined with photovoltaics? That's the question Huiming Yin, associate professor of civil engineering and engineering mechanics, asked and answered by developing an advanced functionally graded material (FGM). His FGM makes it possible to efficiently marry photovoltaics and thermal technology with a novel building integrated photovoltaic thermal (BIPVT) system that produces both electricity and hot water.

"As a civil engineer, I see the problems with our aging civil infrastructure as a challenge to develop materials and designs to not only improve their durability but also enhance energy efficiency," he says.

Sustainable development—the balance of economic, social, and environmental objectives—is inherent in civil engineering and is what drives Yin.

"I am passionate about designing and developing new materials and integrating them into the envelopes of civil infrastructure for both energy harvesting and infrastructure protection," he explains.

His hybrid BIPVT research, which incorporates a rapid and stable method to manufacture the material, has garnered enthusiastic support from the National Science Foundation, the Department of Energy, and private industry.

"Now we are scaling up the manufacture and commercializing the technology," he says.

Key to Yin's research is a focus not only on hybrid materials development, but also on understanding and enhancing a longer lifecycle for structural materials. He established the Sustainable Engineering and Materials Laboratory

Right: Huiming Yin stands next to the Multifunctional Environmental Chamber at Carleton Laboratory used to reproduce climates, accelerate aging, and evaluate energy and environmental impacts. (Photo by Jeffrey Schifman)

Opposite page: A Horiba high-resolution glow discharge profiler for element analysis

at Columbia, in affiliation with the Carleton Laboratory, to deeply delve into investigating lifecycle performance characterization. He developed a multifunctional environmental chamber with industry partners to reproduce various service environments, provide accelerated aging stresses, and measure energy and mass flow in a system.

"There is an emerging need for experimental methods and facilities in lifecycle performance characterization. A longer lifetime of a structural material means a lower annual energy input," he explains. "I'm excited about this new research direction approaching the goal to improve the sustainability of civil infrastructure through discovery, design, and development of advanced materials, structures, and systems."

By Amy Biemiller

CLIMATE + EXTREME WEATHER

A New Approach to Modeling Amazon Seasonal Cycles

Sometimes, taking an approach that is opposite to conventional practice can lead to breakthrough science. That's the case in a research partnership between Pierre Gentine and Adam Sobel. The two have collaborated to develop a new simulation strategy that more accurately models Amazon seasonal cycles. This simulation strategy gives deeper insight into the water and carbon cycles of the Amazon rain forest and better understanding of tropical climates overall.

Detailed in a paper published in January in *Proceedings of the National Academy of Sciences*, the strategy is opposite to current climate models and employs Sobel's weak temperature gradient (WTG) approximation, which had only ever been used for simulations over the ocean. The paper's first author is Usama Anber, Sobel's recently graduated PhD student at Columbia's Lamont-Doherty Earth Observatory.

Below, top: Aerial view of the Amazon rain forest during its dry season (Image courtesy of NASA); *bottom*: Morning fog plays a key role in regulating evaporation and surface radiation in the wet season. (Photo courtesy of Xi Yang)

Opposite page: Hurricane Earl approaches the Bahamas. (Image courtesy of NASA)

"Pierre knew about the land-atmosphere interactions in the Amazon, while my team knew how to simulate tropical weather using the WTG methods in a cloud-resolving model," explains Sobel, professor of applied physics and applied mathematics, who has a joint appointment in earth and environmental sciences. "We didn't know if this approach would work, but it was worth a try."

Climate modeling of tropical rain forests like the Amazon has been problematic in the past because it can be difficult to mathematically represent the delicate interplay of natural variables in the region.

"Water vapor, clouds, and radiation interact with the large-scale circulation of the atmosphere to produce the complex patterns of tropical weather and climate. Making sense of these interactions requires us to piece together processes at multiple scales, since clouds are small while the global tropical circulation is huge," says Sobel.

Chief among inaccuracies of traditional approaches used to model the climate in the Amazon has been a mix-up in modeling the correct seasons for peak evaporation and photosynthesis rates.

"There are certain biases in traditional climate models that typically mix the subtleties of the Amazon wet and dry seasons," says Pierre Gentine, assistant professor of earth and environmental engineering.

But the new modeling approach is able to effectively simulate the climate of the Amazon, where the land and atmosphere interact in a feedback loop that determines the seasonality of precipitation and surface evaporation. That's important in helping better understand what controls climate in the Amazon and predict future climatic conditions for an area that has a big influence on the global climate. For example, the Amazon exchanges vast amounts of water and energy with the atmosphere and ocean, and regulates weather. It also replenishes, redistributes, and purifies much of the world's natural water resources and influences the circulation of ocean currents. Moisture created in the Amazon ends up falling as rain as far away as Texas. And

Adam Sobel (*left*) and Pierre Gentine
(Photo by Jeffrey Schifman)

because the Amazon absorbs 1.4 billion tons of CO_2 annually, it helps reduce global warming by lowering the earth's levels of greenhouse gases. Without that crucial modeling, it's difficult to understand what factors are affecting climate changes in the tropics—and elsewhere.

The model already has shown the key role that morning fog plays in regulating evaporation and surface radiation. Morning fog is present in the Amazon's wet season but absent in the dry season.

"Fog is very important because it shades the surface, so plants have less sunlight. That factor controls the seasonal cycle of the Amazon," explains Gentine. "This helps us better understand the carbon cycle as well. In the dry season, when there is no morning fog, plants receive more sunlight, thereby increasing evaporation and photosynthesis rates and using more carbon dioxide."

Sobel and Gentine now plan to use the new modeling approach to examine the carbon cycle, to see if they can better predict climate change in the continental tropics. Their approach allows them to simulate the ways in which CO_2 exchange at the land surface is related to clouds and atmospheric dynamics.

"How climate change plays out in the tropics depends on the interaction of clouds and the large-scale circulation. This is a fascinating puzzle, and our simulation strategy was designed specifically to help us solve it," says Sobel.

By Amy Biemiller

SEAS Scientists Explore the World's Ever-Changing Climate

Earth's climate is constantly changing. With this change comes an increased frequency of extreme and potentially devastating events like floods, droughts, and storms, which impact populations around the globe. Columbia engineers are working to shed light on what leads to climate variability, how humans play a role, and how we are all affected. Their research is an important part of worldwide efforts to better predict and prepare for the consequences of climate change. Here is a look at three researchers who are at the forefront.

DELVING INTO LARGE-SCALE CHANGES

Climate variability impacts food security, health, and economies. Mark Cane, G. Unger Vetlesen Professor of Earth and Climate Sciences and professor of applied physics and applied mathematics, investigates the disparities of climate past and present for better insight into how to understand, anticipate, and manage the impact.

"I would like to understand the physics of climate variations that impact people on our planet, including the ones we are now inflicting on ourselves," he says.

Cane has been studying the cyclical phenomenon known as El Niño—a complex weather pattern resulting from variations in ocean temperatures in the equatorial Pacific—for more than 30 years. When El Niño forms, it causes well-known patterns of extreme weather events around the globe. His research has informed better understanding of the impact of El Niño on human activity, including agriculture, health, and conflict.

Cane is also concerned that there's still no clear explanation for historically abrupt changes in the paleoclimate, such as a period known as the Younger Dryas—between 11,000 and 13,000 years ago—when the world slipped two-thirds of the way back into a full ice age in just one decade.

"It is disconcerting that we can't explain such a dramatic climate change," Cane explains. "We have done better with explaining smaller-scale changes, like droughts, in the last millennium, which are related to La Niña–like Pacific Ocean states (the opposite of El Niño). It seems that greater solar radiation makes these states more likely to experience droughts, though this idea is still somewhat controversial."

STUDYING WHAT SETS THE STAGE FOR STORMS

Better information about storm risks in the current climate (and in the future) could help societies take actions to be more resilient through better infrastructure and risk management.

Michael Tippett, lecturer in the Department of Applied Physics and Applied Mathematics, explains that climate prediction—unlike weather prediction—deals with statistics of weather events, and some of its variations can be predicted well in advance.

"El Niño can be predicted months in advance. And the impact of anthropogenic climate change on global mean temperature can be projected decades in advance," he says. "The important question is how these predictable climate signals modulate the frequency and intensity of extreme weather like hurricanes and tornadoes."

Over the last few years, Tippett and his team have identified environments favorable for severe thunderstorms and tornadoes.

"Last year, and again this year, we've been able to use that understanding to forecast seasonal tornado and hail activity, something never done before," he says.

Quantifying the risk of rarer events—such as a major hurricane hitting New York—is more difficult because historical records are inadequate.

"We're taking our understanding of tropical cyclone formation, movement, and intensification to build a model that combines statistical and physical knowledge and can inexpensively simulate thousands of years of hurricane activity," explains Tippett. "Such a model can then be used to answer questions about the 100-year storm probability for a particular location."

Above, from top to bottom: Mark Cane (Photo by Eileen Barroso); Michael Tippett; Lorenzo Polvani (Photo by Eileen Barroso)

EXAMINING OZONE DEPLETION

Over the last 30 years, the depletion of the ozone layer due to chlorofluorocarbons (CFCs) has had reverse negative impacts on the climate system. The entire Southern Hemisphere has been affected, as the formation of the ozone has altered winds, rain, and even the currents in the Southern Ocean.

"The ozone hole affected precipitation in southeastern South America as well as Australia and South Africa. In some regions of Argentina, for instance, it's been raining a lot more there over the last 40 years, allowing agriculture to expand," says Lorenzo Polvani, professor of applied physics, applied mathematics, and earth and environmental sciences.

But with stricter regulation of the use of CFCs, the ozone hole is expected to close between 2060 and 2100. "This ozone hole has a cooling effect on the lower stratosphere, and as it closes in the next few decades the resulting warming there will affect the winds in a very significant way," says Polvani. "Regions that benefited from increased precipitation because of the ozone hole will actually face direct consequences with the hole's closure."

Polvani's research has been instrumental in bringing attention to the importance of the ozone hole in climate systems. "International agreements about mitigating climate change cannot be confined to dealing with carbon alone—CFCs and other ozone-depleting substances need to be considered too," he says.

Just as climate change is impacting the environment, it also impacts the practice of engineering. That's why Columbia Engineering researchers are thinking differently about this challenge. Their work underpins mitigation solutions designed to slow the effects of climate change, detailed models to more accurately gauge how solutions will affect society, and adaptation strategies to help the world adjust to expected and actual climate change.

By Jessica Driscoll

ENVIRONMENTAL IMPACT

Exploring a Deeper Understanding of How Humans Affect the World's Water

When it comes to issues like groundwater contamination, it's obvious to Peter Schlosser that human actions have the potential to significantly affect environmental systems. However, he says, such impact is also evident on a much larger scale. Peter Schlosser, Maurice Ewing and J. Lamar Worzel Professor of Geophysics and chair of the Department of Earth and Environmental Engineering, studies water movement, its variability and change in the ocean, continental water bodies, and groundwater using natural and anthropogenic substances and isotopes as tracers.

Below: Peter Schlosser (Photo by Timothy Lee Photographers). *Above*: Danube River; *opposite page*: Pollution and smoke over India (Images courtesy of NASA)

Schlosser states, "In the last 150 years, the earth's temperature has increased by nearly 1 degree Celsius (1.8 degrees Fahrenheit) due to humans' emission of greenhouse gases, mainly burning of fossil fuels." Understanding that the global average temperature jump from the last ice age was only 5 degrees Celsius—and that based on the earth's temperature cycles over the past millions of years, the planet should be in a cooling period—we are about 20 percent into a dramatically fast shift to a warmer world. The implications of this temperature trend include polar ice sheet, sea ice, and mountain glacier deterioration that could flood low-lying land masses and the infrastructure in these regions as well as displace millions of people.

Because natural systems including oceans, estuaries, or rivers are very finely tuned, even small changes sparked by humans, notes Schlosser, can have profound consequences for their dynamics, temperatures, evaporation and rainfall patterns, and potential spread of contamination.

"In groundwater systems, we study how far water is moving through soil across the water table into aquifers so we can understand how pollutants are transported, as well as how long it takes for these contaminants to be flushed through the system," explains Schlosser. "We did several of these studies, including one along the Danube River to measure the infiltration of Danube water into an aquifer used for drinking water. We're also conducting research to better understand the arsenic contamination of groundwater in Bangladesh in order to minimize people's exposure."

In the United States, Schlosser and his students and colleagues have developed methods to quasi-continuously measure minute amounts of inert trace gases injected into rivers and estuaries in order to visualize the effects of a chemical spill or other release of contaminants. And, as ocean temperatures rise, he continues to measure their interaction with polar ice sheets to estimate melting rates and understand how they relate to their destabilization.

Although he originally studied physics, Schlosser became fascinated with the expansiveness of Earth's water systems and water's critical role in so many areas of human life—from climate

to drinking and sanitation to agriculture and food preparation. His research foci intersect at a common goal to identify solutions for negative global and societal consequences arising from human-induced changes to these systems.

"We have to put our research into a context decision makers understand so they can create sensible policies that improve humanity's outlook on local, regional, and global scales," says Schlosser. "For the people of Bangladesh, that may mean drilling deeper wells or sharing deep wells for drinking water. On a global scale, it might be working on climate policies controlling the emission of greenhouse gases to minimize, for example, ice sheet deterioration and sea level rise. We still have a lot to learn about packaging the insights we gain from our research and translating them into strategies for solutions—but that's one of the challenges that drew me to this field."

We have to put our research into a context decision makers understand so they can create sensible policies that improve humanity's outlook on local, regional, and global scales."

Prior to joining Columbia in 1989, Schlosser was an assistant professor at the Institute for Environmental Physics at the University of Heidelberg. In 1993 he was a Vetlesen fellow and visiting professor at the University of Washington–Seattle. He is an elected fellow of the American Geophysical Union, the American Association for the Advancement of Science, and the Explorers Club.

By Jessica Driscoll

Clearing the Air

For chemical engineer V. Faye McNeill, air quality and climate change go hand in hand. McNeill and her research team at Columbia investigate how to improve the predictive power of atmospheric chemistry and climate models, performing laboratory and modeling studies of the complex chemistry and physics of aerosols and ice in the atmosphere to better understand how human activities impact the environment.

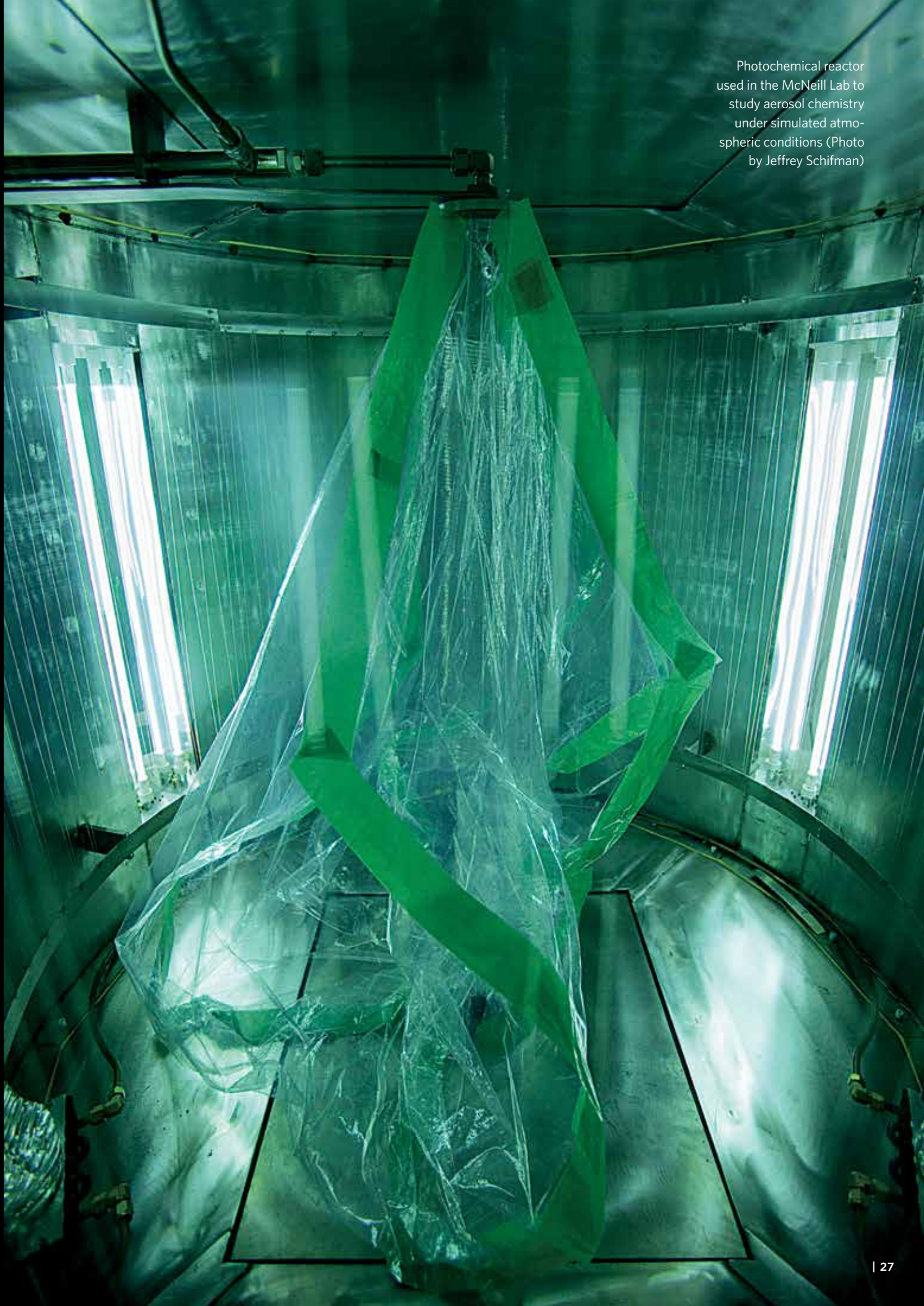
A key focus of their work centers on atmospheric aerosols—small particles suspended in ambient air, also known as particulate matter. They can be emitted directly into the atmosphere through sources like sea spray or a dust storm, but a large percentage of these particles develop from chemical reactions of gases in the atmosphere.

High levels of atmospheric aerosols are a hallmark of poor air quality, and they can negatively impact human health. These particles contain microscopic solids or liquid droplets that can get deep into a person's lungs and aggravate asthma, increase preexisting respiratory infection symptoms, and decrease lung function. They can also lead to irregular heartbeat and heart attacks, difficulty breathing, and premature death in people with heart or lung disease.

High levels of atmospheric aerosols are a hallmark of poor air quality, and they can negatively impact human health.

However, these particles also play several important roles in Earth's climate—serving as seed particles for cloud formation, and absorbing and reflecting the sun's rays to produce a cooling effect, for example. "For this reason, air quality and climate should be considered together when decision makers develop environmental policies," explains McNeill, associate professor of chemical engineering.

"Not all the sources of atmospheric aerosols are well known, particularly not in the case of particles formed from chemical reactions of atmospheric gases," she says. "This makes predicting the amount and location of aerosols,



Photochemical reactor used in the McNeill Lab to study aerosol chemistry under simulated atmospheric conditions (Photo by Jeffrey Schifman)

and using those predictions to develop environmental policies, tricky. A large part of my group's work focuses on unraveling these chemical pathways and determining how the particles' chemistry may change their climate-relevant properties—such as color, which affects their ability to absorb light."

McNeill explains that it's a major challenge in atmospheric chemistry, climate studies, and other disciplines to bridge the scales between the large amount of detailed, molecular-level data researchers get in the laboratory and the coarse-grained information that large-scale models can handle. To meet this challenge, McNeill's team developed the Gas Aerosol Model for Mechanism Analysis (GAMMA). It simulates the evolution of hundreds of chemical species participating in hundreds of chemical reactions, in both gas and particle phases, and the transfer of those molecules back and forth between the phases.

GAMMA analysis led her team to realize that, of those hundreds of species and reactions, only two main reaction pathways completely dominated their chemistry focus.

"This inspired us to develop a more coarse-grained version of GAMMA, called simpleGAMMA, which captures the overall behavior of the detailed model faithfully but has only a few variables and equations," she explains. In this way, simpleGAMMA can be applied to large-scale models without adding a lot of computational complexity, or it can be used for analyzing field data with limited measurements.

McNeill and her team have partnered with several other research groups to implement simpleGAMMA in regional and global atmospheric chemistry and climate models. They've also used simpleGAMMA to analyze field data with their collaborators, especially from the Southern Oxidant and Aerosol Study, which took place in the southeastern United States in 2013.

"We collaborate with other groups in order to include our most significant findings in large-scale models of air quality and climate, thus improving their predictive power," says McNeill. "This is how lab experiments eventually lead to better environmental policies."

V. Faye McNeill (Photo by Jeffrey Schifman)

McNeill was initially motivated to study atmospheric aerosols as an undergraduate student at the California Institute of Technology.

"At that time, Los Angeles had a serious particulate pollution problem, and visibility was low almost every day," she explains. "There were mountains very close to campus that we could only see a few days out of the year. In addition, I've had asthma my whole life, and I had difficulty breathing throughout my time living there. These daily reminders of the issue's importance, together with the very elegant and exciting physics and chemistry of atmospheric aerosols, got me hooked."

> Air quality and climate should be considered together when decision makers develop environmental policies.

McNeill is eager to continue her timely research as worldwide efforts to address the threats of climate change increase.

"Atmospheric aerosols play an important role in global climate, and uncertainty in their sources is one of the biggest unknowns in climate predictions," she says.

Prior to joining Columbia in 2007, McNeill was a postdoctoral research associate in the Department of Atmospheric Sciences at the University of Washington. In 2015, McNeill was awarded the Kenneth T. Whitby Award from the American Association for Aerosol Research, the Association's highest honor for researchers in her career stage.

By Jessica Driscoll

Paste samples for isothermal calorimetry tests to determine the effect of replacing cement with carbonated minerals on hydration kinetics and setting properties. (Photos by Jeffrey Schifman)

Outside-of-the-Box Green Research

Climate experts and environmental engineers are not the only ones chipping away at the grand challenges posed by climate change. Through the study of big data, minerals, materials, and beyond, the following Columbia Engineering professors are working beyond their area of expertise and making important contributions in environmental sustainability.

SHIHO KAWASHIMA
Assistant Professor, Civil Engineering and Engineering Mechanics

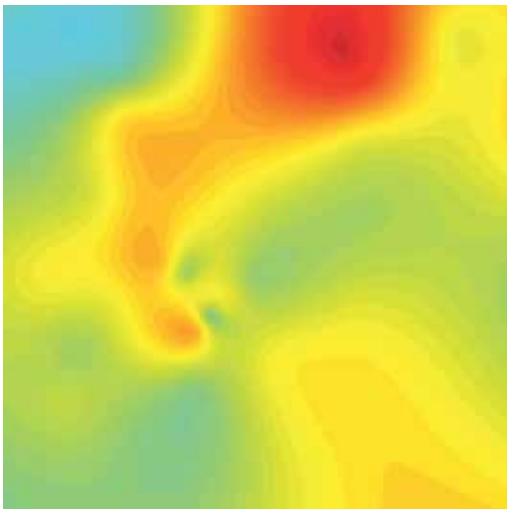
Kawashima studies the rheology of one of the most frequently used materials in the world: concrete. Cement production makes up 5 percent of the world's manmade carbon emissions, so, to this end, she has been working on ways to control the stability of concrete before it sets to improve its long-term performance properties.

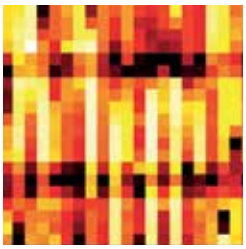
"Good placement of the material can effectively increase the service life of the structure, and that is one key approach to making concrete more environmentally friendly—make it last," says Kawashima.

She is collaborating with fellow engineer Alissa Park, associate professor of earth and environmental engineering and of chemical engineering, on research that combines her studies in cement-based materials with Park's pioneering efforts in the field of mineral carbon sequestration. "We are looking to partially replace the cement content of concrete with an end product of mineral carbon sequestration and determine whether it can serve as an effective substitute material," explains Kawashima. "This would reduce cement content and associated embodied energy and carbon, and contribute towards alleviating already-existing greenhouse emissions."

XIAOFAN (FRED) JIANG
Assistant Professor, Electrical Engineering

In 2012, Jiang was tapped to lead Intel's new Internet of Things research lab in Beijing. On the drive to work one day, he had an idea. What if





Above (clockwise from top left): Air quality heat-map of Beijing in 2013, generated using custom sensors and spatial inference algorithms (Image courtesy of Fred Jiang); Xiaofan (Fred) Jiang (Photo by Tim Lee Photographers); PM2.5 emission patterns of cars on a highway (Image courtesy of Fred Jiang)

Below (from left to right): Shiho Kawashima (Photo by Eileen Barroso); Ponisseril Somasundaran (Photo by Jeffrey Schifman); Clifford Stein (Photo by Eileen Barroso)

he could measure Beijing's smog problem at a citywide scale?

Together with his team, Jiang built a system of low-cost sensors and distributed them throughout central Beijing. To compensate for the lower-quality data, they built a model that pulled in additional environmental information, such as temperature, humidity, and topography data, to improve sensor accuracy and generate fine-grained heat maps. Finished in less than a year, the AirCloud project was one of the first to provide an independent, real-time assessment of particulate pollution levels in Beijing.

Jiang is also focused on the idea of environmental accountability. "Buildings consume 72 percent of electrical energy in the nation," he explains. "We waste more energy in commercial buildings than at home because we're not accountable." Jiang is working on a system that allows commercial buildings to quantify from where, and more specifically from whom, the most energy usage is coming.

PONISSERIL SOMASUNDARAN
LaVon Duddleson Krumb Professor of Mineral Engineering, Earth and Environmental Engineering

Going green is our social responsibility, says Somasundaran. In an article for *Mining Engineering* magazine, he noted: "Ultimately it may serve us all better to follow the spirit of the old Sanskrit saying, '*Nishkama Karma*,' roughly translated as selfless action. So I define sustainability as meeting the needs of the future generations, even if we have to forego some of our own perceived needs."

This altruistic philosophy has guided Somasundaran in his work on sustainability, work that has included the creation of a quantifiable evaluation system to foster "greener" reagents. Various industries have tried to promote greener deeds but lacked a comprehensive definition of greenness. A robust evaluation tool or metric, therefore, is necessary to not only identify the major attributes that characterize greenness, but also calculate the greenness robustly and systematically. Factors such as toxicity, biodegradability, stability, cost, and social aspects all need to be considered in the evaluation. However, such a tool is not yet available or widely accepted. That's where Somasundaran comes in. He and his team have established a Greenness Index tool that evaluates a reagent in an environmentally relevant way. The index uses a holistic approach by examining key features based on the 12 principles of green chemistry, the 12 principles of green engineering, and the International Council on Mining and Metals's 10 principles of sustainable development. The Greenness Index project has been under constant development to provide meaningful assessment of reagents to promote the greening process in various industries.

Somasundaran is also exploring the potential toxicity of nanoparticles and their impact on our global footprint. His objective is to better understand these nanoparticles as they relate to performance as additives in water filters and sunblock, typical household and personal care products, an area in which research is much needed in order to foster the implementation of more sustainable practices.

Shiho Kawashima

CLIFFORD STEIN
Professor, Industrial Engineering and Operations Research and Computer Science

"We all want to help in environmental issues and save energy," says Stein. For his part, Stein, whose expertise lies in big data, is aiming to drastically decrease energy consumption by data centers.

As we advance technologically as a society, we have been able to craft hugely impressive processors that run at faster and faster speeds. But this comes with a substantial environmental

cost—it is estimated that data centers account for 2 to 4 percent of the electricity usage in the United States, a number that will only increase with the trend to create bigger centers. Stein's goal is to find a more environmentally friendly way to run these centers—cutting costs and energy use—without significantly compromising the performance of these centers.

He explores the problem on a theoretical level, using algorithms to determine how processors could perform with decreased levels of energy while maintaining quality of performance. Then he pilots these mathematical models; Stein has applied this work in a collaboration with Google. He has designed algorithms that schedule work in data centers while considering both performance and ways to decrease energy usage. These algorithms look to pack work onto fewer machines, allowing the unused machines to be placed in a low-power state.

Stein plans to apply the same kind of research approach to computer networking, another area in which energy consumption is trending upward as we grow otherwise more productive. "If routers are managed more efficiently, we could make substantial energy savings," he notes. And those are savings that could have exponential effect.

The problems centered on environmental sustainability are just one area of research where SEAS faculty are making a huge impact on a global scale. From civil engineering and engineering mechanics to big data and more, Columbia engineers are certainly thinking outside of the box when it comes to solving some of Earth's grandest challenges.

By Elaine Rooney

Ponisseril Somasundaran

Clifford Stein

Faculty Q&A: Kartik Chandran Professor, Earth and Environmental Engineering

Waste is not a dirty word to Kartik Chandran, professor of earth and environmental engineering, especially when applied to sewage, fecal sludge, or wastewater. He sees these all as enriched resources, replete with nutrients, chemicals, and energy. This past fall, Chandran was awarded a 2015 MacArthur Fellowship for his revolutionary work in transforming wastewater from a pollutant to a valuable resource and usable products like bulk chemicals and fertilizers. The "genius grant" comes with a $625,000 stipend that is given with no conditions—fellows may use the money as they see fit.

A good thing for Chandran because his research on the global nitrogen cycle, resource recovery and reuse, and reengineering wastewater treatment has the potential to save our endangered planet from the negative impacts of climate change and resource shortages. His work has been widely recognized.

In 2011 he received a $1.5 million grant from the Bill & Melinda Gates Foundation to develop a transformative new model for water and sanitation in Africa. Chandran is focused on integrating microbial ecology, molecular biology, and engineering to transform wastewater, sewage, and other "waste" streams from problematic pollutants to valuable resources. Traditional facilities for biologically treating wastewater remove pathogens, organic carbon, and nutrients, where necessary, through decades-old technology that requires vast amounts of energy and resources, releases harmful gases into the atmosphere, and leaves behind material that must be discarded. Chandran's approach to water sustainability investigates ways that take into account the climate, energy, and nutrient challenges we face today.

"In fact, we should remove the term 'wastewater' from our dictionary," says Chandran. "To me, this is enriched water, because it's enriched in chemicals, it's enriched in nutrients, and it's enriched in energy."

We had a chance to sit down with Chandran this winter to find out what it's like to be a noted genius and what he plans to do next.

Chandran's research has the potential to save our endangered planet from the negative impacts of climate change and resource shortages.

Above, top: Kartik Chandran (Photo by Tim Lee Photographers); *bottom*: A highly cost-effective and energy-efficient technology for biological nitrogen removal from wastewater using anaerobic ammonia oxidizing (anammox) bacteria that is being developed by Kartik Chandran's group (Photo by Jeffrey Schifman)

Q: How did you find out that you'd won the MacArthur?

A: I just came back from three hours of lecturing, and there were a few calls on my cell phone from a number I didn't recognize. I didn't call back, but I'm happy they did.

Q: What do you think you'll do with the award?

A: Beyond the support from the MacArthur Foundation, it's really a great recognition for the field of environmental engineering itself. I say this just half-jokingly: The fellowship allows us to elevate the conversation on waste to the dinner table; it makes it a bit more mainstream. And that is what's needed if we want to really make a dent into this complex set of issues. I also think it will allow us to explore some directions that are a bit unconventional, which could potentially have a pretty significant impact on the type of work we do, and on the overall field—the field specifically being recovery and reuse of resources from "waste" or, more appropriately, enriched streams.

Q: Can you tell me more about your research area?

A: I work at the intersection of environmental microbiology, environmental molecular biology, environmental biotechnology, and environmental engineering. We are really trying to harness the power of microorganisms to do many, many things for us simultaneously. We want to achieve clean water for the masses; we want to produce clean energy; we want to convert streams that are conventionally associated with what you might call waste but I don't! We want to have the microorganisms in the stream produce chemicals for us, and more. My approach has always been to try to understand what the organisms can do in the wastewater treatment process itself, try to understand what they are capable of, and then use process engineering techniques to coax this potential out of them. One of the implications of using the term "waste" is then we have something to remove. And we remove waste by putting in even more chemicals, more energy, more resources; and then if all goes well, we have just one thing, clean water, at the end, and yet we've put in so much. And when we do something like this, of course, we have three billion people on the planet who don't have access to this model. So then the point is that we need to stop using terms such as "waste" or "wastewater." Then we can focus on a truly science- and technology-based model for resource recovery and reuse. The implications of this model are substantial, including improved

My approach has always been to try to understand what the organisms can do in the wastewater treatment process itself, try to understand what they are capable of, and then use process engineering techniques to coax this potential out of them.

global access—not just to clean water, but, in addition, clean energy; reduced reliance on fossil resources for chemicals, nutrients; and beyond.

Q: What are some of the applications you are working on?
A: The applications that we have focused on primarily relate to improved water quality and improved human health. But my group hasn't run after water quality in isolation, which is what researchers have done in the past. We look at water quality as one of the multiple, simultaneous end points. So we're trying to improve water quality, but by producing a lot less greenhouse gases, by consuming substantially less energy, while at the same time producing chemicals and fuels that are far higher up on the value chain, for instance, compared to even clean water.

Q: So how do you do it?
A: Well, this is the overall challenge. We have to pick certain components; this cannot be done by me alone, even in my lifetime. This will take several generations of researchers. And even with my generation, engineers alone can't do this. We have to work with other disciplines. I don't consider myself to be just an engineer anymore, given that we do more molecular biology than molecular biologists themselves. The researchers in my group are a mix of engineers, chemists, biochemists, biologists, etc. My group's philosophy is that, while all the researchers come in with different backgrounds, when they finish, they come out with a common language. And it's not one individual language, engineering or biology, it's a mix. This is the new face of environmental engineering; this is what is needed to be able to address such a complex set of challenges.

Q: You've been working with New York City for a while now.
A: Yes, it has been a privilege to work with them on real, at-scale challenges. Over a decade ago, I was part of a group involved in upgrading five of the 14 wastewater treatment plants in the city to achieve nitrogen removal. More recently, we have worked with the city on energy- and resource-efficient nitrogen removal. Such resource-efficient technologies and processes are the driving force behind a center that we are part of at Columbia. We're also pursuing this with several other water utilities in the States and even abroad.

Above: State-of-the-art analytical tools for measuring the presence of pharmaceuticals and other trace organic compounds in water streams (Photos by Jeffrey Schifman)

Q: You are very interested in cities. Why?
A: There are a lot of challenges that need to be addressed in our big cities. Right now our model of cities is that we import resources, water, energy, nutrients, chemicals, and even people. And then what happens when we are done with these things? We just take them out to the fringes and discard them. This is a linear model: use, enrich, and discard, for everything. More and more people are moving into cities. We cannot build bigger and bigger treatment plants, we cannot import more and more energy, we cannot import more and more food—we can't do this. And so one of the directions that I'm especially passionate about—and some of our technologies here, for instance, focus on—is food waste to food, on campus at Columbia. We need to look at a distributed model for resource recovery. And cities offer the ideal palette to do this because everything is right here. The sewage is right here; the enriched streams are right here in these buildings. Why can't we recover anything from them? Why do we need to take them somewhere, spend energy and chemicals and money to take them there, and then complain that we cannot build bigger treatment systems, centralized treatment systems? So we need a distributed model for many of these resources—water, nutrients, energy, perhaps people as well.

Q: What motivates your research?
A: I am driven by the global challenges that we face. As a society, we've been very good at creating problems and challenges. As an engineer, I aim to address and overcome these challenges.

By Holly Evarts

WASTE NO MORE: A NEW GENERATION OF ENVIRONMENTAL ENGINEERS
engineering.columbia.edu/spring2016video

STUDENTS

Ariane Coelho Brotto has been unambiguous about her passion for science since childhood. "It was in ninth grade that I had my first chemistry class and I fell in love with it! From then on, I dreamed to be a chemist, and I aimed all my efforts to be the best I could," she recalls. Currently a PhD student focused in water sustainability solutions in Professor Kartik Chandran's lab, Brotto is well on her way to achieving that goal.

Brotto now recognizes engineering as a perfect conduit to effect the type of change she understands is needed, but it wasn't until she was pursuing a master's degree in geosciences that the native Brazilian began to consider it as a potential educational path. "My interest in coming to Columbia came after reading several papers produced by Professor Chandran's research group on greenhouse gas emissions from wastewater treatment plants. I was working in a pioneer research project in Rio de Janeiro on the same topic, and I realized that I could potentially extend my knowledge and research even further, especially in the fields of engineering and

Ariane Coelho Brotto (Photo by Jeffrey Schifman)

Opposite page: Brotto conducting the GHG monitoring on a Biological Nitrogen Removal Wastewater Treatment Plant

ARIANE COELHO BROTTO

Earth and Environmental Engineering | PhD Candidate

"I came to realize that engineering would provide me with many more opportunities to impact the world with my research."

microbiology." She wasted no time reaching out to Chandran, and when he responded by encouraging her to apply to Columbia to study earth and environmental engineering, the advice spurred a bit of a revelation.

"I came to realize that engineering would provide me with many more opportunities to impact the world with my research."

Brotto describes her research as being the interface of three spheres: sanitation, water quality, and the greenhouse gas (referred to as GHG) footprint. She is exploring ways in which we can decrease the emissions of nitrous oxide, a gas 300 times more potent to the environment than carbon dioxide, during wastewater treatment and in doing so decrease their negative impact. "I investigate how the microorganisms in the biological wastewater treatment produce this GHG under certain operational conditions with the goal of developing strategies to mitigate its production and emission through proper process design and operation of the engineered water systems, as well as assessing evidence for new technologies and carbon credits."

Brotto's timely research tied in naturally with the School's most recent design challenge, launched this past December. The initiative quite literally hit home for Brotto, as it focused on urban water problems specifically in Rio. She first heard about the challenge when Eduardo Paes, the city's mayor, visited Columbia to introduce the Rio Innovation Hub. "On the same day, I contacted the dean's office of SEAS to demonstrate my interest in contributing to the development and implementation of this new center in my hometown," remembers Brotto. "Through the Urban Water Design Challenge I see an open door to start my contribution with this innovation, especially as it's on my field of specialization—water and sanitation."

Brotto refers to her experience studying under Chandran as "intellectually stimulating and life transforming," and aspires to bring home her hard-earned expertise. Her goal upon obtaining her doctorate is to use her work at Columbia and expand upon it to improve circumstances in Brazil and beyond. "I'm hopeful that the results of my research will contribute to substantial changes in the way we deal with wastewater treatment," she describes, adding with infectious optimism her hope for her research: "That in the next few years our treatment plants will become climate neutral (not only in terms of energy use, but also direct emissions from the biological treatment) while benefiting from having quality water and resources from the wastewater."

By Elaine Rooney

JASON KANG

Biomedical Engineering | Senior

Top: Kevin Tyan (*far left*), Jason Kang, and Katherine Jin during a field-testing trip at the PCI Ebola Treatment Unit in Ganta, Liberia; *middle*: Jason and Kevin with some of the health care workers on site; *bottom*: A hygienist field-tests Highlight on a health care worker. (Photos courtesy of Kinnos Inc.)

Opposite page: Jason Kang (Photo by Eileen Barroso)

Jason Kang's father provided him with some crucial advice: "The most powerful lesson my dad taught me about inventing is that the problem is infinitely more important than the solution." For Kang, this principle proved to be formative. As a teenager doing research in the lab of his father (an associate professor at Harvard Medical School and director of its Laboratory for Lipid Medicine and Technology), he grew fascinated with the ability to discover knowledge with potential to solve the world's problems. It wasn't until Kang arrived at Columbia, however, that he connected his passion for problem solving with engineering. "What I love about engineering is that it's all about applications—taking the knowledge that people have discovered from research and making it into something useful to improve the lives of others."

> "My measure of success is the number of people I've been able to help."

Kang, a senior studying biomedical engineering, continues to find himself inspired by SEAS. "Columbia Engineering is always working to get better. Mudd got renovated with the Makerspace, Dean [Mary C.] Boyce started design challenges, and entrepreneurship is getting more and more funding. It's really a place where innovation can thrive."

In October 2014, Kang attended the Ebola Design Challenge where discussion centered around urgent issues in need of solutions. "One of the biggest problems they mentioned that first day was that there was no way to guarantee complete coverage since bleach, which they use for disinfection, is transparent. As a result, a shocking number of health care workers were being infected and dying." Kang, along with friends Katherine Jin '16CC and Kevin Tyan, '16CC came up with the idea to colorize disinfectant to provide better coverage. The three cofounded Kinnos Inc. and devoted months of hard work to perfecting Highlight, a product for which they won the USAID Fighting Ebola Grand Challenge and received national attention in making the list of *Forbes* 30 Under 30 in Healthcare.

For Kang, however, the most thrilling aspect of the project hasn't come from accolades but from seeing the impact. "The thing that's resonated most with me was field-testing Highlight with health care workers in Liberia. They are some of the most inspiring and courageous people I've ever met. To know that I'm working on something that will protect them from infection, to give them confidence in their safety and make their lives even a little bit easier, makes it all that much more worth it."

As for his downtime, Kang loves to unwind by cooking. And if he is not creating his own delicious food, he loves exploring New York City to find it. "You can get these unbelievably fresh lamb dumplings at Golden Shopping Mall in Flushing, and I could eat Cemita's fried chicken sandwiches at Smorgasburg for the rest of my life." He also cites another highlight of a much-decorated Columbia tenure. "Above and beyond everything that's happened in college, the most important thing I'll take away from all of this are my friends."

Kang already has amassed quite a resume, including becoming the vice president of engineering for Jibon Health Technologies before even graduating, and his future promises to be equally bright. Kang and his cofounders plan to continue with Kinnos full time. Their hope is to have Highlight widely distributed, as they continue to explore more problems in need of solutions. "For me," he says, with characteristic altruism, "my measure of success is the number of people I've been able to help." A number that is likely on the rise.

By Elaine Rooney

Columbia's Formula SAE team president Gwen Archambault (*left*) and chief engineer Sydney Sherman standing next to Knickerbocker Motorsport's 2015 racecar. This year the group's five-person board is dominated by women leaders. (Photo by Jeffrey Schifman)

PAY IT FORWARD

Columbia Engineering's female population is growing—and reaching out to the next generation.

At a time when women engineers are making headlines—and pushing back against a culture that hasn't always embraced them—Columbia Engineering students are working to build the future.

According to Jessica Marinaccio, dean of undergraduate admissions and financial aid at Columbia Engineering and Columbia College, the percentage of female Columbia engineers has grown to 46 percent for the class of 2019, up from 29 percent for the class of 2009. And that's no accident.

"Over the last several years, extensive outreach efforts have resulted in growing interest in Columbia Engineering from an exceptional and exceptionally diverse group of students," Marinaccio said. "STEM-focused presentations around the country and on-campus events such as specialized engineering campus tours, Master Classes with prominent Columbia faculty, the Engineering Research Invitational, and the Engineering Women's Forum have helped interested students learn more about the remarkable opportunities available to them at Columbia. We are proud that the current student body is more diverse now than ever before and one of the most diverse in the country."

The surge in female engineers comes at a time when the culture is grappling with what it means to be a woman in the STEM fields. Women are still underrepresented there, and last August thousands of women flooded social media with their pictures under the hashtag #ILookLikeAnEngineer, the response to an essay posted by San Francisco engineer Isis Anchalee detailing the blowback she received—including critiques of her looks and questioning of her engineering bona fides—after appearing in an ad for her company, OneLogin.

But students at Columbia Engineering say the atmosphere on campus is supportive and aspirational—and that comes all the way from the top, with the example being set by Dean Mary C. Boyce.

"It's really important that she's a woman. She has that perspective and has gone through struggles," said Alexandra Pan '16SEAS, president of Columbia's Robogals chapter.

The School's Office of Outreach Programs consistently lends its support too and works closely with many student groups—some with very active roles in STEM outreach. The growing influence of female students can be felt all over campus, students said. Female-focused

Sci-Inspire members, *left to right*: Marie Syku, Rhiana Rivas, Erin Vaughn, Busola Akinniranye, and Bunmi Solano (Photo courtesy of Anna Palmer-Alonso '18SEAS)

groups like Robogals and Sci-Inspire, as well as Girls Who Code, have all received Student Governing Board recognition this academic year. It's also felt in clubs that have been traditionally dominated by men, like Columbia's Formula SAE team, Knickerbocker Motorsports. This year, the group, which designs, builds, and races cars, has its first female chief engineer and its second female president, as well as a female vice president, giving women the majority on the five-person board.

"I definitely feel like the balance of women to men is already changing at the collegiate level, and as more students are being educated, they're going into the field," said Sydney Sherman '16SEAS, the team's chief engineer.

"Columbia didn't always have such representation," Knickerbocker Motorsports president Gwen Archambault agreed. "It's been improving for a lot of social reasons, and it's becoming not so strange to be a girl interested in engineering."

> These students are committed to changing the conversation and banishing the stereotype that women aren't cut out for the engineering field.

And female engineers at Columbia say they are committed to providing role models for the next generation.

Rhiana Rivas '18SEAS is the president and cofounder of the Columbia chapter of Sci-Inspire, a nationwide science outreach program that she describes as helping serve as a pipeline for bringing underrepresented groups, including women, into the STEM fields. Rivas said the program, which sends Columbia students into local elementary schools in the greater Manhattan area, including Harlem and the Bronx, is the sort of thing she would have appreciated.

"Personally, the group is so important to me. I come from the same sort of background and culture of the students Sci-Inspire aims to outreach for," she said. "Any extra help they can get to be inspired and encouraged through science builds a cycle of positive reinforcement."

Sci-Inspire executive board member Erin Vaughn agreed. "You can make an

impact and change the potential direction of someone's life." Her own experience of coming to engineering through her high school robotics team, she said, solidified her commitment to paying it forward.

Minah Kim '17SEAS, who is vice president, external, for Columbia's chapter of Society of Women Engineers, said seeing women in positions of leadership in the field gives aspiring girls and women confidence to pursue their goals.

"A lot of my success has been due to my peers, or people like me who have accomplished things. If there aren't those role models, it's a lot harder," she said. "I'd definitely like to be involved in outreach after I graduate. It's important to help youth discover that engineering is a career path that is viable for everyone."

Students say they're committed to changing the conversation and banishing the stereotype that women aren't cut out for the field.

"There have been studies done that show that girls grow up thinking they're not as good at math, not as good at science, or that the fields are marketed in a way that appeal more to boys than girls," Robogals' Pan said, explaining why she worked to bring the group, an Australian organization created to promote women's participation in engineering, science, and technology, to Columbia.

"Engineering means a lot to me. I can't imagine a different major or career path that would enrich my life any more, but I didn't even know what engineering was until high school," Pan said. "I don't want other students who might be told that engineering is for boys, or who don't even know what engineering is, to miss their opportunity."

By Jennifer Ernst Beaudry

Sydney Sherman (*left*) and Gwen Archambault with the 2016 racecar (Photo by Jeffrey Schifman)

SEAS OUTREACH

Engineering Every Day (EED), home of Outreach Programs at Columbia Engineering, works closely with undergraduate volunteers to provide critical STEM support for local elementary and secondary school students. EED acts as an incubator for STEM outreach groups at Columbia, helping new organizations develop and grow until they can get recognized as official University student activities. This includes early-stage support and advising to ensure new groups have the leadership, infrastructure, contacts, governance, etc., that they need to operate and succeed long term. EED has worked with Sci-Inspire and Girls Who Code since their inception (both launched in 2015) as well as with Robogals, Columbia University Competitions in Math, and Columbia Space initiative, and also collaborates on outreach with established student organizations such as FIRST Robotics, Engineers Without Borders, National Society for Black Engineers, Society of Hispanic Professional Engineers, and Society of Women Engineers.

Prototype of a wearable hand orthosis, developed by Matei Ciocarlie's lab in collaboration with Dr. Joel Stein (Columbia University Medical Center), used to assess the level of force needed to assist hand extension in stroke patients (Photo by Jeffrey Schifman)

HANDS-ON ROBOTICS

As a boy, Matei Ciocarlie, assistant professor of mechanical engineering, loved to build things—Legos were his favorite toy. He was also fascinated by computer programming and algorithms. Once he discovered robotics as a student, his path was set: Robots were the perfect conduit for giving computer programs a physical presence in the world, a way to express intelligence through physical interaction with the environment.

"Robotics, like few other fields," he explains, "combines the study of the body and the mind: the physical mechanism and the algorithms that control it. There can be intelligence at the mechanical level just like at the computational level. And, put together, the body and the mind are much more than the sum of the parts."

Human hands are a perfect case in point. "They are marvelous from a mechanical perspective, equipped with sensors far surpassing our current technology; and, when controlled by the human brain, incredibly versatile," he continues. "If we can match the abilities of the human hand, then I think we've achieved true intelligence in an artificial mechanism."

A major focus of Ciocarlie's research has been on developing versatile manipulation and mobility in robotics, in

particular on building dexterity into robotic hands, and he is on a roll. In the past three years alone, he has won an array of prestigious honors, including the 2013 IEEE Robotics and Automation Society Early Career Award, a 2015 Young Investigator Program grant from the Office of Naval Research, a 2015 NASA Early Stage Innovations grant, a 2016 CAREER Award from the National Science Foundation (NSF), and, most recently, a Sloan Fellowship.

Working in his new Robotic Manipulation and Mobility Lab, Ciocarlie and his students are using robotics to change the world. While robots have already made a huge impact by reliably executing perfectly repeatable tasks such as assembly and manufacturing, he thinks it is now critical for robots to become more versatile and to learn to handle variability and interact with the world more intelligently. Researchers have been focused on robotic locomotion and navigation, but it is no longer enough that robots can move through an environment independently.

Ciocarlie sees robotic manipulation in unstructured environments as a critical research area. "We need to effect physical change on the world not just by moving bodies but by moving things around as well," he says. His group is working on a range of applications that are part of everyday life—from versatile automation in manufacturing and logistics, to mobile manipulation in unstructured environments, to assistive and rehabilitation robotics in health care.

Ciocarlie's NSF CAREER Award is enabling him to explore the fundamental science of manipulation, to develop better tools to make assessments of the mechanisms and methods that enable versatile object acquisition—the process of planning a grasp and then executing it with a hand mechanism to pick up the desired target. His concept is a departure from the "build, then program" paradigm, where the hardware and software components of a manipulator are developed either sequentially or independently.

Prototype of a wearable hand orthosis (Photo by Jeffrey Schifman)

"If we can optimize mechanism designs jointly with planning and control algorithms, using combined quality metrics, then we'll be able to build versatile hands ready for use right after assembly, already known to perform a broad range of useful tasks," he says. "This would make a big difference in areas such as consumer electronics manufacturing, logistics, health care, and even at home."

Ciocarlie is also working with NASA and his colleague Michael Massimino, former NASA astronaut and professor of professional practice in the Department of

"Human hands are marvelous from a mechanical perspective, equipped with sensors far surpassing our current technology; and, when controlled by the human brain, incredibly versatile. If we can match the abilities of the human hand, then I think we've achieved true intelligence in an artificial mechanism."

Matei Ciocarlie (*left*) and students in the Robotic Manipulation and Mobility Lab (Photo by Jeffrey Schifman)

"We need to effect physical change on the world not just by moving bodies but by moving things around as well."

Mechanical Engineering, to expand the manipulative capabilities of robots in space. The so-called Assistive Free-Flyers (AFFs) are designed to share space with astronauts on board the International Space Station, helping with sensing and observation tasks such as surveillance, inspection, and mapping. Ciocarlie's team is developing compact yet dexterous robotic arms and hands, along with the planning and control methods needed to operate them, with Massimino providing critical domain expertise. The idea is to demonstrate new capabilities on such tasks as object acquisition and transport, part insertion and extraction, button or lever operation, docking and perching. "We believe these abilities will greatly increase AFFs' reach, literally and figuratively," Ciocarlie quips.

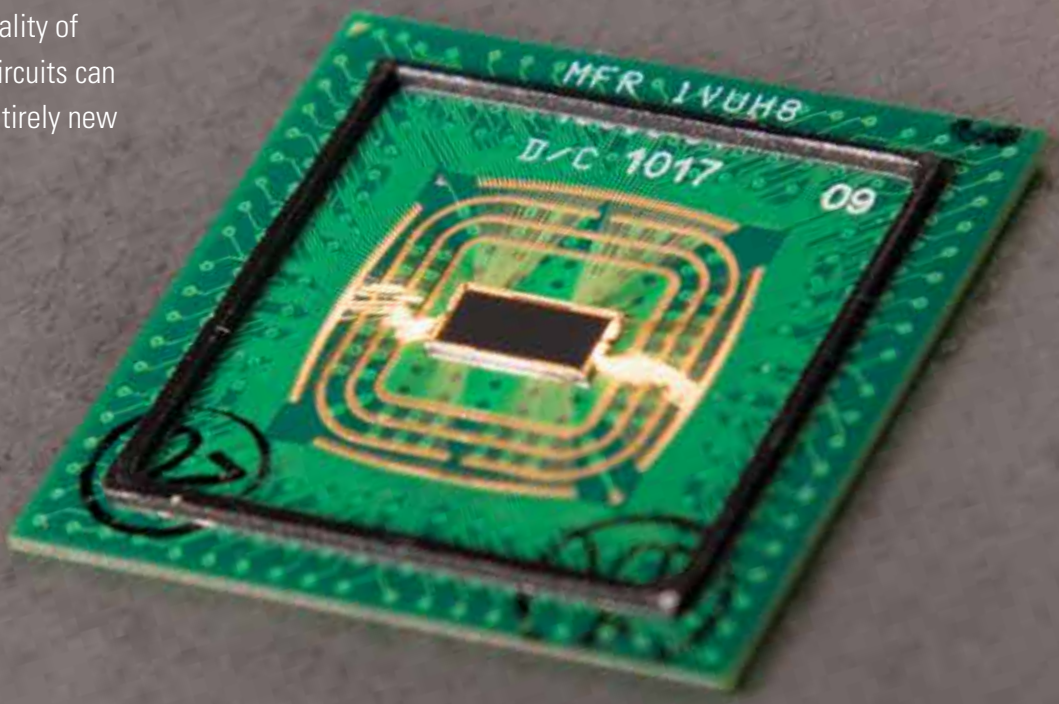
Health care is another big area of focus for Ciocarlie, who is collaborating on an orthotics project with Joel Stein, chair of the Department of Rehabilitation and Regenerative Medicine at Columbia University Medical Center. There are close to 800,000 new stroke victims in the United States every year, and about a third of them do not regain useful function of their upper limbs. Ciocarlie and Stein are developing a wearable device to help with rehabilitation and assistance, one that is simultaneously dexterous for complex manipulation, nonintrusive for daily living, and intuitive to control. They are hopeful their technology will help not only stroke victims but also people with other degenerative conditions that affect manipulation, including myopathies, motor neuron disorders, multiple sclerosis, and others.

"Unlike the elbow and the knee," Ciocarlie notes, "the hand is uncharted territory for wearable assistive technologies because it is so complex—there are so many degrees of freedom needed in such a small package. In fact, I often tell people when they look at a Ferrari or Mercedes and say, 'Oh, that's an amazing piece of equipment,' that the human hand is a much more amazing piece of equipment and most of us are blessed with two of them that function!"

By Holly Evarts

INTRODUCING A BIOLOGICALLY POWERED CHIP

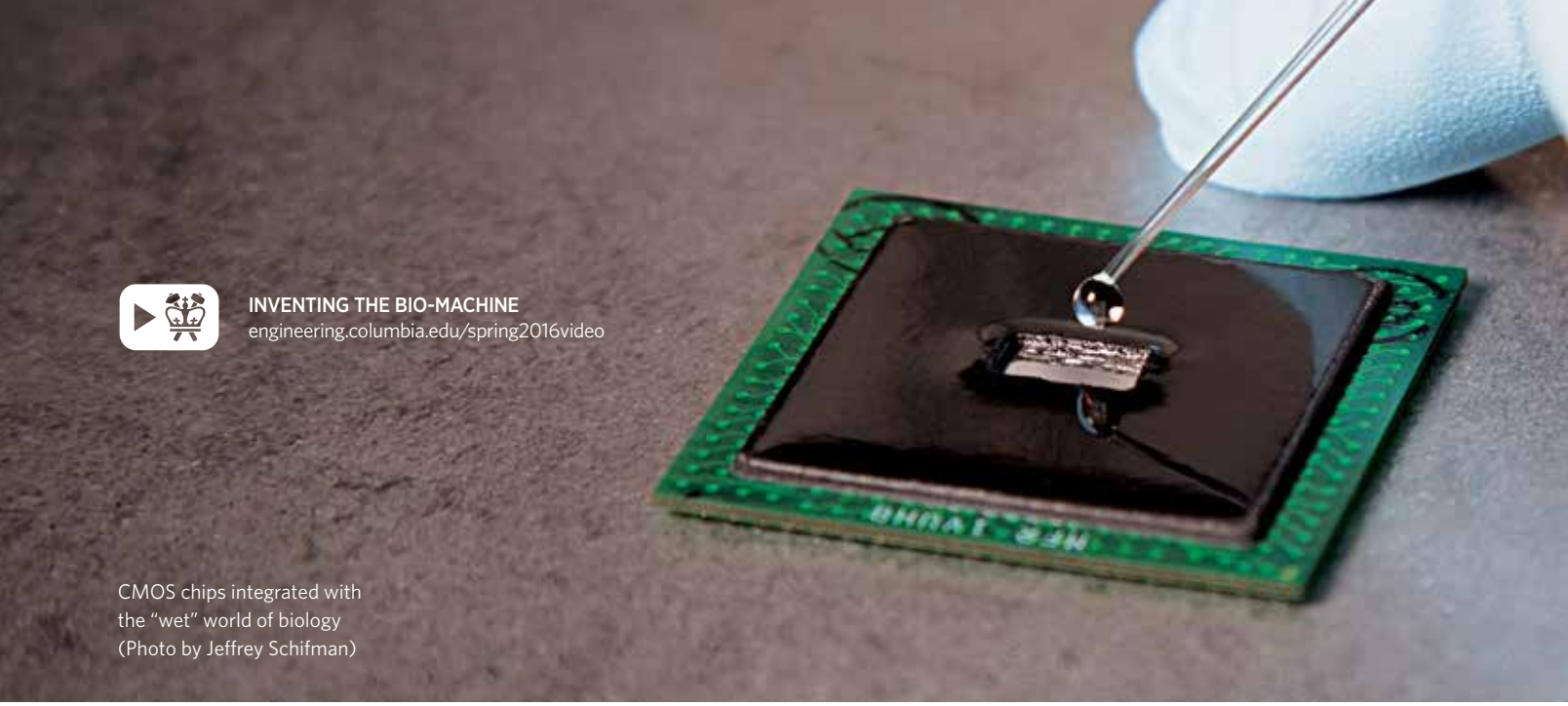
The ability to add the functionality of biological systems to CMOS circuits can one day lead to creating an entirely new class of sensors.



Columbia Engineering researchers have, for the first time, harnessed the molecular machinery of living systems to power an integrated circuit from adenosine triphosphate (ATP), the energy currency of life. They achieved this by integrating a conventional solid-state complementary metal-oxide-semiconductor (CMOS) integrated circuit with an artificial lipid bilayer membrane containing ATP-powered ion pumps, opening the door to creating entirely new artificial systems that contain both biological and solid-state components.

"With appropriate scaling, this technology could provide a power source for implanted systems in ATP-rich environments such as inside living cells," says Jared Roseman PhD'15, who led the study with Kenneth Shepard, Lau Family Professor of Electrical Engineering and professor of biomedical engineering. In Shepard's Bioelectronics Systems Lab at Columbia, researchers are focused on exploiting silicon integrated circuits—typically used in computers and smartphones—as a platform for exploring the life sciences.

"In combining a biological electronic device with CMOS, we will be able to create new systems not possible with either technology alone," Shepard notes. "We are excited at the prospect of expanding the palette of active devices that will have new functions, such as harvesting energy from ATP, as was done



INVENTING THE BIO-MACHINE
engineering.columbia.edu/spring2016video

CMOS chips integrated with the "wet" world of biology (Photo by Jeffrey Schifman)

here, or recognizing specific molecules, giving chips the potential to taste and smell. This was quite a unique, new direction for us, and it has great potential to give solid-state systems new capabilities with biological components."

Despite its overwhelming success, CMOS solid-state electronics is incapable of replicating certain functions natural to living systems, such as human senses and the use of biochemical energy sources. Living systems achieve this functionality with their own version of electronics based on lipid membranes and ion channels and pumps, which act as a kind of "biological transistor." They use charge in the form of ions to carry energy and information—ion channels control the flow of ions across cell membranes. Solid-state systems use electrons; their electronic signaling and power are controlled by field-effect transistors.

In living systems, energy is stored in potentials across lipid membranes, in this case created through the action of ion pumps. ATP is used to transport energy from where it is generated to where it is consumed in the cell. To build a prototype of their hybrid system, Roseman packaged a CMOS integrated circuit (IC) with an ATP-harvesting "biocell." In the presence of ATP, the system pumped ions across the membrane, producing an electrical potential harvested by the IC.

> "With appropriate scaling, this technology could provide a power source for implanted systems in ATP-rich environments such as inside living cells."
>
> —Jared Roseman PhD'15

Roseman and Shepard made a macroscale version of this system, at the scale of several millimeters, to test it out. Shepard notes, "Our results provide new insight into a generalized circuit model, enabling us to determine the conditions to maximize the efficiency of harnessing chemical energy through the action of these ion pumps."

While other groups have harvested energy from living systems, Shepard and his team are exploring how to do this at the molecular level, isolating just the desired function and interfacing this with electronics. "We don't need the whole cell," he explains. "We just grab the component of the cell that's doing what we want. For this project, we isolated the ATPases because they were the proteins that allowed us to extract energy from ATP."

The ability to build a system that combines the power of solid-state electronics with the capabilities of biological components has great promise. "You need a bomb-sniffing dog now, but if you can take just the part of the dog that is useful—the molecules that are doing the sensing—we wouldn't need the whole animal," says Shepard.

"Reducing any idea to practice is always filled with many challenges," says Roseman. "This issue is compounded even further when you are paving the way in a new research area, and things can be frustrating at times when the data is slow to come. These frustrations, however, lead to an indescribable joy when you finally get things to work."

Their work, funded by the W. M. Keck Foundation and the Office of Naval Research, was published December 7 in *Nature Communications*.

By Holly Evarts

Top: Olivier Toubia; *bottom*: Samuel Sia (Photos by Timothy Lee Photographers)

LAB TO MARKET

New Research to Revenue course unites SEAS and the Business School to fast-track valuable ideas to market.

Columbia has world-class research and industry-leading business leaders—and a new class at the Engineering School looks to bring them even closer together.

The new Research to Revenue 4000-level class, co-taught by Samuel Sia, Associate Professor of Biomedical Engineering, and Olivier Toubia, the Glaubinger Professor of Business from the Columbia Business School, is the product of a University-wide mandate to increase cross-pollination between the schools. But more specifically, Sia and Toubia said, the course will foster engineering-business connections that could help bring more ideas to profitable life.

"We have two objectives—one, where we teach the students in both Business and Engineering what needs to be done to bring an idea from lab to market. But the secondary objective is that these students will actually meet each other, and the class will be a forum for engineers to meet MBA students and vice versa," said Sia, who is also faculty codirector of entrepreneurship at Engineering. "There's demand from both sides."

Toubia agreed: "We want to open Business students to the idea that they can just look around campus to find technologies and research they could help bring to market."

The class debuted this spring as a half-semester session open to advanced undergraduate and graduate students. Sia and Toubia put a premium on enrolling students with in-progress projects featuring exploitable intellectual property. With a shortened schedule, "we want to make sure people really get the most of it from day one," Sia said. (The class also coordinates with Columbia Technology Ventures to use the University's patented assets as projects.)

Sia and Toubia tapped faculty from both the Business School and Engineering to lecture on identifying and pursuing IP-based opportunities arising from research.

"I'm excited to welcome a few speakers who are world-class researchers in those fields," Toubia said. "I'm pretty humbled and amazed by the mix of people we have been able to put together."

And the two professors bring their own specialties to the topic.

Toubia, who received his PhD in marketing from MIT, has focused his research on innovation, social networks, and behavioral economics. Toubia also heads up the Eugene Lang Entrepreneurship Center at the Business School. Sia is a serial entrepreneur in the biotech field, having founded Claros Diagnostics and Junco Labs, an SBIR-funded firm that was spun out of Columbia. He is also a cofounder of Harlem Biospace, a biotech incubator in Harlem that offers users shared wet lab space and entrepreneurial support.

And while the course is a pilot—"we're trying to start small in the spirit of startups," Toubia said—if all goes as planned, future tweaks could include lengthening the program to a full semester class or teaching multiple sessions. Sia and Toubia also said they'd consider moving the class to the fall semester, to better align with the Engineering School's entrepreneurial competitions, including fall's Fast Pitch and spring's Columbia Venture Competition.

"We have two objectives—one, where we teach the students in both Business and Engineering what needs to be done to bring an idea from lab to market. But the secondary objective is that these students will actually meet each other, and the class will be a forum for engineers to meet MBA students and vice versa."

—Samuel Sia, Associate Professor of Biomedical Engineering

Even though it's starting small, Sia said he's excited for the ways coupling MBA expertise to the Engineering School's research know-how have the potential to enact meaningful change.

"I'm excited that there's now a chance for our Engineering students working on technologies to be matched up with Business students who are interested in working on hard problems like health or climate change or energy," Sia said. "I think this is one of the more profound things that society expects from universities in general: for us to be doing meaningful, long-term research on hard problems. If we don't do it, who will? And hopefully this is just going to be the beginning."

By Jennifer Ernst Beaudry

COLUMBIA UN

LAUNCH ONLINE DATA SCIENCE EDUCATION SERIES

One of the first universities to offer a degree in data science, Columbia University is now branching online with a new series, Data Science and Analytics in Context.

In partnership with nonprofit education provider edX, a distinguished team of Columbia professors is covering the fundamentals of data science—statistics, machine learning, and algorithms—and the technologies it has spawned, from automated translation to recommendation engines to personalized medicine to wirelessly connected devices.

With real-world examples and interactive exercises, the professors are making key concepts memorable and easy to master. The program is designed for both those considering a career in data science and those curious about exploring what data science has to offer. Courses are focusing on concepts rather than programming. The three-part series started December 14 and will run through April. Soon edX will run the three-part series regularly.

"This course is perfect for anyone trying to understand how data-driven decisions are changing how we live," said Patricia Culligan, a civil engineer who is associate director of the Data Science Institute and helped develop the series. "Our hope is that learners will gain fluency in the language of data analytics and use these lessons to advance their careers."

Taught by Data Science Institute faculty, the courses feature data that has factored into original research, including on the polarization of American politics and the risk factors leading to preterm births.

IVERSITY+EDX

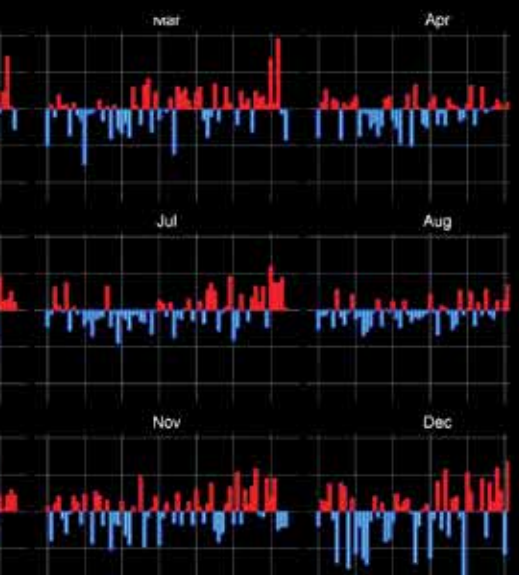
Each course runs for five weeks and requires seven to ten hours of effort per week. Learners can opt to take each course at no cost or for Columbia-approved certification ($99 for courses one and two, and $149 for course three).

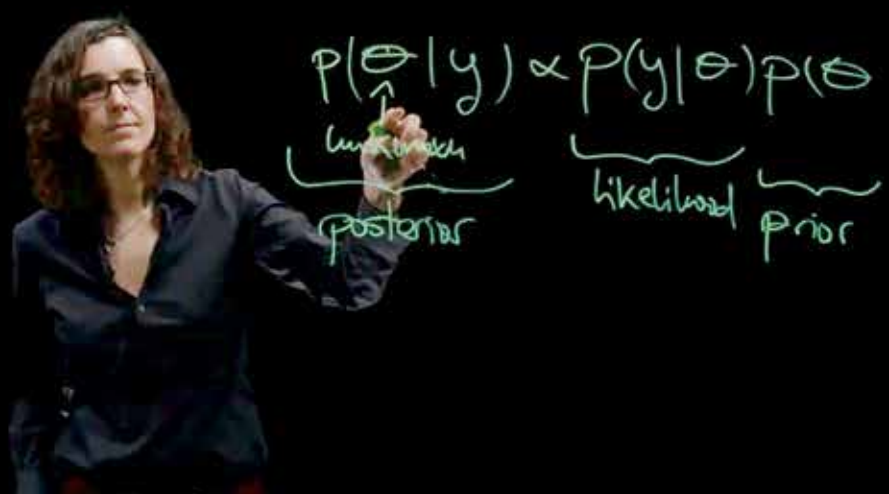
Columbia joined edX, a joint venture between Harvard University and MIT, with the launch of historian Eric Foner's series on the Civil War in 2014. Data Science and Analytics in Context is Columbia's second series to appear on edX, and the first edX XSeries to focus on data science.

> "The global demand for online programs in data science and analytics is massive and growing daily."

"The global demand for online programs in data science and analytics is massive and growing daily," said Anant Agarwal, founder and CEO of edX. "This XSeries is unique in its design to appeal to a very broad audience. It is a great addition to the edX portfolio."

By Kim Martineau





Columbia professors (*left to right*): Tian Zheng (statistics), James Curley (psychology), and Eva Ascarza (marketing)

GOING GREEN ONE MONDAY AT A TIME

David Yeung BS'98 and his startup, Green Monday, want to change the world.

David Yeung BS'98 wants everyone to do their part to solve global warming and food insecurity—and with his company, Green Monday, he thinks he's found a way to mobilize the masses.

Green Monday, which Yeung founded in 2012 with his friend and business partner Francis Ngai, was born over lunch, when the two men discussed social ventures and whether there was the possibility of using them to promote social change and sustainability. And the duo, both longtime vegetarians, came up with a plan: to harness the power of social media to get people to go meatless every Monday. (Why Mondays? "You start a new chapter every Monday—once you hear it, it will ring a bell every week and be a natural reminder," said Yeung.)

"People don't know that their choice of food, their diet, and the leftovers and the waste have a huge impact on global warming," said Yeung, adding that the emissions from the livestock industry are a significant contributor to global carbon dioxide totals. But while convincing the world to go vegetarian full time might be a tall order, getting people to commit to a day of plant-based eating, he said, is achievable. The beauty of Green Monday is in its simplicity: "We're not asking people to convert to a new diet." When you add in the inherent health benefits people can see and the social-media appeal of posting about your meals, he said, "you have the ingredients for success."

The idea is to make the appeal "simple, viral, and actionable"—and so far, it's working.

To date, Green Monday's program is active in more than 10 countries, including the United States, and more campaigns are set to launch in the United Kingdom, Singapore, Japan, Albania, and Germany. In the firm's home in Hong Kong, 1.75 million people—or a quarter of the nation's population—have taken the pledge to go meat-free on Monday, and Yeung said the company is continuing to expand. The organization has been active at Columbia since 2014, and now Washington University in St. Louis and UCLA, along with a number of other U.S. colleges and universities, have signed on.

And scaling up is where even more substantive change lies.

"If you can get everyone in an organization or a group to take a small step, the holistic impact is huge. It's actually not a baby step anymore," Yeung said. "What we do as each individual human being has a big factor in either hurting or saving the planet."

To that end, Green Monday doesn't stop there. The company also operates three other arms: corporate consulting, to help

other firms build their own sustainability programs; impact investing, to start and nourish new companies in the green and healthy living space; and a retail chain and e-tail site, called Green Common, that sell plant-centered foods.

"We try to be very broad and very comprehensive—some people like to call it the Swiss Army knife of tackling sustainability issues," Yeung said.

Yeung credits his time at Columbia Engineering for making Green Monday possible.

"The best thing [about SEAS and the major] is it teaches you how to solve problems—it's not necessarily about writing a program or designing software. It's 'what are the results we need to generate?'" he said.

And the University's place in New York City can't be overlooked either, he said.

"Columbia has the very unique advantage of a global presence. I'm constantly amazed by the network and the wealth of resources this network provides," he said. "The world is getting smaller and smaller, and you cannot look at it from a one-city or one-country point of view. Everything is connected, and I think Columbia is really in a position to groom, educate, and train a new breed of leaders who have a global view. Our world has no shortage of problems—we need passionate, methodical, and creative people to address them."

By Jennifer Ernst Beaudry

Photo by Timothy Lee Photographers

Photo by Timothy Lee Photographers

BUILDING CHANGE

Helen Gurfel BS'96 helps make the places where we live and work greener.

Helen Gurfel BS'96 grew up knowing she wanted to do something socially responsible—and as executive director of the Urban Land Institute Greenprint Center for Building Performance, she's helping reduce the environmental impact of buildings around the world.

Gurfel, who joined the ULI Greenprint Center in 2012, leads a consortium of real estate owners and investors to benchmark and analyze performance, and share best practices, with the aim of reducing carbon emissions and improving the environmental performance of their buildings. And with over 6,000 buildings covering 1.2 billion square feet across 51 countries covered by their group, those impacts are substantial.

"Buildings consume roughly 40 percent of energy used and contribute over 35 percent of total greenhouse gas emissions; improving the environmental performance of properties both reduces emissions and enhances property values," she said.

This past December, Gurfel participated in the UN Paris Climate Conference, where 50,000 delegates representing more than 190 countries met to negotiate the Paris Agreement, which looks to keep global warming below the critical 2°C. As a delegate to the conference's Buildings Day, she joined an alliance of real estate and construction organizations committed to upholding the two-degree goal.

"It felt cautiously optimistic," Gurfel said of the mood in Paris. Being part of the historic talks, she added, was rewarding, and not just because of the progress made. Gurfel traces her interest in international collaboration to childhood, traveling to over 45 countries on six continents, and to her graduate work at the University of Pennsylvania, where she earned a master's in international studies. At Columbia, she studied chemical engineering and premed. "I always wanted to work in a field that drives positive social impact," she said. But after graduation, Gurfel wanted to get some real-world experience and took a job as a consultant with PricewaterhouseCoopers.

She learned a lot on the job and had a great opportunity to live and travel abroad. "I did like the work. I like figuring things out, in part attributed to my engineering education," she said with a smile.

Gurfel values her time at SEAS. "It was an amazing experience and a fantastic community," she added. "My Columbia education gave me a lot of confidence to tackle complex issues."

After earning an MBA from the University of Pennsylvania's Wharton School in 2005, she joined GE Capital in a leadership program where she rotated through a number of departments including real estate portfolio valuations and energy investment. In 2007, she joined a new group for the firm, the Real Estate Global Sustainability Group, where she pioneered a portfolio-wide approach to rooftop solar implementations and developed green programs for GE's portfolios in the United Kingdom, France, and Canada. "It blended energy and real estate in a sustainable way—it was the perfect combination," she said.

"I always wanted to work in a field that drives positive social impact."

It was that background that led ULI to recruit her in 2012. Over the past five years, Gurfel said, the member buildings have reduced their consumption by 11 percent in energy, with a corresponding drop in greenhouse gas emissions. The Greenprint Center has even more ambitious goals going forward: to reduce emissions by 50 percent by 2030.

The group is continually growing, and Greenprint has been developing new public sector partnerships like a recent one with the San Francisco Department of the Environment, where they are digging into the city's analytics and, Gurfel said, "taking the data and making it useful information that people can take action on."

Pushing the industry forward with Greenprint's help is key. This year, said Gurfel, is the warmest since record keeping began in 1880.

"It feels good to be part of the solution," she said, "but clearly there is much more to be done by all."

By Jennifer Ernst Beaudry

JOIN US, ALUMNI! REUNION WEEKEND 2016: JUNE 2 TO JUNE 5

Generations of Columbia engineers will return to Morningside over four invigorating days this spring to reconnect with old friends, make some new ones, and rediscover the campus and city where so many formative memories were made.

Alumni from the classes of years ending in 1 and 6 (e.g., 1966, 1971, and so on) and members of the Golden Lions Society (which includes all alumni who graduated more than 50 years ago) are invited to bring their families and guests to celebrate at events on campus and around New York City, June 2–5. Dean's Day, for all alumni, will take place Saturday, June 4.

During "Back on Campus" sessions, Columbia Engineering faculty and distinguished alums will discuss their research and share their professional experiences. For example, SEAS alum Jamey Barbas BS'83 is scheduled to give a talk. A civil engineer with expertise in long-span bridges, particularly in cold weather climates, she is currently leading the multibillion-dollar Tappan Zee Bridge construction project. Alumni and friends will also hear from Dean Mary C. Boyce, who will detail the School's cutting-edge research in tomorrow's most pressing challenges, ranging from nanoscience and big data to health care and global climate change.

"Reunion is a wonderful opportunity for alumni to see what remarkable progress SEAS has made since they graduated, and to reconnect with the School, their friends, and the faculty," said Dean Boyce. "Reunion is a great way for all of us to celebrate our exciting trajectory."

Events will also include departmental luncheons and the Columbia Engineering Alumni Association's annual awards presentation and welcoming reception, as well as plenty of socials and mixers like wine tastings, dinner dances, Broadway shows, and tours around the city.

"Classmates who have not been back to campus recently will be amazed at both how much the place has changed and how much it has stayed the same," said Joshua Hauser BS'66, MS'68, a member of the 50th Reunion Committee. "I am looking forward to reconnecting, comparing notes about our recollections, and learning what people have done in their years away."

For up-to-date information about Reunion Weekend, visit the School's website at engineering.columbia.edu/reunion.

By Jesse Adams

engineering.columbia.edu/spring2016video

Top: In the first in the Extreme Engineering series, Mike Massimino delves into the future of digital health with Biomedical Engineering Associate Professor Sam Sia, whose lab-on-a-chip coupled with a smart phone empowers patients worldwide; *bottom*: Sit down with Mike Massimino in an animated conversation about exploration meeting innovation in his Extreme Engineering video and lecture series (Videos by Jane Nisselson)

Engineering to the Extreme

It takes one to know one.

As a veteran of two space flights, former NASA astronaut Michael Massimino BS'84 scores pretty high on the extreme engineering scale himself. What's cooler than being an astronaut? So with this in mind, Columbia Engineering and the Department of Mechanical Engineering introduced a new program, Extreme Engineering, "where exploration meets innovation." Dean Mary C. Boyce spearheaded Extreme Engineering with Massimino as a way to excite enthusiasm around all the various fields in engineering.

"This is an opportunity for the School to showcase some of the unbelievably diverse careers students can have in engineering," Massimino says. "Engineers are builders and innovators, yes, but we are also explorers and adventure seekers. We want to show our students some of the cutting-edge things they can do with an engineering degree."

The School has already cohosted six events under the new Extreme Engineering banner this academic year and launched a video series, hosted by Massimino, that showcases SEAS faculty and their "extreme" research. The video series kicked off with Associate Professor Samuel Sia, a biomedical engineer and entrepreneur who has developed low-cost, handheld devices that can rapidly diagnose sexually transmitted diseases like HIV and syphilis in real time.

The first in the Extreme Engineering lectures featured a panel discussion in September with NASA and Mars experts centered on the film *The Martian*, starring Matt Damon and directed by Ridley Scott, followed by a guest talk by Captain Alfred Scott McLaren, an accomplished explorer and scientist. McLaren captivated the audience with his tales of serving aboard five nuclear submarines, including a time he sped across the Atlantic in the world's fastest nuclear submarine to set a record still standing after 50 years.

Students got a treat later in the fall semester when astronaut and ace pilot Captain Scott "Scooter" Altman came to Morningside and gave an Extreme Engineering talk. Referred to as "the real Top Gun," Altman, who did all the actual flying in the hit Tom Cruise film, discussed his extraordinary career spanning the U.S. Navy and NASA. In February, three guest speakers—NASA geologist Dean Eppler, NASA flight controller Allison Bolinger, and astronaut Kjell Lindgren—gave talks about their careers and experiences on the job. So the idea behind Extreme Engineering is to very much underscore the thrill and adventure garnered from the different corners of engineering—from space exploration to the deep sea to incredible advancements in technology, science, and medicine.

Indeed, it's fitting for Massimino to lead this new program. He has logged a total of 571 hours and 47 minutes in space, and a cumulative total of 30 hours and 5 minutes of spacewalking in four space walks. He joined the SEAS faculty in 2014 as professor of professional practice in mechanical engineering and has since introduced a course on human space flight.

"As an engineer, you're really on the edge of what is possible," says Massimino. "We're trying to emphasize this and all the reasons why students became interested in engineering in the first place."

By Melanie A. Farmer

EXPLORING BIG DATA SOLUTIONS FOR THE NORTHEAST

Columbia University is the lead on a $1.25 million project funded by the National Science Foundation (NSF) to share data, tools, and ideas for tackling some of the big challenges facing the northeastern United States.

As lead agency for the Northeast Big Data Innovation Hub, one of four NSF-sponsored hubs, Columbia is bringing together experts in the public and private sector to collaborate on data-driven solutions to problems in health care, energy, finance, urbanization, natural science, and education.

Massive datasets and novel computational techniques are changing how individuals and societies approach day-to-day tasks. Data analytics promise to deliver individually tailored treatment to patients, massively reduce energy use in buildings, and radically improve teaching methods in schools, among other advances.

The Northeast is home to some of the oldest and most diverse cities in the United States, and many of the nation's top universities, hospitals, and banks. "It's an ideal laboratory for testing the potential for data science to improve lives," said Northeast Hub principal investigator (PI) Kathleen McKeown, director of the Data Science Institute and Henry and Gertrude Rothschild Professor of Computer Science. "The Northeast Hub is focusing on extracting insights from large amounts of data that can bring about tangible results."

With 40 universities, and partners in industry, government, and the nonprofit sector, Columbia is identifying high-priority needs in the region. A series of workshops over the next three years will give partners a chance to brainstorm and collaborate on projects that can bring about the greatest impact.

The Northeast Hub is tackling a number of topics including how to encourage data sharing to maximize the potential for discovery, how open data principles can be balanced against privacy and security concerns, and how cities can mine and share data to improve public services and adapt to climate change. Its six areas of focus are health, energy, cities and regions, finance, big data in education, and discovery science, and it also is addressing four overarching themes including data sharing and privacy and security.

The idea for a Big Data hub network came in 2012, after President Obama announced a $200 million National Big Data Research and Development Initiative to apply data analytics to education, environmental and biomedical research, and national security. NSF, one of six federal agencies involved, proposed an add-on initiative that would divide the country into "regional innovation hubs," each harnessing experts in academia, industry, government, and the nonprofit sector, to address problems too big for any one to take on alone.

Planning sessions were held last fall in four regions. NSF announced leaders for the hubs—Columbia for the Northeast; Georgia Tech and North Carolina State University for the South; the University of Illinois at Urbana-Champaign for the Midwest; and the San Diego Supercomputer Center, University of California, San Diego, and the University of Washington for the West.

The Northeast Hub includes all six New England states—Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut—as well as New York, New Jersey, and Pennsylvania. General Electric, Microsoft, and Ericsson are among 20 industry partners; New York City's Office of Data Analytics, Brookhaven National Laboratory, and the Regional Plan Association are among 20 government and nonprofit partners.

The Hub's executive committee is being led by McKeown, the PI; Howard Wactlar, a computer scientist at Carnegie Mellon; Carla Brodley, a computer scientist at Northeastern University; Vasant Honavar, a computer scientist at Penn State; and Andrew McCallum, a computer scientist at University of Massachusetts, Amherst. A full list of partners is available on the Northeast Hub website (http://northeastbdhub.dsi.columbia.edu/).

Last December, the Hub held its first workshop on campus. Speakers included Michael Leiter, a counterterrorism expert and the chief strategy officer at Leidos, a top U.S. defense contractor; and Keith Marzullo, director of the federal Networking and Information Technology Research and Development Program.

By Kim Martineau

Engineering Icon: Santiago Calatrava, Engineer-Architect-Artist

Santiago Calatrava's keynote in November marked the third in the School's Engineering Icons series (Photo by Timothy Lee Photographers)

In the latest installment of the School's Engineering Icons series, the world-renowned engineer and architect Santiago Calatrava shared his career highlights, detailing how art impacts his life and continues to influence his engineering designs.

Calatrava, head of Santiago Calatrava Architects & Engineers, is globally known for his soaring and elegant sculptural bridges, buildings, and public works designs. His many major projects include the World Trade Center Transportation Hub in New York City, the Museo do Amanhã in Rio de Janeiro, the Chicago Spire, and the immense City of Arts and Sciences complex in Calatrava's hometown of Valencia, Spain.

Calatrava has strong ties to Columbia Engineering and the University: two of his children are graduates of the Engineering School, and he holds an honorary doctor of humane letters degree from Columbia. He also endowed a professorship in civil engineering at the School.

Fittingly, Calatrava was introduced by George Deodatis, the Santiago and Robertina Calatrava Family Professor and chair of the Department of Civil Engineering and Engineering Mechanics. In describing Calatrava's extraordinary talents, Deodatis referred to him as "a quintessential Renaissance man . . . one of the world's most prominent architects and a distinguished engineer."

An artist as well as an engineer-architect (Calatrava studied art in Paris before becoming an architect), Calatrava uses all his talents as he approaches the artistic design for each of his projects—from wineries, museums, and footbridges to immense train stations and public spaces. He has a penchant for translating an inspirational painting, work of art, or his own sculptures into a civil engineering structure. He often considers the project's surrounding landscape in his designs as well, whether it is a beautiful, lush countryside of hills and valleys or the more metropolitan terrain of a bustling city.

"It is not the hand that decides the work of an architect or an engineer; it's the eye: the physical eye and the eye in your mind," he said.

In her welcome, Dean Mary C. Boyce shared some of Calatrava's work with the audience, including beautiful images of the first bridge he designed and built, the Felipe II Bridge in Barcelona. "If you are an engineer, perhaps those of you who are architects, you cannot help but see the engineering in every design . . . It's fair to say that Santiago's visually stunning yet profoundly humanistic approach to grand public spaces appears in all his work," she said.

Calatrava's keynote, held November 18 at Faculty House, is the third in the Engineering Icons series, which was launched in the fall of 2013 to bring prominent, game-changing engineers to the School to discuss their real-world experiences with students and alumni. The event was sponsored by Columbia Engineering's Office of Alumni and Development.

By Melanie A. Farmer

New GE Partnership to Advance MRI Research

A new partnership between Columbia and GE Healthcare is set to push the boundaries of MRI research and imaging technology.

The Departments of Biomedical Engineering at the Engineering School and Radiology at Columbia University Medical Center (CUMC), led by Professors Andrew Laine and Larry Schwartz, have collaborated on a deal with GE to narrow the gap between industry and academia. In this partnership with conglomerate GE, Columbia faculty, students, and researchers will have access to new, state-of-the-art imaging machines on campus and technical support to bring their lab work to industry.

"GE has chosen to put a large investment in translational research, and we are the perfect partner," says Laine, biomedical engineering department chair, who has a joint appointment in radiology. "We already have a strong set of faculty and researchers with a rich set of strengths in imaging; in neuroscience, oncology, and cardiovascular diseases; and in big data—many assets GE can tap into."

Chaitanya Divgi, professor of radiology at CUMC and director of the PET Center, worked closely with Laine on the GE pact. He adds, "This new endeavor will facilitate a comprehensive collaboration involving scientists at CUMC, at the Engineering School, and at GE. This new partnership gives all of us the ability to accelerate noninvasive imaging translation from proof of concept through initial human application and ultimately implementation and utilization."

As part of the collaboration, GE is providing the University and NewYork-Presbyterian Hospital with 18 new, state-of-the-art MRI systems. MRI, or magnetic resonance imaging, produces high-resolution images of organs and structures in the body that can display findings (tumors, abnormal tissue structure, bleeding) not detected by other widely used imaging methods like X-ray or ultrasound. Part of the GE partnership also will provide the University with six full-time dedicated technicians who will work with Columbia engineers and clinicians, and a dedicated 3 Tesla (3T) MRI machine, with a more sophisticated system that provides advanced and clearer functional images particularly beneficial when scanning the brain, spine, heart, and musculoskeletal system.

The Zuckerman Mind Brain Behavior Institute (MBBI) at Columbia also will be involved with GE as it continues its critical work in advancing brain-imaging techniques. J. Thomas Vaughan, a world expert in ultrahigh field MRI techniques and technology, joins Columbia this year as University-wide Director of Magnetic Resonance Research—a new position established between MBBI, CUMC, and Columbia Engineering to focus on neurological imaging and clinical translation research. Vaughan will also hold joint appointments in biomedical engineering at the Engineering School and in radiology at CUMC.

In many ways, this new deal with GE is a natural extension of an already-thriving collaboration between the Departments

"We already have a strong set of faculty and researchers with a rich set of strengths in imaging; in neuroscience, oncology, and cardiovascular diseases; and in big data—many assets GE can tap into."

—Andrew Laine, Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Department Chair

of Biomedical Engineering and Radiology. Several Engineering faculty who specialize in imaging have joint appointments in radiology and have ongoing research projects across departments.

"This major academic-industrial partnership is giving us a big boost at a very exciting time for MRI technology," says Laine. "We're looking forward to bringing the innovation of our faculty to bear on existing challenges in clinical translation and imaging science. We believe this can best be accomplished through this exciting GE and Columbia partnership."

By Melanie A. Farmer

Left (*from left to right*): Radiology Dept. Chair Larry Schwartz, Dean Mary C. Boyce, GE CEO Jeff Immelt, and GE Healthcare CEO John Flannery; *right*: Panelists discussed advances in imaging on December 4, 2015, marking the official signing of the Columbia-GE partnership (Photos by Michael DiVito)

VIEW FROM THE TOP

A ribbon-cutting ceremony held in December marked the dedication of the Data Science Institute's new executive offices, located on the top floor of the Northwest Corner Building. Maria Torres-Springer, president of the New York City Economic Development Corporation, emphasized the Institute's role in turning New York City into a powerhouse for innovation. "Our tech ecosystem has become the fastest growing in the world," she said. Attendees included, below from left to right: Patricia Culligan, associate director of the Data Science Institute; David Madigan, executive vice president and dean of Columbia's Faculty of Arts and Sciences; Columbia Engineering Dean Mary C. Boyce; University trustee Armen Avanessians MS'83; University President Lee C. Bollinger; Torres-Springer; G. Michael Purdy, executive vice president for research; and Data Science Institute Director Kathleen McKeown.

SPOT NEWS ROUNDUP

CAMERAS FOR ALL SEASONS

Computer Science Professor Shree Nayar and Makoto Odamaki, a visiting scientist from Ricoh Corporation, have developed Cambits, a modular imaging system that enables users to create a wide range of computational cameras. Composed of a set of five different colored blocks including sensors, light sources, actuators, lenses, and optical attachments, Cambits can readily be assembled to make cameras with functionalities including high dynamic range imaging, panoramic imaging, refocusing, light field imaging, depth imaging using stereo, kaleidoscopic imaging, and even microscopy.

The 3D-printed Cambit blocks are quick and easy to configure and operate when plugged into a host computer, tablet, or smartphone. When a set of blocks is put together, the host device is able to power the camera, recognize the setup, and pull up a menu of options, thanks to novel circuit architecture enabling full configurability.

The proof-of-concept project was developed over two years of intensive collaboration and utilizes a suite of computational photography algorithms implemented by a team of MS project students at Columbia Engineering. Nayar and Odamaki hope to partner with a manufacturer to bring their concept to the public.

"We wanted to redefine what we mean by a camera," says Nayar, the T. C. Chang Professor of Computer Science at Columbia Engineering and a pioneer in the field of computational imaging. "Traditional cameras are really like black boxes that take one type of image. We wanted to rethink the instrument, to come up with a hardware and software system that is modular, reconfigurable, and able to capture all kinds of images. We see Cambits as a wonderful way to unleash the creativity in all of us."

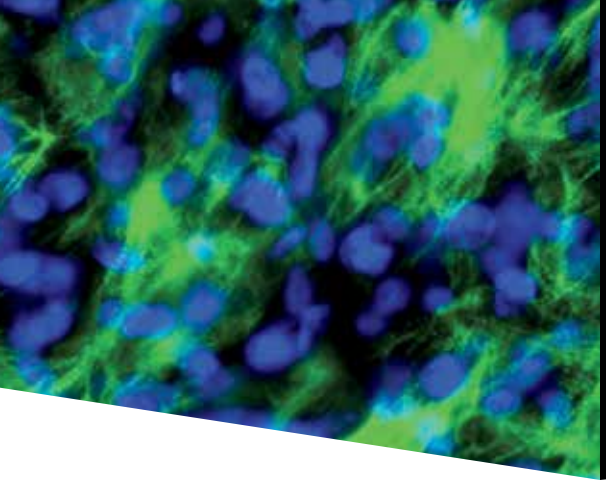
Cambits is scalable: new blocks can be added to the existing set (Photo by Timothy Lee Photographers)

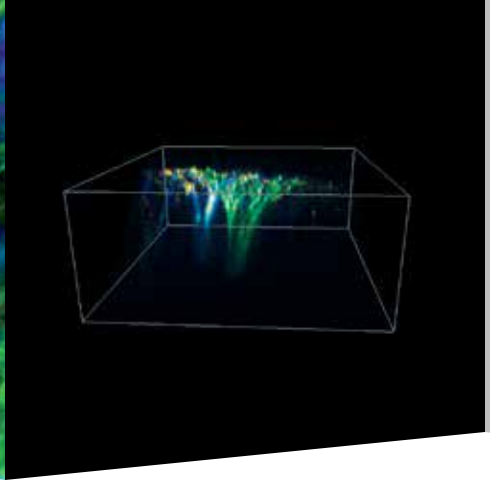
MATERIALS OF TOMORROW

Simon J. L. Billinge, professor of materials science and applied physics, recently received a major grant from the National Science Foundation to help advance his innovative approach to cut the cost of designing custom materials for high-performance devices such as photovoltaics and batteries. The three-year, $983,000 grant, part of a high-profile initiative to fast-track the discovery of new materials, supports research at Columbia University and the National Synchrotron Light Source II at Brookhaven National Lab in Long Island where samples are bombarded with high-energy X-ray beams to probe their nanostructure.

Experiments, with implications for pharmaceutical materials, batteries, catalysts, and novel high-temperature superconductors, explore how the precise atomic structural arrangement of substances affects their behavior. The effort depends on building large databases compiling measured and calculated quantities describing the material structure and properties that will be made available to the larger materials research community. The interdisciplinary project brings together a variety of SEAS faculty, including applied mathematician Qiang Du and computer scientist Daniel Hsu, with expertise in information theory, machine learning, and image recognition.

The goal is to use data analytic techniques, similar to those that power Google and Netflix apps, in combination with latest generation experimental techniques, to accelerate the discovery of novel high-performance materials.





Left: Professor Simon Billinge (Photo by Jeffrey Schifman); *center*: striated ultrastructure containing troponin forms around cell nuclei (Image courtesy of Benjamin Lee); *right*: Apical dendrites of layer 5 excitatory neurons expressing calcium-sensitive fluorophore GCaMP6 in an awake brain (Image courtesy of Hillman Lab)

Initial targets will be cadmium selenide nanomaterials for photovoltaics and flat-panel displays, and lead telluride, useful as a material for waste heat recovery. Billinge, a member of Columbia's Data Science Institute, is also investigating how to measure the active ingredients in complex cutting-edge drugs to help make standardized pills that are easily absorbed into the bloodstream.

BEAT IT

Columbia Engineering researchers, led by Professor Gordana Vunjak-Novakovic, have shown, for the first time, that electrical stimulation of human heart muscle cells (cardiomyocytes) engineered from human stem cells aids their development and function. The team used electrical signals, designed to mimic those in a developing heart, to regulate and synchronize the beating properties of nascent cardiomyocytes, the cells that support the beating function of the heart.

"We've made an exciting discovery," says Vunjak-Novakovic, the Mikati Foundation Professor of Biomedical Engineering and a professor of medical sciences. "We applied electrical stimulation to mature these cells, regulate their contractile function, and improve their ability to connect with each other. In fact, we trained the cells to adopt the beating pattern of the heart, improved the organization of important cardiac proteins, and helped the cells to become more adult-like. This preconditioning is an important step to generating robust cells that are useful for a wide range of applications including the study of cardiomyocyte biology, drug testing, and stem cell therapy. And we think that our method could lead to the reduction of arrhythmia during cell-based heart regeneration."

Vunjak-Novakovic worked with George Eng and Benjamin Lee, both of whom recently received their PhDs from the Department of Biomedical Engineering and were the coleading authors of the study published in *Nature Communications* in January. The team is currently investigating how the immature heart cells develop their beating function and how to promote integration of engineered cells with the heart muscle.

EMBEDDING SECURITY

To the dismay of malware makers hoping to exploit the emerging Internet of Things, HP announced last fall that it would deploy groundbreaking host-based defense technology developed by Computer Science Professor Sal Stolfo and his former student Ang Cui PhD'15.

The Symbiote defense, which originated at Stolfo's lab at the Engineering School and was brought to market by their company, Red Balloon Security, via Columbia Technology Ventures, is featured on four new models of multifunction printers as reducing the threat of embedded device malware attacks on end users and organizations. HP will also deliver a firmware update enabling Symbiote on additional printers going as far back as 2011.

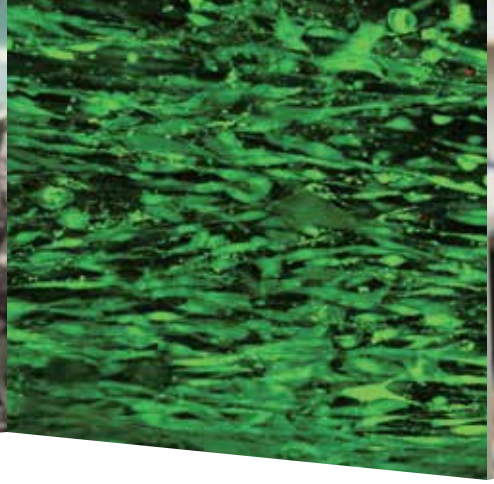
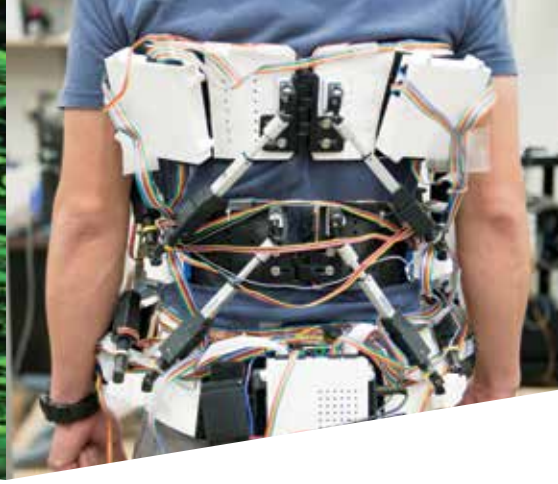
The technology, broadly compatible with printers, routers, cars, phones, medical equipment, and more, is the first intrusion defense to provide persistent implant detection, in-device memory monitoring, and situational awareness to protect against malicious attacks. Installing easily on any device without modifying the hardware or source code, Symbiote works with any operating system to embed intrusion detection functionality directly into binary firmware.

With the backing of the federal Department of Defense and Department of Homeland Security, Symbiote was in the works for over five years of development and prototyping. HP is the first company to deploy the advanced anti-malware technology, and Stolfo and Cui next plan to license it to other major vendors of embedded devices.

HYDRATE OUR TROOPS

Beating out fierce competition from 16 other schools, a team of recent Columbia Engineering graduates won first place for market-ready bioinstrumentation at the Biomedical Engineering Society's inaugural Undergraduate Design Competition. Daniel Huang BS'15, Jason Suh BS'15, Shawn Thomas BS'15, and Jennifer Xiong BS'15 presented the Hydrassistant, an advanced dehydration sensor tailored for military use, which began as their senior design project advised by Professor Barclay Morrison III and has continued to evolve postgraduation.

The U.S. military alone reports over 1,500 cases of heat illness each year attributable to dehydration. Hydrassistant is a portable and noninvasive device that uses conductivity sensors to analyze saliva as a biomarker in dehydration diagnosis, particularly amid the physical stress and extreme heat of military field operations. It is integrated with military-grade CamelBak gear for easy

deployment on the battlefield. The team competed against five other finalists in oral presentations at the Society's 25th annual convention last October in Tampa, demonstrating their product's relevance to compelling clinical needs, market and regulatory viability, business plan, and novelty, among other criteria.

Mentored by Aaron Kyle, senior lecturer in Biomedical Engineering Design, the Hydrassistant team continues development on their novel diagnostic techniques to assess dehydration for personnel operating in field settings.

BRACE YOURSELF

Conventional treatment is constricting and uncomfortable for the approximately one in 500 adolescents who need to wear rigid plastic braces around their hips and torsos to help correct idiopathic scoliosis, a disfiguring and potentially dangerous sideways curvature of the spine. But advances from roboticist Sunil Agrawal, professor of mechanical engineering, include creating dynamic spine braces that could soon allow patients a full range of motion in their everyday lives.

Agrawal and collaborators David P. Roye of Columbia University Medical Center (CUMC) and Charles Kim of Bucknell University received a $1 million grant from the National Science Foundation's National Robotics Initiative to support their work on revolutionary flexible braces that modulate corrective forces on the spine in desired directions as patients move, grow, and progress throughout the course of treatment.

Prototypes consist of adjustable rings that fit around the human torso. One model has compliant components able to adjust stiffness in specific directions without a power source, while, in a more high-tech version, the rings are dynamically actuated by servomotors to control the force and position applied to the body as sensors transmit data to an onboard computer for monitoring and fine adjustments. The team is currently developing a third hybrid prototype for long-term, low-power use, and planning clinical tests with young scoliosis patients at CUMC.

THE FUTURE OF MICROSCOPY

For her groundbreaking work providing high-resolution, real-time, 3D imaging of the living brain, Professor Elizabeth Hillman has won a major grant from the National Institutes of Health as part of the White House's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative.

The three-year, $1.83 million award, the first for Columbia Engineering, will help fund development of Hillman's SCAPE microscope (swept, confocally aligned planar excitation microscopy), which far surpasses most other technologies in terms of 3D imaging speed. SCAPE allows easy observation of neurons communicating with each other in large volumes of neural tissue, and of some small creatures' entire nervous systems. As a cheaper and simpler alternative to prior methods, it may soon be poised for widespread use across the life sciences.

Hillman, associate professor of biomedical engineering and of radiology, is head of the Laboratory for Functional Optical Imaging, a principal investigator at Columbia's Mortimer B. Zuckerman Mind Brain Behavior Institute, and a member of the Kavli Institute for Brain Science. She formally debuted SCAPE in *Nature Photonics* last February, and was quickly inundated with international requests for systems and collaborations. She's been working on commercializing the technology, available for licensing from Columbia Technology Ventures. In November, she was elected a fellow of the Optical Society of America for her "pioneering contributions to biomedical optical imaging, spectroscopy, and microscopy."

30 UNDER 30 GAME CHANGERS

This year's *Forbes* 30 Under 30 list featured several young Columbia engineers making waves in and beyond their professions.

Jason Kang '16SEAS was recognized in the Healthcare category for Highlight, a powdered additive for disinfectant solutions that help treat surfaces. Developed with Katherine Jin '16CC and Kevin Tyan '16CC, the patent-pending product temporarily colorizes decontaminated surfaces while enhancing adhesion and antiviral potency, protecting health personnel potentially exposed to diseases like Ebola.

The trio founded their company, Kinnos, after participating in the School's Ebola Design Challenge in fall 2014, soon persuading the New York City Fire Department to add Highlight to its HazMat unit's decontamination protocol. Subsequently, Kinnos won the USAID Fighting Ebola Grand Challenge, earning support for further testing, manufacturing, and deployment.

Forbes also honors the work of Adam Elmachtoub (in the Science category), assistant professor of industrial

Left: Richard Osgood; *center*: Stem cells grown on nanofibers (Image courtesy of Helen Lu); *right*: Sunil Agrawal's prototype for a wearable spine brace (Photo by Jane Nisselson)

engineering and operations research and a faculty member of the Data Science Institute; and Michael Wang (Manufacturing & Industry), an adjunct assistant professor of electrical engineering. Elmachtoub explores how businesses can use data science to work more efficiently, while Wang, cofounder of the startup FutureAir, innovates connected air conditioners and fans to reduce carbon emissions.

Additionally, the list features two SEAS alumni: venture capitalist Rami Rahal MS'09 (Venture Capital), cofounder and general partner at Blue Cloud Ventures; and Chelsey Roebuck BS'10 (Education), cofounder of Emerging Leaders in Technology and Engineering (ELiTE). Blue Cloud is a growth-stage firm focused on software-as-a-service companies, while ELiTE helps promote diversity in STEM fields.

A LIFE IN LASERS

In honor of his contributions to integrated optical devices, Richard M. Osgood, Eugene Higgins Professor Emeritus of Electrical Engineering and professor emeritus of applied physics, has been named a fellow of the National Academy of Inventors (NAI).

Osgood's specialties include new classes of lasers; the dynamics of lasers' material medium; the physics, chemistry, and applications of laser surface interactions; computational electromagnetics; and integrated optical devices in silicon and other optical materials. He has 480 journal publications and has received 23 patents, while his lab has been involved in many startups focused on optical materials and materials processing and on optical design software.

A member of the Columbia Engineering faculty since 1981, he cofounded the Columbia Microelectronics Sciences Laboratories (MSL), codirected the Columbia Radiation Laboratory (CRL), and headed up the Columbia University Center for Integrated Science and Engineering (CISE), now the Columbia Nano Initiative. He took a three-year leave of absence to serve as associate laboratory director for basic energy sciences at Brookhaven National Laboratory, where he oversaw the National Synchrotron Light Source, the Center for Functional Nanomaterials, and the Chemistry, Physics, and Materials Science Departments.

Osgood is also a fellow of the American Physical Society (APS), the Institute of Electrical and Electronics Engineers (IEEE), and the Optical Society of America (OSA). Last year, he received the 2015 IEEE Photonics Society Quantum Electronics Award; he is also a recipient of the OSA's R. W. Wood Award for his research in laser surface chemistry for electronic materials processing and of a Guggenheim fellowship.

READY . . . SET . . . REPAIR

Biomedical Engineering Professor Helen H. Lu recently won a three-year Translational Research Award grant totaling $1.125 million from the Department of Defense (DoD) for research on tendon-to-bone integration for rotator cuff repair. The funding, part of the DoD's Orthopaedic Research Program, will support preclinical trials testing a nanofiber-based device to help encourage biological healing between tendon and bone after surgery on the rotator cuff, a commonly injured set of tendons and muscles helping connect the shoulder and upper arm.

Lu has collaborated for a decade with William Levine, chair and professor of orthopedic surgery at Columbia University Medical Center, and researchers including lecturer Katherine E. Reuther, to resolve a major problem with tendon repair. Conventional repair simply reconnects the torn tendon to the upper arm without promoting its integration with bone, leading to a high re-tear rate after surgery. Their innovative approach regenerates the tendon-to-bone interface with a biomimetic nanofiber scaffold coupled with controlled stem cell differentiation, in which parallel nanofibers help foster integrative repair of rotator cuff tears in rebuilding tendon-to-bone connections layer by layer.

The nanofiber-based approach may soon herald a new generation of soft tissue fixation devices for use in sports medicine and treating degenerative joint diseases. Further in the future, Lu anticipates the formation of composite tissue systems and, someday, total joint or limb regeneration.

Compiled by Jesse Adams

Left: Michael Wang, adjunct assistant professor of electrical engineering; *right*: Adam Elmachtoub, assistant professor of industrial engineering and operations research

FACULTY NEWS

NEW FACES AT SEAS *(JOINED AS OF JANUARY 1, 2016)*

TAL DANINO

Assistant Professor, Biomedical Engineering
Postdoctoral Research Fellow, MIT, 2015; PhD, University of California at San Diego, 2011;
BS, University of California at Los Angeles, 2005

Tal Danino specializes in engineering biological organisms for novel health and environmental applications, beginning from a quantitative understanding of how networks of genes interact to establishing design principles for engineering biological behaviors though genetic programming. A 2015 TED fellow, he was most recently at the Koch Institute for Integrative Cancer Research at MIT. Here at Columbia, he plans to teach courses in synthetic biology.

SUMAN JANA

Assistant Professor, Computer Science
Google U.S./Canada Fellowship in Security, Stanford University, 2012–2014;
PhD, University of Texas, Austin, 2014; MS, University of Utah, 2009; BE, Jadavpur University, India, 2003

Suman Jana specializes in computer security and privacy, including augmented reality applications and web-based systems. His award-winning research has helped report and fix over 200 high-impact security vulnerabilities across a wide range of software. A former researcher at Google, Microsoft, and Bell Labs, Jana is teaching Advanced Topics in Network Security.

KAREN KASZA

Assistant Professor, Mechanical Engineering
Postdoc Research Fellow, Sloan Kettering Institute, 2010–2015; PhD, Harvard University, 2010;
BA and BS, University of Chicago, 2003

Karen Kasza works to better understand the principles underlying the mechanics, self-organization, and morphogenesis of living tissues across the molecular-, cellular-, and tissue-length scales, with a focus on how tissues are shaped during embryonic development. The goal is to use this understanding to shed light on human health and disease and also to learn how to better build tissues in the lab. Her experimental approach integrates quantitative in vivo live imaging, micromechanical studies, and genetics. Kasza was recently awarded a Clare Boothe Luce professorship by the Henry Luce Foundation. She is currently teaching the course Mechanics of Fluids.

MATTHIAS PREINDL

Assistant Professor, Electrical Engineering

Postdoc Research Fellow, McMaster University, Canada, 2014–2015; PhD, University of Padua, Italy, 2014; MS, ETH Zurich, Switzerland, 2010; BS, University of Padua, Italy, 2008

Matthias Preindl focuses on the design and control of power electronic and motor drive systems with applications in electrified transportation systems, renewable-energy power plants, and smart grids. Preindl has been a post-doctoral research associate at the McMaster Institute for Automotive Research and Technology and a sessional professor in the Department of Electrical and Computer Engineering, both at McMaster University, Canada. He plans to teach courses in electrical engineering with emphasis on power electronics and related topics.

PROMOTION TO FULL PROFESSOR

JOSE BLANCHET

Industrial Engineering and Operations Research

Using probabilistic methods to explore the evolution of "black swans," or unlikely situations almost impossible to anticipate, Jose Blanchet builds sophisticated computer models of financial portfolios to shock with random events like bond defaults and bankruptcies. He combines applied probability, computational finance, queuing theory, simulation methodology, and risk theory to help investors recognize warning signs before extreme events occur. The recipient of a Presidential Early Career Award for Scientists and Engineers, Blanchet serves on the editorial board of several leading journals of stochastic operations research.

KARTIK CHANDRAN

Earth and Environmental Engineering

Kartik Chandran's research focuses on reengineering the global nitrogen cycle and applying it to produce clean water and clean energy. He integrates microbial ecology, molecular biology, and engineering principles to transform sewage and other "waste" streams from pollutants to precious resources. He and his lab study how to harness microbial communities in natural and engineered settings to efficiently produce fertilizers, commodity chemicals, energy sources, and clean water. In 2015, Chandran was named a MacArthur fellow for his work and, in 2011, he received a major grant from the Bill & Melinda Gates Foundation to develop new models for water and sanitation in Africa.

VISHAL MISRA

Computer Science, joint appointment in Electrical Engineering

Vishal Misra specializes in using mathematical modeling to examine complex network systems, particularly the Internet. A widely cited expert on net neutrality, he has made major contributions to network traffic modeling, congestion control, and Internet economics, in addition to founding the data center storage startup Infinio and the popular sports website Cricinfo, now an ESPN affiliate. A fellow of the Institute of Electrical and Electronics Engineers (IEEE), Misra is the recipient of CAREER awards from the National Science Foundation and the U.S. Department of Energy.

Dear Fellow Columbia Engineers:

The spring semester of 2016 is well underway here in Morningside. Seniors and graduating master's and doctoral candidates are already looking to the world beyond campus, as well as eyeing final projects, exams, and possible summer internships. As alumni, we too can look ahead with some anticipation to Reunion Weekend 2016, to join with our fellow Columbians in celebration of our lifelong connections to this great institution. It promises to be a great Reunion Weekend, and we look forward to seeing many of you there.

What a year it has been so far! We've seen a remarkable expansion of our School's faculty, with many world-class scholars and researchers added to the already-impressive ranks of Columbia Engineering professors. The ribbon cutting and dedication of the Beacon Space in the Northwest Corner Building in December 2015 marked the opening of the Data Science Institute's permanent home. In alumni news, the Columbia Engineering Young Alumni Board hosted its widely popular Blue and White Gala in March of this year, the highlight of a busy social season for those engineers in the New York area. CEYA's signature event continues to attract and strengthen the bonds of all recent graduates of Columbia Engineering. The Columbia Engineering Alumni Association's gala on the evening of Thursday, June 2, 2016, in Low Memorial Library, serves as the official welcome dinner for Reunion Weekend. It is also the venue for conferral of the CEAA's highest honors—the Egleston, Johnson, and Pupin Medals—to a set of very accomplished Columbians. All Engineering alumni and guests are welcome to join us for this annual celebration.

Be sure to check your e-mail for updates and details on the many ways you can stay involved with our School in the months ahead. We hope you will connect with the CEAA and CEYA via Facebook and our websites, myceaa.org and ceya.engineering.columbia.edu, where you will find news of past and upcoming events.

Professor Emeritus Rene B. Testa
MS'60, EngScD'63
President
Columbia Engineering Alumni Association

Jessica Aspis
BS'08, '13BUS
President
Columbia Engineering Young Alumni

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Alumni Assocation

COLUMBIA | ENGINEERING
YOUNG ALUMNI

Class Notes: Undergraduate Alumni

1945
Class Correspondent:
Gloria Reinish
reinish@fdu.edu

1951
Class Correspondent:
Ted Borri
tjb63@columbia.edu

1953
Class Correspondent:
Don Ross
dross52@optonline.net

1955
Class Correspondent:
Leo Cirino
lcirino3333@gmail.com

1956
Class Correspondent:
Lou Hemmerdinger
LHemmer@aol.com

Lou Hemmerdinger writes, "It was a beautiful day when we held the annual Florida Luncheon of the Columbia Class of '56 at Prime Catch in Boynton Beach, FL. Everyone had a great time meeting old friends and enjoying the food and views of the Intracoastal waterway. We were fortunate to have Lindy Gallagher '82BUS, president of the Alumni Association of the Palm Beaches, and Dr. Jerry Spunberg '73CC, ARC Chair for Broward and Palm Beach Counties, speak to us about the admissions rates to the College and Engineering (7%), and describe some of the activities we can participate in as members of the Palm Beach Alumni Association.

Additionally, we spoke of our 60th Reunion in June and the activities planned for the event. But above all, the luncheon provided everyone a chance to relive the Columbia experience with old friends!"

Harold Reisman PhD'65GSAS writes, "In 2015, my wife, Miriam, and I celebrated our 80th birthdays and our 55th wedding anniversary. In January, our first great-grandchild was born in Los Angeles. A boy! In June, we attended the Bar Mitzvah of one of our three sabra grandsons in Israel. We returned to Israel in November for our granddaughter's beautiful wedding and then flew back to California for our San Diego grandson's Bar Mitzvah. In early December, we flew to Cape Town, South Africa, where we joined a three-day safari at Lentaba Camp, followed by a cruise stopping in Namibia before crossing the Atlantic to Rio de Janeiro. After so many happy events, it was good to return home to Carlsbad, CA, on December 24 to prepare for the start of a new year with more celebrations to come."

1959

Class Correspondent:
Betsey Altman
bmeca@comcast.net

1961

Class Correspondent:
Doug Kendall
dkjr@roadrunner.com

1962

Class Correspondent:
Marshal (Mickey) Greenblatt
mg840@columbia.edu

1963

Class Correspondents:
Chuck Cole
ccole6250@att.net

Mark Herman
mnh18@columbia.edu

Stephen Rosen MS'64 writes, "Thirty-four years after founding AKRF Inc. and growing the company into a 300-person environmental, planning, and engineering company with offices in four states, I have decided to slow down and split my time between Singer Island, FL, and Westport, CT. I will continue working for AKRF, but only part time."

1964

Class Correspondent:
Tom Magnani
tm421@columbia.edu

1966

50TH REUNION

To take an active role in your Class Reunion activities, please contact Jack Reilly at jr2813@columbia.edu or 212-851-0734.

1969

Class Correspondent:
Ron Mangione
Ronaldm@archeng.com

1971

45TH REUNION

To take an active role in your Class Reunion activities, please contact Jack Reilly at jr2813@columbia.edu or 212-851-0734.

1973

Michael Best is chief engineer of Taylor Freres & CIE, which served as financial and technical advisor to Generadora Electrica San Rafael, a 30 MW hydroelectric project in Mexico recognized as Latin America Energy Deal of the Year by Infrastructure Investor.

Daniel K. Moy MS'75 writes, "After 42 successful years post–Columbia Engineering working in both the private and public sectors, I have retired and embarked onto the next phase of my life. I graduated in 1973 with a BS in Operations Research and in 1975 with an MS also in OR."

1975

Billie Tekel Elias writes, "I recently accomplished something I always talked about doing: I published my first book. It's an homage to my late mother, the most colorful and upbeat person I ever knew. I'm already at work on my next project, a book about my dad, who was (before he died last year at age 94) one of the last people alive to have worked on the Manhattan Project."

1976

40TH REUNION

To take an active role in your Class Reunion activities, please contact Star Sawyer at ss3858@columbia.edu or 212-851-2402.

1976

Denise Alevy writes, "My love of travel has led me to become a travel consultant. I am a member of Virtuoso, the by-invitation-only group of elite travel advisors. I have combined the skills I learned at Columbia with my passion for travel. Through my personal relationships in the travel industry I am able to deliver the highest level of service. I draw upon my experience of traveling to over 120 countries. My inside access to hotels, cruises, and tours allows me to take care of my clients' details so they can focus on the enjoyment of traveling. You can reach me at contactdenise@me.com."

1978

Class Correspondents:
Larry Chung
lpc34@columbia.edu
Peter Luccarelli
peter.luccarelli@pliplaw.com

Below, top: Daniel K. Moy '73, MS'75; *bottom*: Denise Alevy '76

1979

Class Correspondent:
Stewart Levy
srlevy@att.net

Alan Reznik writes, "We are finally settled in our home in Milford, and my medical practice merged with three other groups. The larger group has over 40 MDs and I have been elected chief medical officer. At the same time, invention remains my side hobby, with six patents and counting. My latest is on Internet search and represents a shift in search conceptually to help restore serendipity. Life is busy. Elizabeth has continued to work with our dog Sophie doing dog therapy at the Foundation School. She is a founding member of "Food for Kids." The program provides food for those elementary students already in meal programs who don't have enough to eat on the weekends and come to school hungry on Mondays. Both are extremely rewarding and worthwhile endeavors. This year Sophie was invited to graduation as an Honorary member of the graduating class. Our kids are now young adults in the real world. Sam has a PhD in organic chemistry from Columbia and works for BMS; Michele works for Gramercy Tech in NYC; and Jane, after graduating UPenn two years ago, has decided to apply to medical school. Exciting times for everyone!"

1981

35TH REUNION

To take an active role in your Class Reunion activities, please contact Star Sawyer at ss3858@columbia.edu or 212-851-2402.

Class Correspondent:
James Reda
jfreda@jfreda.com

1982

Class Correspondent:
Dan Libby
kdl26@columbia.edu

Following a 33-year career, **Jim Reinish** retired from the Port Authority of New York and New Jersey, where he had served in several executive positions including, most recently, manager of the agency's Central Automotive Division. In that position, he received national recognition for his efforts to increase the environmental sustainability of the agency's multibillion dollar automotive fleet. In retirement Jim has provided consulting services, as director of business development, to the ACF Group, which uses compressed natural gas platforms and offers fleet vehicle conversions and fabrications in addition to advisory services, vehicle maintenance, and fuel management. He also continues to provide tutoring services for standardized tests including the SAT, ACT, GRE, and GMAT. Jim and his wife, Lisa, relocated to Rochester, NY, to be close to their daughter, **Ariel BS'10**, who, following her recent graduation from the University of Rochester Medical School, as well as her marriage, is a pediatric resident at U of R's Strong Memorial Hospital. Jim and Lisa's son, Daniel, is a high school teacher in Virginia. Their youngest daughter, Shelby, passed away on June 20, 2014, following complications from brain surgery. Jim and Lisa have established a memorial in her name at the Edmond J. Safra Family Lodge on the grounds of the National Institutes of Health campus in Bethesda, MD. The Safra Lodge provides no-cost accommodations to families of patients receiving care at the NIH Clinical Center. The Family Lodge is designed to foster much-needed rest and relaxation. The Family Lodge is located within walking distance to the NIH Clinical Center, where patients are treated for rare forms of cancer and many other medical conditions. Jim and Lisa stayed at the lodge during Shelby's surgeries. Members of the Columbia community who are interested in making a donation to the memorial should contact Jim at jim@reinish.net.

1985

Paul Chiu '94BUS and **Laiyan Wong** are happy to announce that their son William will be starting Columbia College in the fall of 2016.

1986

30TH REUNION

To take an active role in your Class Reunion activities, please contact Star Sawyer at ss3858@columbia.edu or 212-851-2402.

1987

Rick Penza has taken a position as advisory software engineer at IBM.

1988

Class Correspondents:
Caryn Frick
carynfrick@gmail.com
David Shofi
dshofi@atmi.com

1989

Class Correspondent:
Shreosee Roy
Shre.roy@att.net

Shawn Kolitch MS'90 made national news in January for orchestrating a rare temporary restraining order and seizure effort at the Consumer Electronics Show (CES) in Las Vegas. Acting on behalf of client Future Motion, Inc., he

Below, top: Shawn Kolitch '89, MS'90; *bottom*: Sara Kim '02 and Stephen Muench '02 welcomed their child, Emily

brought a patent enforcement action in Nevada federal district court against Changzhou First International Trading Co., Ltd., which was exhibiting a "Surfing Electric Scooter," accused of violating patents on Future Motion's ONEWHEEL self-balancing electric vehicle. The products resemble a skateboard with one large wheel in the center, using built-in sensors to measure orientation information to move according to how a rider leans. Shawn led two U.S. marshals onto the floor of CES to carry out the court's seizure order, attracting much interest at the high-profile tech gathering.

1990

Class Correspondent:
Laura Cordani Christopher
zchristophers@gmail.com

1991

25TH REUNION

To take an active role in your Class Reunion activities, please contact Star Sawyer at ss3858@columbia.edu or 212-851-2402.

Class Correspondent:
Radhi Majmudar
radhi@majmudar.org

1992

Class Correspondent:
Janneth Ignacio Marcelo
jannethmarcelo@gmail.com

1993

Class Correspondent:
Herbert Kreyszig
Hek7000@gmail.com

1994

Robert Salazar writes, "I was recently promoted to Sr. Engineering Manager, responsible for the Airframe and Mechanical Systems Engineering Department at AeroVironment Inc. in Simi Valley, CA. I am looking forward

abamerican.com

Alum's Spicy Startup Catches the Oprah Effect

Brian Ballan BS'04 is bringing all of his varied experience to A&B American Style, the hot sauce company he cofounded in 2011, and people are taking notice. The brand's focus on flavor (not just mouth-searing heat) has gained traction with retailers—and caught the attention of media mogul Oprah Winfrey herself, who included the company's three-sauce multipack on her 2015 Favorite Things list.

"The last couple of months were crazy. I'm still catching up on sleep now," Ballan said in an interview in January.

After getting his degree in management systems, Ballan spent several years in the financial world. At Citigroup, he spent four years on the strategy team and was part of the group tasked with addressing the fallout from the recession: "It was a once-in-a-lifetime, hopefully, chance to be at the epicenter of a major financial crisis."

But while working there, he noticed certain habits in his colleagues.

"There were some who cared about what they ate, but most were eating garbage all the time—and for no reason," he said. "That struck a chord with me: food should be more considered than it is."

So Ballan took action. Five days after leaving his position at Citigroup in 2010, he started as a line cook at New York City hot spot Buddakan.

"I didn't know anything about the food industry except as someone who ate food," he admitted. "I went from being an avid home cook to cooking at one of the busiest restaurants in the world. It was an overwhelming experience."

And after a year on the line, he joined forces with a childhood friend who had been making hot sauces at home.

"After I tasted one—and I was a cook at this point with a more educated palate—I was really impressed. It tasted like fresh chili peppers in a way that I don't think anything else on the market did," he said.

The two formed A&B in 2011. In 2012, Ballan returned to Columbia and earned an MBA at the Business School in 2013. "I can't stay away from Columbia. I love it there," he joked.

By early 2014, the duo had made their way into New York–area retailers, including Fairway and Whole Foods, and had a thriving e-commerce business.

Getting the nod in Oprah's fabled end-of-the-year list last year was great for business, Ballan said. "We did as much sales in the last two months as we had done in the rest of the year up to that point—and it was also a vote of confidence." Building on it, in 2016, the brand will launch new products that follow the same principles of high-flavor and high-quality ingredients.

"Now we have very substantial external validation that we can make high-quality products," Ballan remarked. "The kind you can trust to be the best."

By Jennifer Ernst Beaudry

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twitter.com/CUSEAS

youtube.com/ColumbiaSEAS

instagram.com/Columbia Engineering

to advancing technologies and products for the ever-expanding commercial and military Unmanned Air Vehicle markets."

1996

20TH REUNION

To take an active role in your Class Reunion activities, please contact Star Sawyer at ss3858@columbia.edu or 212-851-2402.

Class Correspondent:
Enrico Marini Fichera
em75@columbia.edu

Noha El-Ghobashy MS'00 has been appointed executive director of the American Society of Mechanical Engineers (ASME) Foundation. A mechanical engineer with two decades of experience across the corporate, academic, and nonprofit sectors, she will lead an organization that annually devotes nearly $2 million in program support including university scholarships, K-12 STEM initiatives, and other programs aimed at benefiting the global engineering profession. An advocate for engineers to power social change, Noha has spearheaded collaborations around the world to sustainably help underserved populations. Recently selected as one of *New York Business Journal*'s Women of Influence, she is the founding president of Engineering for Change, LLC, a global alliance of 15 organizations providing cutting-edge technology solutions to communities in need.

2000

Class Correspondent:
Daisy Chow
daisy@caa.columbia.edu

2001

15TH REUNION

To take an active role in your Class Reunion activities, please contact Beth Manchester at em2702@columbia.edu or 212-854-4472.

Class Correspondent:
Catherine Marcinkevage
marcinkevage@gmail.com

2002

Class Correspondent:
John Morris
jpm53@columbia.edu

Stephen Muench and **Sara Kim** welcomed their second child, Emily, on October 2, 2015, in NYC. Stephen works for Murex and Sara is an endodontist.

2003

Class Correspondent:
Amar Doshi
abd19@columbia.edu

Vincent Piau, his wife, Constance '02BC, and big brother Adam welcomed baby girl Emmeline Avery Piau on August 12, 2015.

2004

Class Correspondent:
Eric Rhee
eric.rhee@gmail.com

Eric Rhee writes, "Hello everyone from the Class of 2004! This set of updates is exciting, especially since our basketball team has a 5–1 record in the Ivy League!

This set of updates is also special because it's the baby edition! My wife and I are so in love with our daughter, Madeleine, who was born this past November. In October, **Jeanny Yang** and her husband had a baby boy named Benjamin. Last but not least, **Jay Mung** and his wife had their second child, Emilia, in January. Also, double congrats to Jay, who was recently recruited to lead an awesome team of biomedical engineers at Apple. By the next issue, we'll be sure to have a couple more birth announcements and hopefully some more career updates!"

2005

Class Correspondent:
Devang Doshi
devang.doshi@gmail.com

Devang Doshi writes, "It is always enjoyable to reflect back on our Columbia careers, but we are now doing it with amplified hindsight bias, as our alumni relationship is entering its second decade!

I recently got an update from fellow classmate **Katy Briggs**, who just cofounded a structural engineering company in the San Francisco Bay Area called BASE Design Inc. Kudos to Katy for pursuing her dream of design, and forming a company that focuses on retrofitting existing buildings in such a cultured city. To those of you in the Bay Area that are looking to connect, please reach out to her! Separately I caught up with **Girish Gupta**, who is currently moving across the country to his dream job at Khan Academy in Mountain View, CA. Girish was previously working at Amplify, where he led the company's social learning products and created an open crowdsourcing platform for educational video. At Khan Academy, he will be leading content strategy.

Innovation from our class is not limited to the West Coast! Fellow classmate **Surag Mungekar**, along with a few friends, has created a powerful new educational tool for companies, called Grovo. The company focuses on employing microlearning to help companies educate their workforce, and ultimately, close the digital skills gap. Late last year, I ran into fellow classmate **Hiram Lucena**, who recently moved to the DC metro area. Hiram, who

recently celebrated his 5-year anniversary with wife, Veronica, is an entrepreneur that works in financial and leadership coaching with Transamerica/World Financial Group. He is focused on the underserved community, empowering them to take control of their finances. He is searching for leaders who share a similar drive and compassion to join his mission.

Babies, babies, babies! In the past year, a number of fellow alumni have increased the legacy pool for future Columbia students. Gratefully, my wife and I too have joined their ranks! Congratulations to the families of fellow classmates **Michael Thole**, **Amil Mody**, **Girish Gupta**, **Shantanu Jani**, and **Linnea Goodman**!"

2006

10TH REUNION

To take an active role in your Class Reunion activities, please contact Jack Reilly at jr2813@columbia.edu or 212-851-0734.

Class Correspondent:
Nick Jennings
nfj2003@caa.columbia.edu

2007

Class Correspondent:
Tamsin Davies
tamsin.davies@gmail.com

2008

Class Correspondent:
Amy Lin
seas2008.engineeringnews@gmail.com

2010

Class Correspondent:
Heather Lee
meheatherlee@gmail.com

Chelsey Roebuck was named one of *Forbes*' elite "30 Under 30" leaders transforming education for his work as cofounder of Emerging Leaders in Technology and Engineering (ELiTE), a youth development organization promoting diversity in STEM fields. ELiTE connects young thinkers' access to programs for hands-on problem solving.

2011

5TH REUNION

To take an active role in your Class Reunion activities, please contact Beth Manchester at em2702@columbia.edu or 212-854-4472.

Class Correspondent:
Justin Merced
jmm2238@columbia.edu

2012

Class Correspondents:
Rebecca Frauzem
rfrauzem@sbcglobal.net
Hannah Cui
hannah.cui@gmail.com

2013

Class Correspondent:
Mary Byers
mbyers2202@gmail.com

2014

Class Correspondent:
Victoria Nneji
vcn2101@columbia.edu

Akshay Shah, a business analyst at McKinsey & Company, is among the inaugural group of Schwarzman Scholars, 111 "future leaders of the world" who will pursue a master's degree at Tsinghua University thanks to a new scholarship program sponsored by Stephen A. Schwarzman, chair and cofounder of the Blackstone Group. Akshay was among 3,000 applicants from 135 countries to vie for the opportunity to attend Tsinghua's new Schwarzman College in Beijing for an all-expenses-paid, one-year course of study and cultural exchange leading to a master's degree from one of China's most prestigious institutions. As an electrical engineering major at SEAS, Akshay conducted research in Professor Harish Krishnaswamy's Columbia high-Speed and Mm-wave IC (CoSMIC) Lab. The native of Bangalore, India, was class president for the Class of 2014, served as a Columbia University Senator, and helped lead TEDxColumbiaEngineering.

Florida SEAS/CC Class of '56 luncheon: *Standing (from left)*: Doris Eskenazi, Lee and Gene Seidler, Lisa and Mike Spett, Dina and Gershon Vincow, Fran and Stan Manne, Dan Link, Anita and Louis Hemmerdinger, Judy and Maurice Klein, Jackie and Don Roth; *seated (from left)*: Leila Kazimir, Murray Eskenazi, Don Kazimir, George and Barbara Burton, Margo and Bob Siroty, Ed Botwinick.

2015

1ST REUNION

To take an active role in your Class Reunion activities, please contact Beth Manchester at em2702@columbia.edu or 212-854-4472.

Save the Date!
Reunion:
June 2–5, 2016
Dean's Day:
June 4, 2016

Below, top: Emmeline Avery Piau, daughter of Vincent Piau '03 and wife, Constance '02BC; *bottom*: Eric Rhee '04 and his wife welcomed Madeleine.

Program Notes: Graduate Alumni

APPLIED PHYSICS AND APPLIED MATHEMATICS

Shantikumar Nair MS'78, PhD'83 writes, "I am now the dean of research at Amrita University, the highest-ranked private university in India by *Times Higher Education*. I moved to Amrita University in 2006, before which I was an associate professor at University of Massachusetts at Amherst, MA. I am also director of the Centre for Nanosciences and Molecular Medicine at the University's Amrita Institute of Medical Sciences. Recently I was invited to give a talk at the UNAI-START (United Nations Academic Impact–Science and Technology Accelerating Rapid Transformation) conference, on the role of nanotechnology in developing new solutions for energy, water, and health care—problems reaching crisis proportion in our world and requiring urgent action across all levels. I was also recently awarded the prestigious Professor C. N. R. Rao Award for outstanding contributions in the field of nanotechnology."

BIOMEDICAL ENGINEERING

Jules Scogna MS'13 writes, "After graduating with my master's in biomedical engineering, I went directly to work at Bigelow Aerospace in Las Vegas, NV, as a mechanical engineer. It was a fantastic opportunity and one I never could have gotten without the experience I gained at Columbia. Both coursework and hands-on experience in the biomed machine shop were key to getting a great offer. I worked on a range of challenges in the private space industry, particularly multiple inflatable orbital habitats for both NASA and private use. The BEAM module, for which I designed systems including valves, deployment mechanisms, and soft goods layers, is scheduled to launch to the International Space Station aboard SpaceX CRS-8 in March. I also developed state-of-the-art carbon dioxide removal systems with regenerative molecular sieve technology for the BA330 program, aiming for a self-sustainable, inflatable craft for six astronauts.

In August of 2015 I started at Blue Origin, a privately funded aerospace company focusing on suborbital and orbital reusable rockets. I am a mechanical engineer in the Fluid Systems Design group currently designing valve systems used on our new Shepard suborbital rocket. This valve system must operate in extreme environments down to cryogenic liquid oxygen and hydrogen temperatures, yet close and seal leak tight in 500 milliseconds. On November 23, Blue Origin's New Shepard became the first rocket to travel to space and land back on Earth. It is nearly impossible to put that day into words; it is something I will never forget. Landing a rocket is incredibly difficult, and, even having recently started, I was on console running the new heat exchange system with launch operations and mission control. Watching the rocket land was truly a life-changing event, and my small part is something I will cherish forever."

CIVIL ENGINEERING AND ENGINEERING MECHANICS

Amy Moselhi MS'06 writes "Since graduating, I have been working in the construction management of heavy civil engineering projects in New York City. At Tully Construction I managed a portfolio in excess of $100 million as the project manager of the East Side River Parks Project, DSNY 56th Street Garage, New York Police Academy site work, the Cannon Place retaining wall replacement project, and many more. After an eight-year tenure at Tully, I moved to United Structure Solution Inc. in March of 2015 as their CEO. This was a very exciting opportunity to lead a minority MWBE/DBE firm that specializes in high-end architectural and ornamental iron work. USS Group is a full-service union contractor with a 13,000-square-foot fabrication shop in East Williamsburg. Our labor force has been widely recognized on many public projects for its exceptionally good workmanship and attention to detail. We are thrilled to have been involved in the Transportation Hub, Croton Water Treatment Plant, 63rd Street subway, 7 line, NYPA facility in Queens, 99 Church Street, Delta terminal at LGA, Tower 4, Liberty Park, Old Westbury, Stony Brook University, Newtown Creek, and much more. Our group of engineers ensure that the project is successfully delivered and are available to meet and brainstorm on issues that come up during the construction process. USS Group (unitedstructuresolution.com) is also committed to helping young tenacious engineers prosper. Recently we hired a wonderful new Columbia grad with an OPT from her F1 visa.

Over the years, I have on multiple occasions taught individual lectures about project management and engineering and have, on two occasions, spoken about women and minorities in construction on campus at events organized by student organizations. As a graduate, I am always eager to motivate young minds at Columbia and remain open to helping any of those who contact me through LinkedIn. Many have asked for guidance developing their CV and for connections for professional networking.

Opposite page, from top to bottom: Shantikumar Nair MS'78, PhD'83 after speaking at the United Nations; Artwork by Amy Moselhi MS'06; Alexei Masterov MS'07; Suzanne (Young) Bell MS'82

As a hobby I have continued to follow my passion for art and have been published! My gallery can be seen at www.moselhigallery.com."

COMPUTER SCIENCE

Alexei Masterov MS'07 writes, "For the past five and a half years, I've worked at Google, in the capacity of a product manager (among other things), and I've helped a very talented team of computer vision researchers, scientists, and engineers launch personal photos annotation, enabling people to search through their personal photos for the first time. Try searching for "me and [your spouses name] on the beach" on photos.google.com and you'll be amazed at the quality of the result."

Vinay Sharma MS'10 writes, "2015 was a year of changes in both my careers as an engineer and an artist. After nearly five years of working as a graphics hardware engineer at Intel I decided it was time for a change, and I recently transitioned within Intel to the PCH group as a SOC Engineer. New challenges ahead and lots of learning to come, I am sure. I am excited with this new role and looking forward to working with a team of smart engineers. In my art career, exciting things happened last year. I worked on collaborative projects and shows with renowned Sacramento artist Taylor Gutermute, and also became one of the top 109 printmakers in the country to be featured in a national-level printmaking show—the North American Print Biennial 2015, held by the Boston Printmakers Society. My work was featured on the cover page of the catalog too. It's been a great achievement for me, as 1,981 entries were received from 699 artists across 49 states. On a personal front, I took a trip to Ghost Ranch in New Mexico for an art retreat this year, and it was a life-changing experience creating art on the stomping grounds of the immortal Georgia O'Keeffe. The sights and sounds that the land of enchantment brought me were inspiring, as were the words of Georgia O'Keeffe: "I've been absolutely terrified every moment of my life—and I've never let it keep me from doing a single thing I wanted to do." Last but not least, I would like to thank my parents and faculty at Columbia because of whom I spent a brilliant academic year in New York City that made me the person I am today."

John Terzis MS'15 has been using his machine learning degree and interest in all things big data to build and manage a multi-node Hadoop cluster that performs quantitative analysis on large streams of log and time series data for a distressed asset private equity firm. He's been living in Scottsdale, AZ, which offers a fledgling tech scene and excellent lifestyle, in his opinion, for engineers who want to attain the elusive work lifestyle balance that Silicon Valley is lacking. When he's not tinkering with some Deep Learning library, he's been hiking, playing tennis, going on road trips, and exercising his dog, Dennis.

EARTH AND ENVIRONMENTAL ENGINEERING

Alan Shapiro MS'14 writes, "In the last year, I've been active in building a Columbia alumni community in Western Canada, both on the coast in Vancouver, BC, and further inland in Edmonton and Calgary, Alberta. I continue to work as a geoscientist for PGL Environmental Consultants in Vancouver and have been involved in a wide range of real estate development, government, First Nations, and industry projects."

Suzanne (Young) Bell MS'82 writes, "After three years working as a research engineer following my time at Columbia, I went to Stanford Law School to become a technology and IP lawyer and have been practicing law in Silicon Valley ever since at Wilson Sonsini Goodrich & Rosati (partner since 1996). I have maintained my ties to Columbia, including serving on the Board of Visitors under Dean Galil a number of years ago. And, I am happy to report that my youngest daughter (I have three daughters) is now at Columbia Engineering as a first year—class of 2019!"

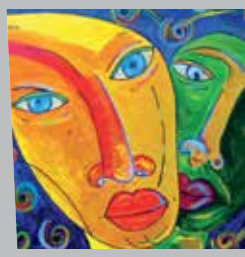
ELECTRICAL ENGINEERING

Pamir Ozbay MS'10 writes, "After practicing engineering for six years, I've decided to join the dark side by becoming an MBA student at London Business School. I never thought I would be studying for finals again in my late 20s, but here I am!"

INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH

Aik-Ping Ng MS'03 writes, "I just moved to Hong Kong for a new experience after living in Beijing for the past seven years. Apart from work, I'm spending my free time working on a book project. It's a slow and laborious process, but definitely highly rewarding and therapeutic. I'll be sure to update all of you if and when I get to the finish line!"

Rami Rahal MS'09 was recently named one of *Forbes*' "30 under 30" venture capitalists making major impact on their field. He is cofounder and general partner at Blue Cloud Ventures, a New York–based growth-stage firm focused on software-as-a-service companies. After helping raise more than $65 million, Rami has invested in 16 promising endeavors, with two major exits so far from his first fund.



Herbert H. Kellogg BS'41, MS'43, Professor Emeritus

Professor Emeritus Herbert H. Kellogg BS'41, MS'43, a pioneer in the physical chemistry of extractive metallurgy, member of the National Academy of Engineering, and passionate advocate for developing the mining industry's environmental awareness, died January 17, 2016, one month short of his 96th birthday.

Kellogg earned his BS degree in metallurgy in 1941 from Columbia, where he was elected to Tau Beta Pi and received the Illig Medal. He continued his studies, mentored by the legendary Arthur Taggart, and received his MS in mineral engineering in 1943. He joined the faculty of Pennsylvania State University as an assistant professor in mineral preparation and, in 1946, returned to Columbia Engineering as an assistant professor of mineral engineering.

During his 44-year career at Columbia Engineering, Kellogg built teaching and research programs in extractive metallurgy that paved the way for the School's leadership in the field. He was promoted to full professor in 1956 and was recognized worldwide for his expertise in physical chemistry of high temperature metallurgy. He was named Stanley-Thompson Professor of Chemical Metallurgy in 1968 and was subsequently elected a fellow of the Metallurgical Society of AIME (American Institute of Mining, Metallurgical, and Petroleum Engineers) and a fellow of the Institution of Mining and Metallurgy, London. Kellogg received the AIME's James Douglas Gold Medal and, in 1978, was elected to the National Academy of Engineering for "strengthening the scientific base of metallurgical processes, and ability to unite theoretical studies with practical industrial needs."

Throughout his tenure at Columbia, Kellogg emphasized the environmental impact of metallurgical processes and the importance of optimizing the consumption of energy and mineral resources. Paul Duby EngScD'62, professor and former chair of the Department of Earth and Environmental Engineering, was a student of Kellogg's and, with other grateful students, established the Herbert H. Kellogg Fellowship in 1988 to ensure that future generations of students could follow the paths that Kellogg created.

Kellogg consistently emphasized as well the professional responsibility of engineers to conserve the earth's resources and to protect the environment, paving the way for Columbia Engineering's current faculty to create innovative approaches to promote sustainability in all areas.

A memorial service is being planned for June in Palisades, NY.

Joseph F. Engelberger BS'46, MS'49, Robotics Pioneer

Joseph F. Engelberger BS'46, MS'49, renowned "father of industrial robotics," died December 1, 2015, at his home in Connecticut. Engelberger was a visionary physicist, engineer, and businessman who as founder and longtime head of Unimation Inc. brought automation to factory floors and revolutionized manufacturing around the world. Later, he focused his formidable attention on developing robots to assist with hospital care.

Born in Brooklyn in 1925, Engelberger joined the U.S. Navy at age 17, learning physics on the job, working on atomic research at Bikini Atoll in the Marshall Islands. After the war, he came to Columbia Engineering to earn a bachelor's degree in physics, going on to also attain a master's in mechanical engineering while designing nuclear power control systems for a manufacturing conglomerate. He then formed his first company, Consolidated Controls Corporation.

In 1956, Engelberger met inventor George Devol; their shared interest in scientist and sci-fi author Isaac Asimov and programming machinery helped spark the Unimate, a versatile robotic arm that quickly transformed the industry following its introduction to automotive manufacturing in 1961. Produced by Unimation Inc., the Unimate allowed for faster, more precise production, limiting workers' exposure to hazardous conditions. Licensing the Unimate around the world, the company grew to employ more than 1,000 and was sold to Westinghouse in the early 1980s.

Engelberger then began to develop increasingly autonomous machines, consulting with NASA and industrial scientists on robots for space exploration and precision manufacturing. He also founded Transitions Research Corporation, later Helpmates Robotics Inc., to create robotic couriers to deliver supplies in hospitals and other facilities.

A member of the National Academy of Engineering, "Joe" was a tireless champion of robotics who authored influential books, testified before Congress, and even appeared on *The Tonight Show Starring Johnny Carson*. The most prestigious annual award of the Industrial Robotics Association is named in his honor.

In Memoriam: Alumni

1940

William (Bill) Reagh Hutchins MS'41, '39CC, 96, passed away on August 22, 2015, in Boone, NC. He was born in New York City, the only child to the late Leroy William and Mabel Reagh Hutchins. After entering college at the age of 16, he received BA, BSEE, and MSEE degrees, all from Columbia Engineering, where he organized its first student broadcasting system and was a member of the Sigma Xi scientific research society. During World War II he worked in the laboratory of Major Edwin Howard Armstrong, the inventor of FM radio, a SEAS alumnus and former faculty, helping to develop the first continuous wave FM radar early-warning system. He moved to Massachusetts in 1946 to design and direct the construction of the first FM radio station in New Bedford, WFMR. The remainder of his career was spent in the defense electronics industry, leading engineering and management teams at Raytheon, Aerospace Corporation, and Sanders Associates. Following his retirement, he moved to Chapel Hill, NC, where he was active in the Quarter Century Wireless Association and the Orange County Radio Amateurs. He was preceded in death by his first wife, of 48 years, Dorothea Johnston, and his second wife, of 18 years, Grace Coltrane Kilkelly. He is survived by three children, a stepson, and two grandchildren.

1945

Edward W. Coffey of Wellesley, MA, passed away on October 31, 2015, at the age of 92. Ed was born in Bronx, NY, to Ruth and Edward F. Coffey. He received a BS in electrical engineering from Columbia in 1945 and his master's degree in electrical engineering from the University of Pennsylvania in 1960. He met Mary Petrosky at a dance in New Jersey and they married in 1949, eventually raising six children. Ed worked for RCA in New Jersey, and in Burlington, MA. In 1971, he moved to Lockheed Corp. in Huntsville, AL. He retired to Wellesley, MA, after a stint in the Peace Corps in Malawi, Africa. During his professional career, he worked on making machine guns work for fighter aircraft, ranging systems for the rendezvous of lander and orbiter Apollo 11 moon landing missions, and radar-based wind-shear detection systems for the U.S. Air Force. He is survived by his six children and five grandchildren.

William Charles Reinig passed away on August 25, 2015, in Annapolis, MD. He received a bachelor's degree in mechanical engineering from Polytechnic Institute of Brooklyn. He attended Columbia Engineering in the Navy V-12 College Training Program from 1943 to 1945. After the war, Bill worked as a reactor health physicist at the Hanford Works in Washington State and subsequently as leader of the radiation protection program for the nation's first peacetime reactor during its startup and initial operation at Brookhaven National Laboratory. In 1951, he led a research team that measured the natural radioactivity of 6,000 square miles of the DuPont-operated Savannah River Site (SRS) and its environs outside of Aiken, SC. This was the first large-scale environmental assay of naturally occurring radioactivity. The study was completed in 1953 and still serves as a national benchmark for responsible environmental stewardship. The monitoring system and stations established at that time have measured and reported radioactivity annually for over 60 years. Bill held a number of technical and management positions at SRS; thereafter, he was appointed deputy general manager for environmental safety and health. Bill was active in professional societies. He was elected chairman of the American Board of Health Physics. In 2006, he received the McAdams Award of the HPS for his significant contributions to the radiation protection profession. He served on the National Council on Radiation Protection (NCRP). Bill published over 40 technical papers and was editor of the book *Environmental Surveillance in the Vicinity of Nuclear Facilities*. He is survived by his children, James and Christine, as well as four grandchildren.

1949

Richard Dupuis, Sr., 90, of Stone Harbor, NJ, passed away on October 28, 2015. He was born in Brooklyn, NY, a son of John A., Sr., and Jessie May Young Dupuis. Richard served in the U.S. Army during WWII, from 1943 to 1945, in Rhineland, Central Europe, and the Ardennes, where he was wounded, and received the Purple Heart. He married Phyllis Irene Kelley in 1954; she predeceased him in 2011. Richard was a mechanical engineer at Raytheon Co. in Philadelphia until his retirement. He was a life member of the Disabled American Veterans and a member of the American Society of Mechanical Engineers. For many years he was a church organist in the Philadelphia area. He is survived by a son, Richard, Jr.; daughter, Ann Hozack; five grandchildren; and two great-grandchildren.

1950

Julius DiFranco MS'56 of Long Island, NY, passed away on November 15, 2015. He was 90. Julie, as he was known, grew up in Corona, Queens, and served in the U.S. Navy during the WW II Pacific campaign. He graduated with high honors from Columbia Engineering with degrees in electrical engineering. Julie had a successful career at Sperry Corporation as the head of Advanced Research. He coauthored a graduate-level textbook, *Radar Detection*, still in print today. He was elected a fellow of the IEEE for outstanding contributions to his field, and he was awarded a patent for Radar System Multiple Beam Scanning in Elevation. Julie was the beloved husband of wife, Agnes, and father of Greg, Julie, Claudia (Bob) Corbett, and the late Christian. He is also survived by grandchildren Andrew, Joseph, James, and Christian.

Norman David "Stormin' Norman" Redlich MS'52 of Los Angeles, CA, passed away on September 7, 2015, at the age of 88. Norman enlisted in the U.S. Army Air Corps at 17, but was not called to active duty until he was 18 and one day before the first atomic bomb was dropped on Hiroshima. He served in the Occupation Forces in Germany and stayed in the Army Air Corps Reserves, holding the rank of sergeant, and earning the nickname "Stormin' Norman." After the military, he went back to college at Columbia and earned BS and MS degrees in industrial engineering. He then received a commission as second lieutenant in the U.S. Air Force Reserves and transferred to Inactive Reserves in the rank of captain. He worked in aerospace for most of his career. Some of the programs he worked on were On Board Computer for Minuteman ballistic missile; Avionics system for F-111 Aircraft, Apollo program; Space Shuttle; Spacelab experiments; Communication satellites; and Control Consoles for Drones.

In 1960, he and his wife, Carol, moved to Orange County, CA, and became active in the synagogue they joined, and he was elected president of Temple Beth Sholom, in Santa Ana, CA. In retirement, he gave seminars on "Cost Estimating for Government Contracts" for three years. His wife of almost 60 years predeceased him, along with his sister and parents. He is survived by his two daughters, Fawn and Michele, and two grandsons.

1955

Alphonse J. Angelino, 85, of Glenville, NY, passed away on December 19, 2015, with his family at his side. Born in Carlstadt, NJ, he was the son of the late Alphonse and Malida Angelino. Al, as he was known, received a full N.R.O.T.C. scholarship to Columbia Engineering, where he earned a BS in mechanical engineering and was an associate member of the Society of Sigma Xi and the National Honorary Research Society. He was commissioned a second lieutenant in the U.S. Marine Corps in 1952. He served as a marine until 1954 and continued to serve with the U.S. Reserves as captain until 1964. Al also received an MS in mechanical engineering from Union College and an MBA from the State University of New York at Albany. Al built a more-than-33-year career with GE. In 1964, he was one of the few civilians who qualified as the Engineering Officer of the Watch, who was responsible for directing the control of the nuclear reactor in Navy nuclear vessels. As a professional engineer, he was a member of ASME, ANS, and Elfun Society (GE Management). He retired from GE in 1988. In retirement, Al taught math at Hudson Valley and Cobleskill Community Colleges. He was a communicant of the Church of the Immaculate Conception. He taught religious education, was a member of the R.C.I.A. team, and was a core committee leader in the RENEW 2000 program. For 20 years, Al was active in Residents Encounter Christ, a prison ministry for the Albany Diocese, and also led a bible study group at the Saratoga County Jail. He was always generous in sharing his time, wisdom, experience, and talents with everyone. He had a great love of his country, his church, and especially his family. He was preceded in death by his brother, Henry Angelino. He is survived by his wife, Norma; four children; eight grandchildren; and several nieces and nephews.

1956

Louis Hemmerdinger BS'56, MS'58, who serves as alumni class correspondent for the Class of 1956, writes, "**Mark Carter** passed away on September 26, 2015. Mark was a student at Science High School, entered Columbia College in 1952, and two years later majored in civil engineering. He became a protégé of Professor Burmeister, a renowned soil mechanics expert, and would make this his lifelong specialty. During his four years at Columbia he played on the varsity fencing team, and being 6'4" he had an arm advantage that helped the team win several titles in those years. Mark went on for his master's degree at Columbia in soil mechanics and was hired by the famous bridge builders, Amman and Whitney. He helped in defining the load-bearing strength of the ground beneath the Verrazano Bridge piers and in the design of the bridge itself. He also built roads in the jungle areas of the Philippines and other Southeast Asian countries. Later, he cofounded a consulting firm in New York City specializing in soil evaluation and foundation design. He often stated that if he stood anywhere in NYC he could see a building that he had worked on. Our families were close friends for over 65 years. Mark and I worked for the Columbia Engineering Fund in the 1970s and '80s, maintaining relationships with our classmates. His last several years were in the Hebrew Home in Riverdale, NY, overlooking the Hudson River and a few miles north of Bakers Field. From time to time, local high school students visited him for lectures on civil engineering and the design of the Verrazano Bridge. Mark is survived by his wife, Ellen; four daughters, Robin, Rosalind, Rachel, and Ruth; and eight grandchildren."

1959

Luigi Lucaccini writes, "**Henry Rosenfeld** passed away in Tuckahoe, NY, on December 26, 2015. We were freshman roommates in 1955. Henry was born in Chile but raised in Argentina, where he completed secondary school. He graduated from SEAS in 1959 with a degree in electrical engineering and subsequently obtained his MBA at NYU. Henry returned to Argentina in the 1960s to join the family firm. Their company was a successful South American distributor of U.S. television series, having transitioned from similar, earlier work representing major Hollywood film studios and distributing their products. During this period, Henry was tapped to join the Argentinian government in the area of housing and served two years as vice president of Argentina's Banco Hipotecario. In Argentina, he met and married his wife, Leonor. In 1975 they relocated to the US to raise their children and settled in Scarsdale. Henry became actively engaged in a program of personal investing and intellectual pursuits, balanced by thoughtful attention to improving his golf game at the Scarsdale Country Club. Henry was generous, intelligent, and equipped with a dry sense of humor, someone who held strong political opinions, but nevertheless remained loyal to his friends, regardless of political differences. As freshmen, I remembered Henry as a traditional fellow raised in a traditional family with traditional values. He was amused to reflect later on the fact that he was apparently the only freshman at Columbia that year who arrived with a wardrobe of tailored suits (each included a vest) and a personal shoeshine kit. His outgoing and generous personality helped establish our suite in Livingston Hall as a gathering place for Columbia students from Latin America. Henry was preceded in death by his wife in early 2015, leaving behind his daughters, Jessica and Julia, his son, Diego, four grandsons, and the many friends he made at Columbia and along the way."

1968

Ivan S. Sandler (EngScD, Civil Engineering and Engineering Mechanics) of Merrick, NY, passed away on August 4, 2015. He was 73. Ivan graduated with an engineering degree from Cooper Union and received his doctorate from Columbia Engineering. He was with the engineering consulting firm Weidlinger Associates Consulting Engineers, retiring as a principal after 47 years. He received the Mel Baron Award in 2003, given for unique contributions to computational structural dynamics and the shock- and vibration-related specialty fields, as well as for lifetime achievement. He was vice president of the Archaeological Institute of America and the Long Island Society and member of Tau Beta Pi. He was the beloved husband of Joan Sandler, loving father of Tracey Sandler and Karen Sandler, and grandfather of Cora.

1970

Richard C. Sussman, 66, of Munster, IN, passed away on October 9, 2015. A graduate of Columbia Engineering and MIT, with a doctorate in materials science, Richard enjoyed a 38-year career in the steel industry. He worked for Armco Steel in Cincinnati, and Allegheny Technologies and J&L Specialty Steel in Pittsburgh. He retired from Arcelor Mittal in 2013 as head of research and development. During the course of his career, he received many awards and recognition for his technical expertise in steel. He held multiple patents, was widely published in technical journals, and lectured at universities around the world. Richard was president of the company he founded, Enhanced Technology Services, specializing in innovation training and consulting to manufacturers. He is survived by his wife of 35 years, Pamela; daughter, Lilly (Mark) Overbeck; son, Elliott Sussman; grandson, Brooks Overbeck; mother, Sara Sussman; sisters, Diane (John) Arch and Lynn (Yitzchak) Alster; and many nieces, nephews, and cousins. He was preceded in death by his father, Walter Sussman.

1982

San Chin "Mike" Fang (PhD, Electrical Engineering) of New Providence, NJ, passed away on December 8, 2015. He was 63. Mike was born in Taipei, Taiwan, and immigrated to the US at the age of nine. He obtained a bachelor's degree from Princeton University, a master's degree from Stanford University, and a PhD from Columbia Engineering. He worked as an electrical engineer at Bell Labs for 10 years before joining Delphi Technology in 1993. He is survived by his wife, Anne Mary; his children, Gregory, Alden, and Wesley; and his brother, San Kong.

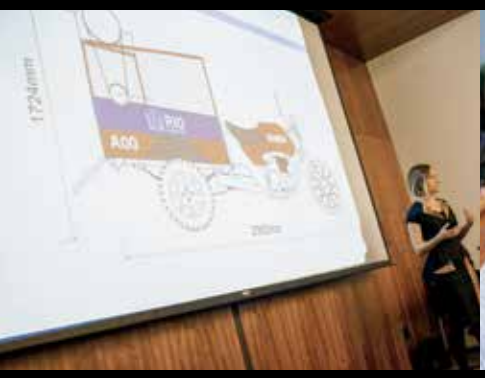
Other Deaths Reported

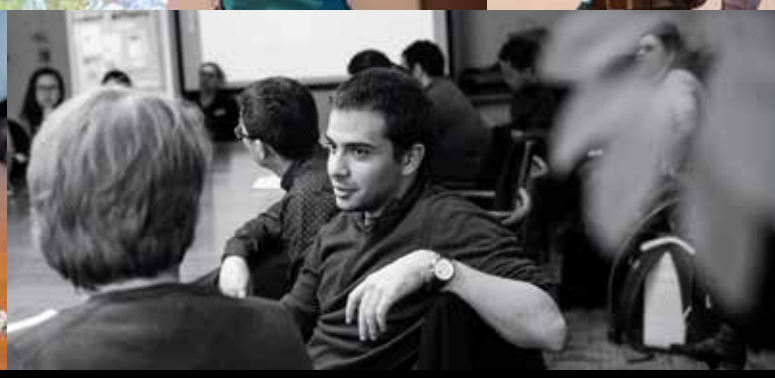
We also have learned of the passing of the following alumni and friend of the School:

Aimison Jonnard BS'39
William Vermeulen BS'41, '39CC
Lawrence Zoller BS'41, '39CC
Joseph Gold BS'43, MS'47
Floyd Hasselriis BS'43
Rudolf Henning BS'43
Herbert H. Waller BS'43
Daniel H. Robbins BS'44, MS'49
Robert H. Bartlett BS'46
Robert Rozett BS'46, MS'47
John C. Studebaker BS'46
William Turunen MS'46
Hugh E. Perkins BS'47, '41CC
William J. Carley MS'48
Robert C. Huber BS'49, MS'50
Sasha Komsa BS'49
Roger D. Lopez BS'49, MS'50
James E. Ewing BS'50
George A. Read BS'50, MS'51
Charles Wunderlin MS'50
John Arbuthnott Jr. BS'51
Sema Lerner MA'51
Nathan B. Marple BS'51, MS'52
Joseph V. Meister BS'51
John W. Oplinger BS'53, '52CC
Joseph A. Gaudio BS'54, '53CC
Frederick P. Schmaelzle BS'54, '53CC
Charles C. Stewart Jr. BS'54
Edward Dicorcia BS'55, MS'56, '51CC
Ori Eventov BS'56
Howard S. Greer BS'56
Godfrey Martin BS'56
Allan Gaines BS'57, MS'63
Edward Petrak BS'57
Edward J. Stern BS'57
Stephen Drezner BS'59
Robert C. Kavee MS'59
Chitta Mitra EngScD'59
Gerry Post MS'59
Raymond Weisgerber MS'60
Abe Goldstein EngScD'62
Paul Y. Soong MS'62, EngScD'64
David D. Yue MS'63, '61GS
Andres Debouchet MS'66
David S. Shapiro BS'73
Paul Rooy BS'78
Margaret O'Driscoll MS'82
Chaim Ferestanfeld MS'83
Andreas Petrides BS'84
Kirk Clifford Preuss BS'86

Friend
Clyde Y. C. Wu

ENGINEERING DESIGN CHALLENGE TAPS WATER INNOVATIONS





Water—a precious resource that poses many challenges in urban areas—is one of the world's most complex concerns facing engineers, planners, and policy makers alike. To this end, Columbia Engineering, in a recent partnership with the Columbia Global Centers | Rio de Janeiro, launched a design challenge in December centered on the multifaceted challenges of urban water. Columbia students, postdocs, faculty, and staff from all Schools were invited to participate, as were counterparts at the Federal University of Rio de Janeiro (UFRJ).

Multidisciplinary teams are collaborating on innovating engineering, planning, policy, and public health solutions to address such problems as delivery systems for access to clean water, enhanced collection and treatment of wastewater, safer water storage, and smarter planning and response for extreme weather events. The goal is to produce a viable design concept to earn further support and develop a technology-centered innovation or policy change that could be presented in Rio later this year.

Like many cities, Rio has experienced population growth far outstripping its municipal infrastructure, and struggles to treat the tremendous volume of wastewater and solid waste entering the city's waterways and Guanabara Bay daily. Additionally, standing water contributes to serious health concerns including mosquito-borne illnesses like dengue fever and the Zika virus.

Following presentations in December and February, 10 finalist teams representing both universities were selected to move forward and hone their ideas with guidance from mentors from Columbia and UFRJ. These teams are working on projects ranging from novel approaches to improve wastewater treatment, to a solar-powered propeller that agitates standing water and may prevent mosquito reproduction, to low-impact pipe repair using a mechanical system to apply liners. The design challenge is the second from Columbia Engineering, following 2014's Ebola challenge, which spurred several promising innovations to combat the spread of infectious disease.

By Jesse Adams

(Photos by Timothy Lee Photographers)

DONOR SPOTLIGHT

Sam Park BS'85

Empowering Students for the "Third Semester"

Sam Park BS'85 is making sure Engineering students take full advantage of their time at Columbia. Park is one of the leading alums behind the Columbia Engineering Internship Fund (CEIF), which allocates funding to eligible SEAS students who are pursuing low-paying or unpaid summer internships, especially overseas. Since its establishment in 2013, the CEIF has distributed awards ranging from $500 to $5,000. In 2015, the Fund distributed almost $79,000 to help students pursue engineering opportunities in Bolivia, Ethiopia, Germany, Ghana, and India, as well as across the United States.

Park said his motivation to help launch and continue CEIF is rooted in his days at the Engineering School.

"When I was in college, I didn't have a lot of means to enjoy the 'third semester'—that's what I called it—over the summer, because I had to work. I lost a lot of opportunities and wasn't able to take advantage of travel," he said. "I always thought that if the School invests $50,000 in the financial aid they give kids every year, to have them work someplace that just pays the bills instead of advancing their interests seems like a waste of that third semester. If alumni are looking for a place to invest, helping fund a summer program is a great deal—it's essentially like buying an additional semester for a few thousand dollars."

"I really believe that the kids who can't afford to do what others can should be supported by alumni," he added. "We're making an investment in a kid—a commitment to the movers and shakers of the future."

Today, Park is the president and founder of Boston-based real estate development firm Sam Park and Co., as well as its affiliate company, SPC Capital. At SPC, he spearheads large-scale construction projects from planning to construction. Some of the company's past projects include advising on Gillette Stadium in Foxboro, Massachusetts, and, with Boston University, the redevelopment of the Armory and Kenmore Square.

His work has built steadily on the jobs he started after his graduation from Columbia, when, as an engineer for Vollmer Associates, he worked on projects that shaped the face of New York City, including the reconstruction of the West Side Highway, the creation of Battery Park City, and the construction of Arthur Ashe Stadium.

His time in New York was foundational, he said. "I loved the city. When I was looking at schools, I came up to New York from the suburbs of D.C. and found it was awe inspiring to realize that this was the capital of the world," he said. "It was eye opening and I never looked back."

And while his memories of Columbia are fond, Park admitted it's looking ahead that gets him excited.

"I walk around campus and there's a much higher level of energy, a much higher degree of community," he noted. Park gives credit to the School's leadership for that change.

"I would tell you that a large reason is I see the energy that Dean Mary Boyce brings to the campus," he said. "They have a really special person in her."

Jill Galas Hickey, director of annual giving at Columbia Engineering, said the CEIF embodies Boyce's vision for the School.

"It is important for students to have experiences outside of the classroom and to be able to focus on their learning and not finances," she said. "This fund allows students to dive into their industry and get the experience they need to be a well-rounded candidate for future job opportunities or for when they're considering graduate programs."

Park said he's also inspired by the passion of the students at Columbia.

"The energy, enthusiasm, and the involvement in state-of-the-art programs—it's all fascinating to me," he remarked.

And Park has firsthand knowledge. One of his daughters—he's the father of four—is a sophomore in Columbia College. And next fall, another daughter will be joining SEAS. It's given him some ideas, he said, laughing.

"Sometimes I think, maybe I'll try to get back in, but I'm not sure my daughters would be thrilled if I showed up on campus."

By Jennifer Ernst Beaudry

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Video screens line the newly renovated hallway on the fourth floor of Mudd. (Photo by Jeffrey Schifman)

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