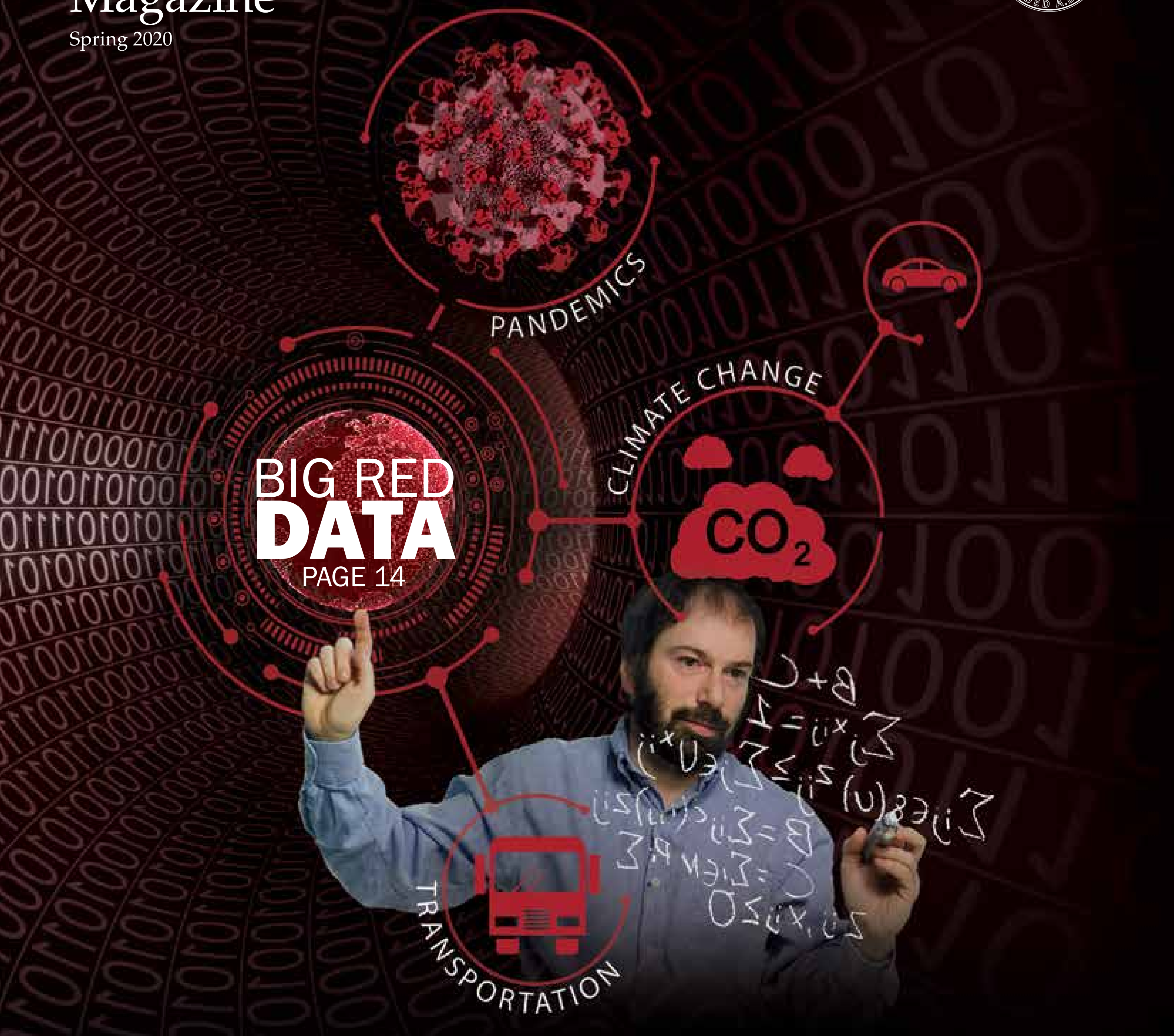
Cornell Engineering
Magazine

Spring 2020



BIG RED DATA

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CORNELL ENGINEERS ARE CRUNCHING NUMBERS TO FIGHT EVERYTHING FROM CORONAVIRUS TO CLIMATE CHANGE

CornellEngineering Magazine

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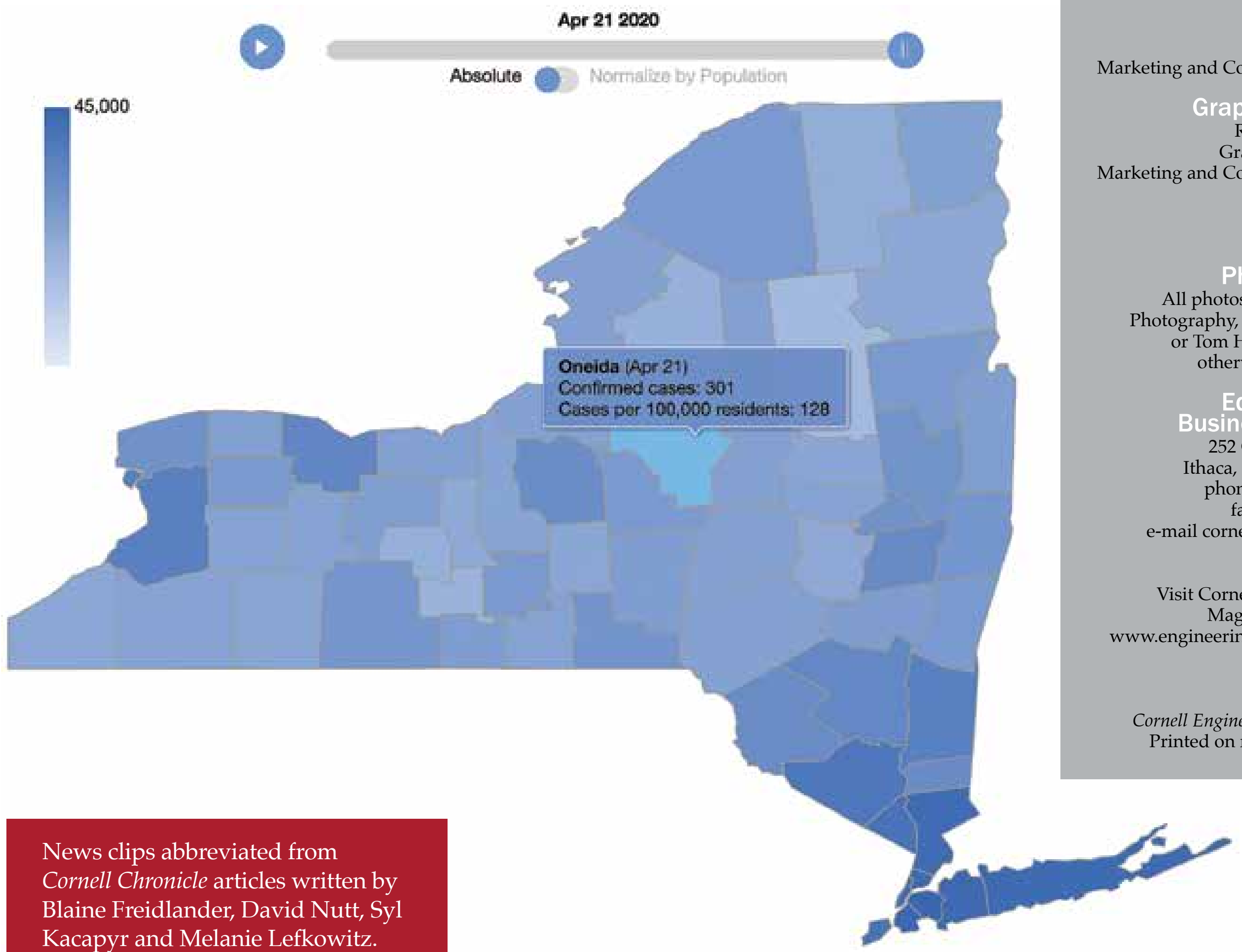
WEBSITE CHARTS COVID-19 SPREAD ACROSS NY STATE

A website developed by a Cornell team offers insight into the rate of coronavirus infections across New York state over days, charting daily and cumulative totals of new cases to help users see whether they're flattening the curve.

The site, covid19.cheme.cornell.edu, is updated daily with data from all 62 of the state's counties and provides easy-to-use interactive visualizations depicting the virus' spread or slowdown by county or statewide.

"When we had to shut down our lab, we wanted to see what we could do with our expertise in systems engineering to help the public and provide timely information," said Fengqi You, the Roxanne E. and Michael J. Zak Professor in Energy Systems Engineering, who is leading the effort. "We're viewing this as a citizen science project, but one where accuracy and primary data are paramount."

The site includes a play button and a slider where users can watch how infections spread day by day across New York state, as well as interactive charts offering different ways of viewing the outbreak statewide or by county. Users can view the total number of new infections by county, as well as a chart showing the numbers of infections per 100,000 residents for each county since the first COVID-19 case was reported in New York state on March 2.



News clips abbreviated from *Cornell Chronicle* articles written by Blaine Freidlander, David Nutt, Syl Kacapyr and Melanie Lefkowitz.

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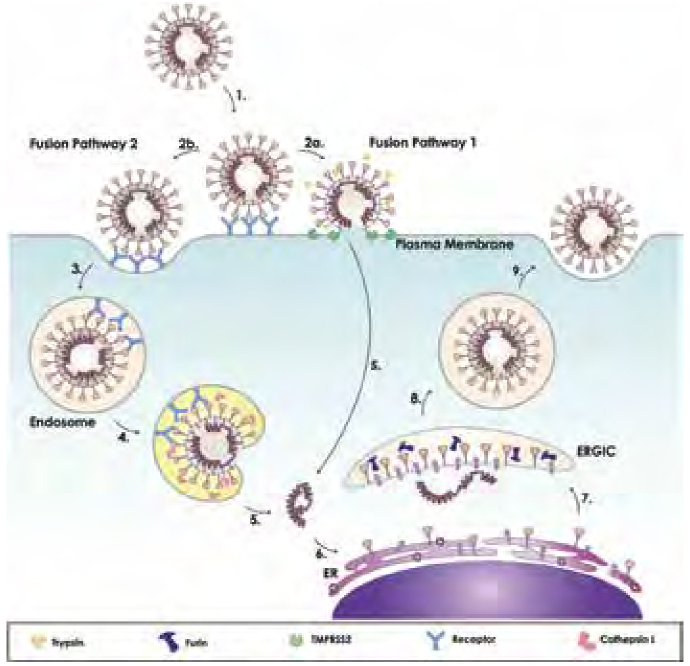
RESEARCHERS SEEK UNIVERSAL TREATMENTS TO IMPEDE CORONAVIRUS



Model of coronavirus dual entry pathway. This model depicts the two methods of viral entry: early pathway and late pathway. As the virus binds to its receptor, it can achieve entry via two routes: plasma membrane or endosome.

New research from a team of Cornell collaborators points to a possible target for antiviral treatment for COVID-19.

The researchers—led by Susan Daniel, associate professor in the Smith School of Chemical and Biomolecular Engineering, and Gary Whittaker, professor of virology at the College of Veterinary Medicine—initially set out to analyze the structure and characteristics of SARS-CoV and MERS-CoV with a focus on the spike protein, specifically the fusion peptide, that allows these viruses to infect cells by transferring their genome.

As the current pandemic escalated, the researchers compared the biological sequences of the fusion peptides of SARS-CoV to SARS-CoV-2, the virus that causes COVID-19, and found them to be a 93% match.

"What's really interesting about SARS-CoV and MERS-CoV, and this new virus, SARS-CoV-2, is this particular part of the protein, the fusion peptide, is almost exactly the same in those three viruses," Daniel said. "Blocking the fusion step is significant because the fusion machinery doesn't evolve and change as fast as other parts of the protein does. It's been built to do a particular thing, which is to merge these two membranes together. So if you can develop antiviral strategies to reduce that efficiency, you could have potentially very broadly-acting treatments."

The group found that calcium ions interacting with the fusion peptide can change the peptide's structure, and how it interacts with membranes in ways that promote infection in MERS and SARS. Now, Daniel is leading a team of scientists investigating the impact of FDA-approved calcium-modulating drugs on lessening COVID infection, thanks to a Fast Grant funded by the payments company, Stripe.

"The subtleties are what make this virus so interesting," Daniel said. "For some viruses, calcium has no effect on infection, but for coronavirus, we are seeing that it does.

The team's findings have also led to supplemental funding from the National Institutes of Health (NIH), through its Research Project Grant program, to develop an antibody that could block the virus's entry by interacting with the fusion peptide. And an adjacent collaboration between Daniel, Whittaker and Nicholas Abbott, a Tisch University Professor in the Smith School of Chemical and Biomolecular Engineering, was recently awarded National Science Foundation (NSF) Rapid Response Research funding to explore additional properties of the fusion peptide, which could help researchers predict what cells are likely to get infected.

On the Web

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CELL-FREE BIOTECH COULD DRIVE COVID-19 THERAPEUTICS

A biomanufacturing company spun out of Cornell research is seeking to rapidly translate an antibody therapy against COVID-19 by using cell-free biotechnology based on glycoengineered bacteria. And it could scale up the production 10-times faster than conventional methods.

The company, SwiftScale Biologics, was co-founded by Matt DeLisa, the William L. Lewis Professor of Engineering in the Smith School of Chemical and Biomolecular Engineering, and his longtime collaborator, Michael Jewett, a professor of chemical and biological engineering at Northwestern University.

DeLisa's research group focuses on engineering biological machinery in cells, and in 2018 they pioneered a method for cell-free manufacturing of glycosylated proteins—proteins with a carbohydrate attachment. The combination of DeLisa's protein glycosylation technologies and Jewett's knack for developing cell-free protein expression systems has the potential to create glycosylated protein drugs such as therapeutic antibodies, and led to the launch of their company last year.

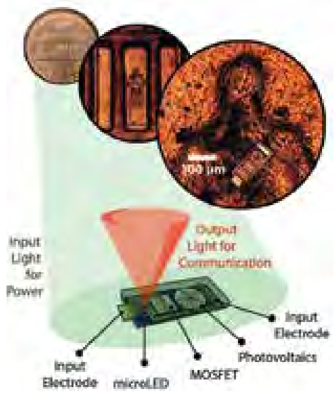
The low-cost, rapid manufacture of therapeutic antibodies could be pivotal in combating the spread of COVID-19. The conventional means for manufacturing antibody drugs relies upon the use of mammalian cell lines, specifically Chinese hamster ovary (CHO) cells. Production can take nine months or more. SwiftScale's use of cell-free lysate derived from E. coli bacteria could shrink that timeline down to a month, which amid a pandemic could be "game changing," DeLisa said.

SwiftScale intends to produce antibody therapies that target cancer, but as COVID-19 emerged over the last several months, the company realized it could leverage its rapid, adaptable technology to potentially treat those infected with the virus instead. They have partnered with a biotherapeutics company, Centivax, that has identified several lead antibody candidates it believes could be used against the virus.

Centivax is planning to begin a phase I/II clinical trial in late July, with SwiftScale ramping up its capabilities to produce 100,000 doses a month for 10 months if the trial is successful.

MASS-PRODUCED MICROSCOPIC SENSORS SEE THE LIGHT

Theologians once pondered how many angels could dance on the head of a pin. Not to be outdone, Cornell researchers who build nanoscale electronics have developed microsensors so tiny, they can fit 30,000 on one side of a penny.



This image shows a voltage-sensing OWIC as it fits inside the Lincoln Memorial on the back of a penny, and a schematic of an OWIC's components. Photo Credit: Alejandro Cortese.

There's more to these tiny sensors than just their diminutive size: They are equipped with an integrated circuit, solar cells and light-emitting diodes (LEDs) that enable them to harness light for power and communication. And because they are mass fabricated, with up to 1 million sitting on an 8-inch wafer, each device costs a fraction of that same penny.

The collaboration is led by Paul McEuen, the John A. Newman Professor of Physical Science, and Alyosha Molnar, associate professor of electrical and computer engineering. The team's paper, "Microscopic Sensors Using Optical Wireless Integrated Circuits," published April 17 in *PNAS*.

Working with the paper's lead author, Alejandro Cortese, Ph.D. '19, a Cornell Presidential Postdoctoral Fellow, they devised a platform for parallel production of their optical wireless integrated circuits (OWICs)—microsensors the size of 100 microns (a micron is one-millionth of a meter), mere specks to the human eye.

Placing tiny circuits on a silicon wafer is relatively easy in the nanotech arena, McEuen said, but adding LEDs is a special challenge because they are made with a different material: gallium arsenide. In order to transfer the LEDs to a wafer with the electrical components and integrate them, the researchers developed a complicated assembly method that involved more than 15 layers of photolithography, 30 different materials and more than 100 steps.

Once the OWICs are freed from their substrate of silicon, they can be used to measure inputs like voltage and temperature in hard-to-reach environments, such as inside living tissue and microfluidic systems. For example, an OWIC rigged with a neural sensor would be able to noninvasively record nerve signals in the body and transmit its findings by blinking a coded signal via the LED.

As a proof of concept, the team worked with the lab of Chris Xu, professor of applied and engineering physics and a co-author of the paper, and successfully embedded an OWIC with a temperature sensor in brain tissue and wirelessly relayed the results.

ENGINEERS DONATE MEDICAL SUPPLIES, 3D-PRINTED GEAR, EXPERTISE

Donated surgical masks, N95 respirators and other biomedical supplies to protect health care workers.

As hospitals across the country try to manage a surge in coronavirus patients while also facing a global shortage in the protective gear needed to treat them, the Cornell community has banded together to donate crucial medical supplies to local and regional health care providers.

Among others, Ankur Singh, associate professor in the Sibley School of Mechanical and Aerospace Engineering, donated 500 surgical masks, N95 respirators and other biomedical supplies that he had originally obtained for researching the H1N1 virus and cancer. The Civil and Environmental Engineering Machine Shop and the Bovay Lab also donated masks.

Students in Cornell Engineering's Student Project Teams were adamant about donating 300 of their N95 respirators, plus assorted nitrile gloves and disposable coveralls, as they closed down their fabrication spaces in the basement of Upson Hall. Working with the facilities staff in Upson Hall, the students arranged to get their supplies delivered to the Tompkins County Health Department.

"Their level of dedication and commitment is really impressive," said Lauren Stulgis, the Swanson Director of Student Project Teams. "Their initial reaction wasn't about how the shutdown impacted them personally, but rather to think about what they could do that's helpful in this situation."

Kirstin Petersen, assistant professor of electrical and computer engineering, was forwarded an email from a Weill Cornell Medicine radiologist asking for 3D-printed protective visors.

"She asked whether this was doable, and my partner (Nils Napp, assistant professor of electrical and computer engineering) and I reached out to everyone we knew, and they reached out to everyone they knew, and the ball got rolling," Petersen said.

Petersen and other faculty members gained permission to access campus as essential personnel in order to activate their printers and now the effort is producing an estimated 400 protective visors a day. The Cornell Campus-to-Campus bus made a special trip to deliver the first shipment to New York City on March 27.

Other faculty and students dedicated their engineering expertise to finding solutions to the ventilator shortage caused by the pandemic.

Sam Feibel '19, M.Eng. '20, joined the Ventilator Project—founded by entrepreneurs with the goal of developing a mass-manufacturable ventilator that doesn't require use of Ambu-bags or other critical medical equipment.

Derek Warner, associate professor of civil and environmental engineering, developed a prototype ventilator using a readily-available bilevel positive airway pressure machine that is similar to a sleep apnea device. He demonstrates in a YouTube video that the machine's control board can be fooled into functioning at the pressure levels needed for intubated mechanical ventilation by placing it inside a pressurized box.

https://youtu.be/GA66kLzWKcs

A closeup view of protective visors on a 3D printer. Photo Credit: Jenny Sabin Studio.

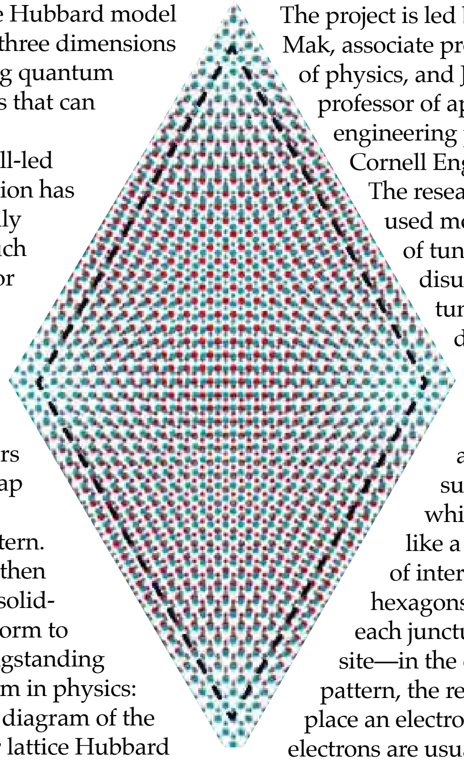
MODEL SIMULATOR HELPS RESEARCHERS MAP COMPLEX PHYSICS PHENOMENA

To understand the behavior of quantum particles, imagine a pinball game—but rather than one metal ball, there are billions or more, all ricocheting off each other and their surroundings.

Physicists have long tried to study this interactive system of strongly correlated particles, which could help illuminate elusive-physics phenomena like high-temperature superconductivity and magnetism.

One classic method is to create a simplified model that can capture the essence of these particle interactions. In 1963, physicists Martin Gutzwiller, Junjiro Kanamori and John Hubbard—working separately—proposed what came to be called the Hubbard model, which describes the essential physics of many interacting quantum particles. The solution to the model, however, only exists in one dimension. For decades, physicists have tried to realize the Hubbard model in two or three dimensions by creating quantum simulators that can mimic it.

A Cornell-led collaboration has successfully created such a simulator using ultrathin monolayers that overlap to make a moiré pattern. The team then used this solid-state platform to map a longstanding conundrum in physics: the phase diagram of the triangular lattice Hubbard model.



Cornell researchers stacked two atomic monolayers of a semiconductor—tungsten disulfide and tungsten diselenide—to create a moiré superlattice that acts as a simulator for the Hubbard model. This simplified system enables the team to better understand the essential physics of many interacting quantum particles.

The project is led by Kin Fai Mak, associate professor of physics, and Jie Shan, professor of applied and engineering physics at Cornell Engineering. The researchers used monolayers of tungsten disulfide and tungsten diselenide to create a pattern called a moiré superlattice, which looks like a series of interlocking hexagons, and in each juncture—or site—in the crosshatch pattern, the researchers place an electron. These electrons are usually trapped in place by the energy barrier between the sites. But the electrons have enough kinetic energy that, occasionally, they can hop over the barrier and interact with neighboring electrons.

"If you don't have this interaction, everything is actually well understood and sort of boring," said Mak. "But when the electrons hop around and interact, that's very interesting. That's how you can get magnetism and superconductivity."

So far, the researchers have used the simulator to make two significant discoveries: observing a Mott insulating state, and mapping the system's magnetic phase diagram. Mott insulators are materials that should behave like metals and conduct electricity, but instead function like insulators—phenomena that physicists predicted the Hubbard model would demonstrate. The magnetic ground state of Mott insulators is also an important phenomena the researchers are continuing to study.

TWO-STEP METHOD PATCHES HERNIATED DISCS

Anyone who has tried to repair a flat tire knows it's not enough to re-inflate the tire. The tire also needs to be soundly patched.

A similar principle applies to treating herniated discs. After a rupture, a jelly-like material leaks out of the disc, causing inflammation and pain. The injury is usually treated one of two ways: A surgeon sews up the hole, leaving the disc deflated; or the disc is refilled with a replacement material, which doesn't prevent repeat leakages. Each approach on its own isn't always effective.

A collaboration led by Lawrence Bonassar, the Daljit S. and Elaine Sarkaria Professor in the Meinig School of Biomedical Engineering and in the Sibley School of Mechanical and Aerospace Engineering, combined these methods into a new two-step technique. This approach uses hyaluronic acid gel to replace the leaked material and a collagen gel to seal the hole, resulting in a "patched" disc that maintains mechanical function and won't collapse or deteriorate.

"This is really a new avenue and a new approach to treating people who have herniated discs," Bonassar said. "We now have potentially a new option for them, other than walking around with a big hole in their intervertebral disc and hoping that it doesn't re-herniate or continue to degenerate. And we can fully restore the mechanical competence of the disc."

Bonassar's research group seeks engineering-based solutions for degenerative disc disease. Over the last decade, the group has developed a collagen gel that incorporates riboflavin, a photoactive vitamin B derivative. Instead of sewing up a ruptured disc, the researchers can patch it by applying their gel and shining light on it to activate the riboflavin.

The resulting chemical reaction causes fibers in the collagen to bond together, and the thick gel stiffens into a solid. Most importantly, the gel provides a more fertile ground for cells to grow new tissue, sealing the defect better than any suture could.

To keep the disc pressurized and mechanically functional, Bonassar worked with Fidia Farmaceutici, an Italian pharmaceutical company that manufactures a hyaluronic acid gel used in Europe.

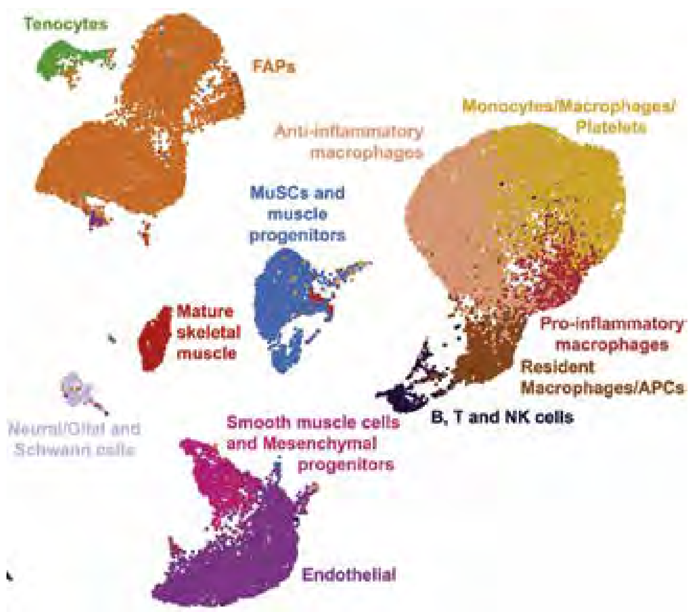
The technique only takes five or 10 minutes and can be applied in conjunction with a discectomy, the hourlong procedure by which the leaked nucleus pulposus is removed from the nerve root. The technique could be used to address other types of disc degeneration, or integrated into other spinal procedures and therapies.

The researchers developed a collagen gel that incorporates riboflavin, a photoactive vitamin B derivative. When a light is shined on it, the riboflavin is activated and the thick gel stiffens into a solid. Video: cornell.edu/video/two-step-method-patches-herniated-discs.

MUSCLE STEM CELLS COMPILED IN 'ATLAS'

Muscle repair is a crowded, complicated business. Many different types of cells are bumping around, chattering and trying to coordinate with each other as they work to regenerate new tissue.

A team of Cornell researchers led by Ben Cosgrove, assistant professor in the Meinig School of Biomedical Engineering, used a new cellular profiling technology to probe and catalog the activity of almost every kind of cell involved in muscle repair. They compiled their findings into a "cell atlas" of muscle regeneration that is one of the largest datasets of its kind. This resource provides a comprehensive picture of the many intricate cellular interactions in tissue self-repair and may potentially lead to better rehabilitation strategies and support for patients recovering from muscle injuries.



Assembly and curation of a scRNA-Seq atlas of mouse muscle regeneration.

Cosgrove worked with Cornell's Biotechnology Resource Center to use single-cell RNA sequencing to analyze the gene expression signatures in thousands of individual cells, all taken from the actively regenerating muscles of mice—including the rare muscle stem cells that drive the repair process. Cosgrove also collaborated with Iwijn De Vlaminck, the Robert N. Noyce Assistant Professor in Life Science and Technology in the Meinig School of Biomedical Engineering. Together, they applied new algorithms to filter the extensive collection of molecular information.

The researchers profiled and collected approximately 35,000 individual cells. The resulting atlas is a benchmark technical resource for researchers studying skeletal muscle tissue.

"Because we have such a large dataset, it helps us frame a number of hypothesis-driven questions about not only which cells are involved, but how they are communicating with each other," said Cosgrove. "This resource enabled us to ask 'What molecular signals are one type of cells sending to the other cells within the process of muscle repair?'"

Cosgrove's lab has already put the atlas to good use by identifying how a class of proteins called syndecans play a pivotal role in enabling muscle stem cells to make a binary choice during the process of muscle regeneration. As they are dividing, the stem cells chose either to replenish the stem-cell population, or they turn into the mature myofiber cells that replace damaged muscle tissue. Their findings show that syndecan-related variations may help direct how muscle-stem cells respond to signals from their neighboring cells and which outcome they chose.

QUADRUPLING TURBINES, U.S. CAN MEET 2030 WIND-ENERGY GOALS

The United States could generate 20 percent of its electricity in a breezy way within 10 years according to new Cornell research.

"The United States currently produces about 7 percent of its electricity from wind energy," said Sara C. Pryor, professor in Earth and Atmospheric Sciences. "This research shows that a quadrupling of the installed capacity of wind turbines from 2014 levels will allow us to attain the goal of 20 percent of electricity from the wind, without requiring additional land, or negative impacts on systemwide efficiency or local climates."

Pryor worked with Rebecca J. Barthelmie, professor in the Sibley School of Mechanical and Aerospace Engineering, and postdoctoral researcher Tristan J. Shepherd to develop scenarios for how wind energy can expand from current levels to one-fifth of the entire U.S. electricity supply by 2030, as outlined by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) in 2008.

Called the "20% Wind Scenario," the NREL report noted that generating 20 percent of U.S. electricity from wind could eliminate approximately 825 million metric tons of carbon dioxide emissions in the electrical energy sector in 2030.

But, the researchers asked, does quadrupling the number of wind turbines reduce the efficiency of turbine fleets that gather energy? And can that generation negatively affect the local climate?

"The 'theft' of wind by upstream wind turbines reduces the overall power produced by the total ensemble of wind turbines and the enhanced mixing (turbulence) can alter local climate conditions close to wind turbines," said Barthelmie.

The researchers offered scenarios—such as repowering turbines with improved technology—for expanding the installed capacity of wind turbines without using additional land. The researchers demonstrated that expansion of the installed capacity has a tiny influence on system-wide efficiency and very small impacts on local climate that are reduced by deploying large, state-of-the-art turbines.

MEI-WEI '72 AND AMY CHENG ESTABLISH DISTINGUISHED LECTURE IN TECHNOLOGY

Mei-Wei '72 and Amy Cheng have established the Distinguished Lecture in Technology at Cornell University, providing an intimate forum for CEOs and other leaders of transformative companies to interact with the university community.

Anne Chow '88, M.Eng. '89, MBA '90, CEO of AT&T Business, will be the inaugural speaker and will give the talk "Leading as a Lifelong Learner" on a date to be announced.

The focus of the Cheng Distinguished Lecture is technology leadership and the impact of technology on society. CEOs and other business leaders invited to give the lecture will use their unique perspectives to help faculty and students understand the broader implications of their research and how it is applied. Distinguished lecturers will also share their thoughts on disruptive technologies, strategies for successful decision-making, and innovation in science and engineering.

The annual lecture is also an opportunity for CEOs to gain exposure to emerging technologies being developed at Cornell, boosting the university's reputation among corporate leaders and encouraging new partnerships between industry and campus. Lecturers engage with university leadership, faculty and students during the visit.

The lecture is supported by Cheng, who retired in 2014 as president and CEO of Siemens Ltd., China. He currently serves as the non-executive chairman of HCP Packaging and non-executive chairman of Interplex, among other responsibilities. He was previously group vice president for Ford Motor Company and vice president, regional executive and president of GE Appliance, Asia. Cheng earned a B.S. in Operations Research and Information Engineering from Cornell.

Chow is a fitting inaugural distinguished lecturer. She is the first women to hold the position of CEO of AT&T Business and is the first women-of-color CEO in AT&T's history. With decades in the industry, she has led several global organizations through major transformations, developing strategies for growth while remaining passionate about education, diversity and inclusion, advancing women in technology and cultivating next generation leaders. She holds an MBA from The Johnson School at Cornell and a B.S. and M.Eng. in electrical engineering from Cornell Engineering.

Mei-Wei Cheng

'BOREHOLE OF OPPORTUNITY' ATTRACTS INTERNATIONAL SCIENTISTS

Participants of the International Continental Scientific Drilling Program workshop at Cornell, Jan. 8-10, 2020.

Scientists and engineers from around the world gathered in Cornell's Snee Hall, Jan. 8-10, to design experiments that could be incorporated into the university's proposal to dig a 2.5-mile-deep borehole as part of an enhanced geothermal energy system.

About 35 researchers traveled to campus for the workshop, where they were joined by about 20 Cornell faculty members, students and facilities professionals. The workshop was sponsored by the International Continental Scientific Drilling Program, a nonprofit organization that promotes subterranean investigations.

Scientific access to deep continental boreholes is uncommon, as the holes are mostly dug by industry, which generally does not share access or data. Access is critical to learning about rock mechanics, hydrogeology, seismology, microbiology and other information about the planet.

Cornell is proposing a borehole on campus property to serve as a test well for Earth Source Heat, an enhanced geothermal system that would use the Earth's thermal energy to heat most of the buildings on campus.

The test well would help inform the design of the system, but also serve as a "borehole of opportunity," as some workshop attendees called it—the opportunity to learn more about the subsurface.

"The geology beneath central New York is old, relatively cold and far from a tectonic plate boundary, which is similar to a large part of the continents," said Patrick Fulton, assistant professor of earth and atmospheric sciences and a member of the workshop's organizing committee. "By studying the processes and conditions that operate here, there is excitement about the potential for showcasing how sustainable energy solutions can be utilized in a lot of areas in the U.S. Northeast and globally."

Extensive discussion focused on the opportunities to learn about the mechanical interactions of deep rocks with stresses and strains in the subsurface. The relative lack of seismic activity in the Ithaca area means there is rarely any data that would offer insights into the subsurface, according to Terry Jordan, the J. Preston Levis Professor of Engineering and leader of the workshop's organizing committee.

"The rock consists of solid minerals, natural discontinuities and fluids in small pore spaces," Jordan said. "What are the mechanical interactions between those parts? How may that rock system respond to any changes in fluids or stresses or minerals? The workshop illuminated that science-focused borehole tests and experiments can offer unique opportunities to probe this rock behavior."

The workshop's participants represented Germany, Japan, China, the Netherlands and Switzerland as well as 12 U.S. states and regional universities including Syracuse University, the University at Buffalo, Binghamton University, State University of New York College at Oswego and St. Lawrence University.

"These are ideal experiments that would solve key questions that scientists rarely have the opportunity to work on," said Jordan. "There's just a massive amount of excitement that Cornell is the place to do all this."

10 YEARS!

LANCE COLLINS' LEGACY

As Lance Collins, the Joseph Silbert Dean of Engineering, completes his second and final term as dean, *Cornell Engineering Magazine* looks back at his decade-long tenure and his many achievements.

Collins joined Cornell in 2002 as a faculty member specializing in the application of numerical simulations to turbulent processes. As the first African American director of the Sibley School of Mechanical and Aerospace Engineering, and later as the first African American dean at Cornell University, Collins elevated the college as one of the premier engineering research and education institutes in the world.

Collins will be joining Virginia Tech as the inaugural vice president and executive director of its new Innovation Campus following the completion of his term on June 30.

Said Collins: "I'm looking forward to serving out my last semester at Cornell, and although my time in Ithaca will soon end, I expect to discover the sentiment that many of our alumni have shared with me—namely, that Cornell will always hold a special place in my heart."

2010

Collins becomes first African American dean

Collins becomes the first African American dean in Cornell University history.

University wins Cornell Tech bid for Roosevelt Island

Collins was a member of the core leadership team that won the Cornell Tech bid for Roosevelt Island in New York City. He has since served on the board of directors for the Jacobs Technion-Cornell Institute at Cornell Tech, the joint venture between the Technion-Israel Institute of Technology and Cornell. Collins has also played an instrumental role in the hiring and promotion of faculty, and the launching of new engineering degree programs at Cornell Tech.

2011

White House recognizes college diversity programs

Collins supports Diversity Programs in Engineering such as CURIE Academy, CATALYST Academy, Coleman Leadership, and Ryan Scholars. In 2011, the White House recognized these programs with the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.

2012

Support grows for student project teams

Collins helps secure a $10 million gift from John Swanson '61, M.Eng. '63, to support student project teams and other learning initiatives. Project teams have since grown to 29 teams comprised of about 1,100 students, most of whom are engineering students.

Engineering Leadership Program established

Collins establishes the Engineering Leadership Program to provide structured education and training in leadership development. Throughout his tenure, Collins emphasized the value of leadership qualities in engineers, noting many students will one day manage projects, lead working groups, and start or lead companies.

2013

College launches 'Breaking the Rules' brand

Collins launches Cornell Engineering's first branding campaign effort, which engaged hundreds of students, faculty, staff, and alumni to develop a new and unique brand position for the college in the higher education marketplace. The 'Breaking the Rules' brand platform has been incorporated into the college's website, magazine, social media, merchandise, videos and facilities.

Teaching Excellence Institute receives $5 million gift

Collins helps secure a $5 million gift from the McCormick family for the McCormick Family Teaching Excellence Institute, supporting faculty use of traditional and non-traditional methods for teaching students.

2014

The Cornell University Board of Trustees reappoints Collins to a second term as the Joseph Silbert Dean of Engineering

Cornell Engineering Sesquicentennial
Collins honors the college's history by leading a multi-day celebration in October that featured talks from notable alumni and past leaders, presentations on the college's history, panels discussions on the future of the college, the unveiling of a time capsule, and the unveiling of a plaque honoring the college's first women engineer, among other events.

Meinig School of Biomedical Engineering established
Collins helps secure a $50 million gift that establishes the Nancy E. and Peter C. Meinig School of Biomedical Engineering, representing at the time the largest single philanthropic commitment by individual donors to one of the university's colleges in Ithaca. He subsequently launched the biomedical engineering undergraduate program, which has since graduated its first class. The school's graduate program was less than six years old when Collins began his tenure as dean, but quickly grew to prominence and is now ranked the #14 biomedical graduate program in the nation according to *U.S. News & World Report*.

***Forbes* ranks Cornell the fourth most entrepreneurial school**
Collins' work in establishing an ecosystem of entrepreneurship at the college helps land Cornell University at #4 on the Forbes list of Most Entrepreneurial Schools. Collins helped to develop, or integrated into the college, the following programs: eHub, eLab, Rev: Ithaca Startup Works, Commercialization Fellows, Scaleup and Prototyping Awards, Entrepreneurship Minor, and the Praxis Center for Venture Development.

Collins receives inaugural Mosaic Medal of Distinction
Collins is recognized for his efforts in diversifying the college's student body and creating an inclusive environment with the Mosaic Medal of Distinction. Awarded by the alumni organization Cornell Mosaic, the medal recognizes Cornellians for creating opportunities for diverse communities.

Samuel C. Fleming Molecular Engineering Laboratories named
Collins helps secure a $10 million gift from the Fleming family to establish the Samuel C. Fleming Molecular Engineering Laboratories in the newly renovated Olin Hall. The labs were cited by *Reuters* in its 2019 list of the World's Most Innovative Universities, which ranked Cornell at #9.

Cornell establishes the Sustainable Cornell Council
Collins is named to the leadership team of the Sustainable Cornell Council, which replaced the Senior Leaders Climate Action Group and directs the university's role as an international leader in addressing climate change and promoting sustainability by using the campus as a living laboratory. As co-chair, he has encouraged adoption of the living laboratory model—the practice of using the campus's buildings, energy, water, waste, grounds, people, and transit as systems for exploring and demonstrating new sustainable solutions. One such project is the proposed implementation of Earth Source Heat, an enhanced geothermal system that would heat Cornell's campus and help the university achieve its 2035 carbon neutrality goal.

Coronavirus pandemic
Collins leads the college during the coronavirus pandemic, ensuring the college takes a leading role in preserving faculty research, remote teaching, staff positions, and student recruitment.

2015 | 2016 | 2017 | 2018 | 2019 | 2020

Cornell Engineering launches capital campaign
Collins initiates a capital campaign to renovate most engineering buildings on campus. Completed renovations include Kimball Hall, which received LEED Gold status for its use of recycled materials and a state-of-the-art heating and cooling system; Upson Hall, which includes laboratories built for modern research, flipped classrooms, space for project teams and makers, and a wing that united many robotics labs in one location; Olin Hall, the first phase of which established state-of-the-art molecular engineering laboratories; and Weill Hall, which added new laboratories, classrooms and meeting spaces. A future renovation of Hollister Hall will see the demolition of Carpenter Hall to make way for Hollister's new north wing, which will include room for new faculty and administrative offices, student meeting spaces, a library and research laboratories.

Smith School of Chemical and Biomolecular Engineering named
Collins helps secure $50 million from Robert F. Smith '85 to support chemical engineering and diversity initiatives. The Robert Frederick Smith School of Chemical and Biomolecular Engineering was named following the gift and a series of new programs such as the Smith Scholars and the Smith Initiatives were launched.

Engineering Distinguished Alumni Award is established
Collins establishes the Engineering Distinguished Alumni Award to recognize college alumni whose extraordinary leadership and vision have broken the rules to push traditional boundaries and transform the world. Recipients to date are David Duffield '62, MBA '64 (2018), Irwin Jacobs '54, BEE '56 (2019), Robert F. Smith '85 (2020).

Collins receives the Edward Bouchet Legacy Award
Collins is recognized for his efforts in diversifying the college's student body and creating an inclusive environment with the Edward Bouchet Legacy Award. The award, established by Howard and Yale universities, recognizes educators and advocates committed to cultivating a new generation of scholars, particularly those who promote diversity and inclusion.

Cornell Engineering achieves undergraduate gender parity
Collins grows the population of undergraduate women to 50%, up from 33% at the beginning of his tenure as dean. The five-year graduation rate and average GPA has remained equal among genders, and tenure-track women faculty has grown to 21%. Collins has also doubled the percentage of undergraduate underrepresented minorities during his tenure.

Q&A WITH DEAN COLLINS

Lance Collins reflects on his decade-long tenure as the Joseph Silbert Dean of Engineering, including his thoughts on leading through a crisis, his favorite moment, and the one 'rule' he was proud to break.

What is a specific memory from your time as dean that you'll always remember?

I recall speaking to Cathy Dove, who was associate dean of administration at the time, just after Stanford announced that they had decided to withdraw their bid for the applied sciences competition in New York City. Cathy and then-Provost Kent Fuchs were in New York overseeing negotiations with the city's Economic Development Corporation. It was just another Friday afternoon. For context, you have to remember that this competition was a day-in, day-out grinding slugfest, and there was no indication that one university was ahead of the other. Cathy, this calm, strong leader—the task master who had orchestrated our pre-proposal, proposal and final negotiations—got on the phone and couldn't get the words out. After three or four tries, I was able to make out two words, "Stanford withdrew." Instantly a wave swept over me and I knew Cornell Tech was born. That moment stands out because it speaks to the magnitude of the institutional change. Speechless indeed.

You led the college through the Great Recession and now through the COVID-19 pandemic. What have you learned from leading during times of crisis?

There is a saying that you should never waste a crisis. That's not to be cruel, but it's a reference to the fact that as resources dwindle, you are forced to focus on activities with the highest strategic value. For example, following the Great Recession, then-Provost Kent Fuchs led the university through a budget overhaul to create what we then called the "New Budget Model," and now we're much stronger institutionally to handle the COVID-19 economic fallout. I don't mean we're richer, just better managed and with more refined tools to help us handle the economic rough waters ahead with our more transparent and uniform budget model.

Right now, I believe we are experiencing a disruptive event in higher education. Consider the fact that every university across the country, in a few short weeks, has shifted to online delivery of its curriculum. Faculty are through the learning curve and will now have the opportunity to see advantages to some—not all—aspects of online education. There's an opportunity for universities to rethink how they deliver their curricula, and for companies working in the education market to be inspired to develop the new platforms for online learning.

Beyond the COVID-19 fallout, what will be the most pressing challenge faced by your successor?

There's no question Cornell Tech remains an incredible opportunity for Cornell Engineering and I think we can further exploit that opportunity. The next dean has to focus on very dramatically upping our game in New York City and taking advantage of the city's potential as a leverage point for entrepreneurship across the college and the whole university.

Another big challenge will be the physical plant. The aging infrastructure on the quad won't sustain a premier engineering college forever. I started the process and we made some good progress, but the next dean is going to have to build on that.

Is there a rule or status quo you were proud to break?

I am proud that Cornell Engineering has shattered the myths that women and minorities aren't equal to the task of becoming an engineer. We broke the rules by changing the narrative around diversity. Historically, people have often viewed diversity and excellence as competing interests, and Cornell Engineering has established unequivocally that they are perfectly aligned and mutually reinforcing. You just have to be on our campus to feel the vibrancy of our college.

Maybe the next dean will get to make an historic announcement about minorities the way I got to about gender parity. Keep breaking that rule!

Is there anything else you'd like to say to the Cornell Engineering community?

I will miss Cornell. It's an obvious sentiment, but it's true. I feel like I grew more here than any other point in my career and more here than at any other institution. It's definitely a bittersweet experience to be leaving Cornell, but it will always be a part of me.

> **"WE BROKE THE RULES BY CHANGING THE NARRATIVE AROUND DIVERSITY."**
> **— Lance Collins**

BIG RED DATA

CORNELL ENGINEERS ARE CRUNCHING NUMBERS TO FIGHT EVERYTHING FROM CORONAVIRUS TO CLIMATE CHANGE

By Chris Woolston

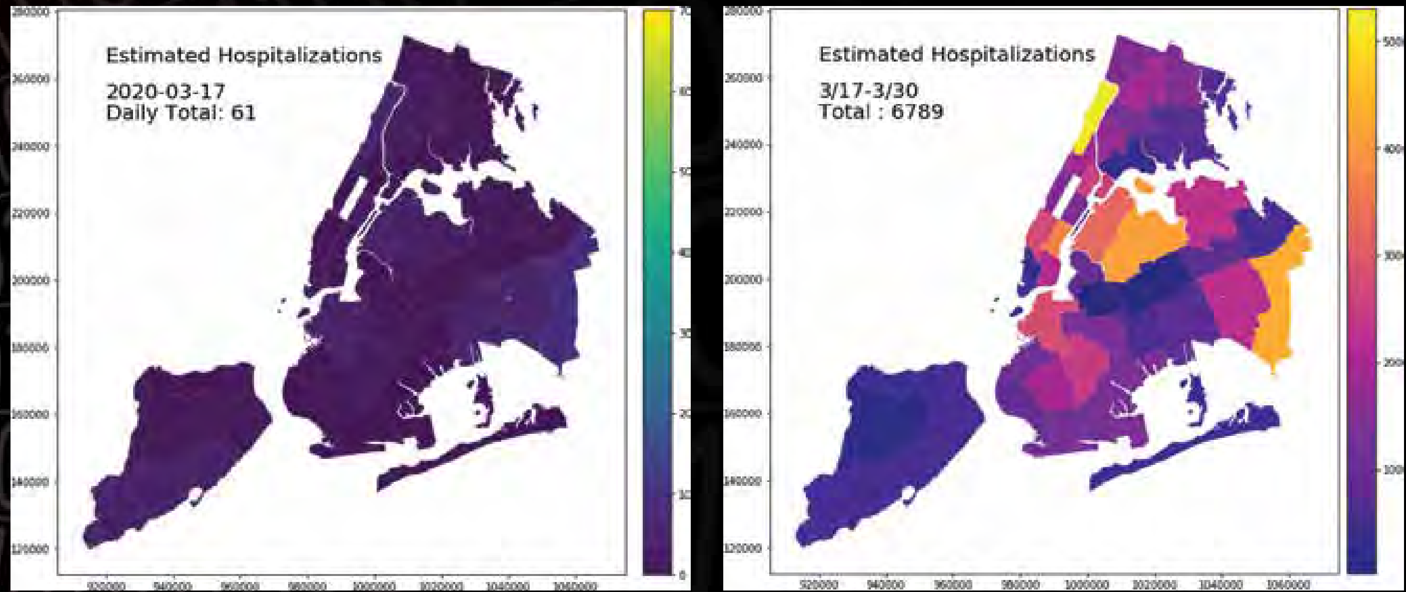
Data scientists never really know where their work is going to take them. David Shmoys, the Laibe/Acheson Professor of Business Management and Leadership Studies at Cornell Engineering, has applied his mathematical tools to topics ranging from woodpecker populations to bike sharing programs. And when a global pandemic broke out, he was ready to shift his attention to the biggest crisis of our time.

Nobody really saw the novel coronavirus coming, but data scientists at Cornell had still been preparing for the moment. Over the years, they have been developing models and mathematical techniques to address the most vexing problems in the world—whether pandemics, climate change, or transportation. At Cornell, data science is a collaborative effort involving researchers from many different fields including biology, the social sciences, physics and engineering. Much of the work happens in three key hubs: the School of Operations Research and Information Engineering (ORIE), the Center for Data Science for Enterprise and Society (where Shmoys is the director) and the Institute for Computational Sustainability. The work crosses disciplines and borders, with direct impacts on critical care units in New York City, hydroelectric dams on the Amazon, and many places in between.

Using "big data" techniques to address real-life problems is the guiding mission of all three entities, Shmoys says. As he explains, big data could be applied to all sorts of esoteric topics, but Cornell researchers aren't running numbers just for the sake of mathematical challenge. "We're using computational tools to improve decision-making capabilities." Shmoys says. "We are especially attuned to problems that impact society."

Data in a time of coronavirus

Of course, there's no bigger problem right now than the novel coronavirus. As the pandemic gained steam, Cornell data scientists were called to action. In response to a request for expertise from the office of New York Governor Andrew Cuomo, Shmoys and colleagues have been tracking the spread and developing models to predict the need for ventilators and other vital pieces of equipment. Meanwhile, Peter Frazier, an associate professor in ORIE, has been crunching numbers on the best way to test large groups of people and potentially get them back to the workforce. "Even though we didn't expect this pandemic, it's very much in our wheelhouse," Frazier says. "Our goal is to develop and apply math that's useful and practical."



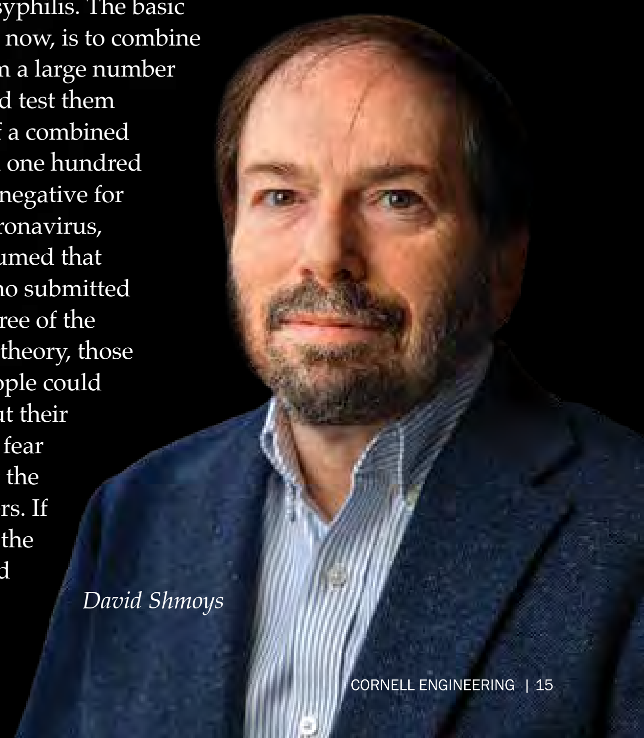
A map of estimated COVID-19 hospitalizations in New York City developed by Professor David Shmoys using data science.

The pandemic has raised questions that are as urgent as they are complex. For example, a wide range of variables can affect the need for ventilators in New York City, and the facts on the ground are in constant flux. In order to build models to predict the most likely outcomes, Shmoys and colleagues collected data from around the world to learn more about transmission rates and the chances that an infection leads to significant illness. They've also taken a hyper-local view by tracking cases of coronavirus infections by zip code, a critical piece of information for understanding the demographics of the disease at a neighborhood-by-neighborhood level. "You can think of this epidemic as multiple micro-epidemics," Shmoys says, each with its own unique challenges.

Shmoys notes that Cornell data scientists have a history of responding to public health crises. During the anthrax scare of 2001, John Muckstadt, then the Acheson/Laibe Professor of Business Management and Leadership in ORIE, worked closely with Dr. Nathaniel Hubert at Weill Cornell Medicine to develop possible approaches to mass antibiotic distribution against the potential biological weapon. "That set off a number of projects that explored both operational issues and system modeling approaches to improving medical care and understanding the progression of a disease," Shmoys says. "It's been a recurring theme of work within ORIE at Cornell."

Thinking big about coronavirus testing

For his part, Frazier is exploring the possibility of "group testing," an approach first developed in World War II to screen soldiers for syphilis. The basic idea, then as now, is to combine samples from a large number of people and test them all at once. If a combined sample from one hundred people tests negative for the novel coronavirus, it can be assumed that everyone who submitted a sample is free of the infection. In theory, those hundred people could then go about their day without fear of spreading the virus to others. If it's positive, the testers would have to go



David Shmoys

back to the original samples to zero in on affected people.

The approach is relatively simple in concept, but it raises extremely complicated mathematical questions. For starters, what's the optimum number of people to test at a time and how often do they need to be tested? The answers depend on many factors, including the prevalence of the virus. "If one out of ten people had the virus, testing one hundred people at a time would be a waste because almost every sample would come back positive," Frazier says. "But if the infection rate is more like one in a thousand, testing large groups of people makes more sense."

Things only get more complicated from there. Widespread group testing would raise thorny logistical issues, Frazier says. "If you're collecting saliva from 320 million people once a week, and delivering it to one of the 12 labs in the U.S., that's going to take a lot of cars and planes," he says. If that day comes, Frazier and other Cornell data scientists will be ready to offer mathematical guidance. "We have a lot of experience dealing with uncertainty," he says.

Frazier had been working on the mathematics of group testing in a much different context long before the new coronavirus came on the scene. Instead of searching for a sign of disease in a group of people, he was looking for faces in photographs. Pictures from a cousin's wedding seemingly don't have much in common with pandemics, but Frazier explains that the mathematical concepts behind the search is very similar. When looking for faces, it helps to sample multiple locations at once. If there's no face in that sample—in other words, if that sample tests negative— the search can continue elsewhere. If it comes back positive, the computer can take a close look.

Carla Gomes

"WE'RE USING COMPUTATIONAL TOOLS TO IMPROVE DECISION-MAKING CAPABILITIES. WE ARE ESPECIALLY ATTUNED TO PROBLEMS THAT IMPACT SOCIETY."
— David Shmoys

The wide world of computational sustainability

Just as Frazier and Shmoys apply their mathematical techniques to widely varying problems, Carla Gomes, professor of computer science and the director of the Institute for Computational Sustainability, takes a large view of a field that she helped pioneer. As the name implies, computational sustainability uses data science to address sustainability issues for human well-being. Gomes works on complicated projects including bird migrations, fishery quotas in Alaska and hydroelectric power in the Amazon, but she always follows the same rule when choosing a topic: She'll only tackle the mathematics if she can collaborate with top conservation scientists in their respective fields who can guide her through the core issues. "I work on problems when I have access to the highest levels of expertise," she says.

For her work on hydroelectric dams, Gomes works closely with Alex Flecker, a professor of ecology and evolutionary biology, and a large international and interdisciplinary group of ecologists, hydrologists and social scientists, among other disciplines, many from the Amazon region. Together, they are using data science to understand how and where dams could be placed in the Amazon River basin to deliver the highest possible benefits with the least amount of environmental downsides. "Everybody thinks that hydropower is automatically clean energy, but there are a lot of trade-offs," she says. As Gomes, Flecker and an international team of co-authors recently described in a paper in *Nature Communications*, the giant reservoirs created by dams can become sources of methane, a potent greenhouse gas. "If you don't plan properly, hydroelectric energy can be dirtier than coal," she says.

With hundreds of potential dam sites under consideration, choosing the best approach quickly becomes an exercise in astoundingly large numbers. "I have a computer with one terabyte of memory that's completely dedicated to keeping track of possibilities," Gomes says. "The number of potential combinations exceeds the number of atoms in the universe," she says.

Decaying trees, which enhance greenhouse gas production, in the Santo Antônio reservoir. Photo Credit: Rafael M. Almeida.

As part of her sustainability mission, Gomes is also collaborating with R. Bruce van Dover, Chair of the Department of Materials Science and Engineering, and others on developing materials for fuel cells, devices that turn fuel such as hydrogen into usable electricity. To aid in the search for the right materials, Gomes, van Dover and colleagues are developing a robot named SARA (scientific autonomous reasoning agent) that can use artificial intelligence algorithms to test and develop possible options.

Endless data

With so many possible applications for their mathematical approaches, data scientists will never run short of targets. If and when the coronavirus pandemic fades or fuel cells are perfected or Brazil installs its last hydroelectric dam, other problems will be waiting. And if another unexpected global crisis arises, the tools that data scientists have already built will almost certainly come into play again. "The advances in computational methods provide many opportunities," Shmoys says.

The Santo Antônio hydropower dam, recently built in the Brazilian Amazon. Photo Credit: Rafael M. Almeida.

INSIDE THE NEW SAMUEL C. FLEMING MOLECULAR ENGINEERING LABORATORIES

By Chris Dawson

Chris Alabi

"THE NEW SPACE IS REALLY EVERYTHING I HOPED IT WOULD BE. COMPARED TO MY OLD SPACE, IT GIVES US ALL A SAFER, CLEANER ATMOSPHERE TO WORK IN, WITH OUR OWN HOUSE VACUUM AND NITROGEN AND AN AUTOCLAVE AND DISHWASHER FOR STERILIZING GLASSWARE. MOST IMPORTANTLY, THE HUMAN ELEMENT IS HUGE. IN THE NEW SPACE, OUR GROUP NOW INTERACTS WITH MORE PEOPLE WHO ARE WORKING ON SIMILAR AND DISPARATE RESEARCH AND WE ARE ALL ABLE TO LEARN FROM EACH OTHER."

— Chris Alabi

As an undergraduate at New York University and Stevens Institute of Technology, Chris Alabi was a self-described lab rat. "I worked as an undergraduate researcher in Professor David Schuster's lab for four years," says Alabi. "I basically lived there; I did all my homework in the lab. The lab was it, and everything else simply existed around the lab. It became my home."

Now that he is an associate professor in Cornell's Robert Frederick Smith School of Chemical and Biomolecular Engineering, Alabi is the one making undergraduate and graduate researchers feel like his lab is a home. His lab is in the north wing of Olin Hall in the newly created Samuel C. Fleming Molecular Engineering Laboratories. These labs are the result of a generous gift from Samuel '62 and Nancy Fleming.

Olin Hall had not had a major overhaul of laboratory space in more than 30 years, so the Fleming's gift is very much appreciated by the three professors who now occupy the space. The 7,300 square feet of new labs are being used for research into drug design, drug delivery, biomedical diagnostics, and the discovery of new materials. The work done by Alabi and the other professors in the Fleming Labs covers all of these bases and more. Gathering them together in a dedicated space with shared resources and ease of contact and collaboration is a realization of Sam Fleming's vision in giving the gift.

"The new space is really everything I hoped it would be," says Alabi. "Compared to my old space, it gives us all a safer, cleaner atmosphere to work in, with our own house vacuum, nitrogen, and an autoclave and dishwasher for sterilizing glassware. Most importantly, the human element is huge. In the new space, our group now interacts with more people who are working on similar and disparate research and we are all able to learn from each other."

When Alabi says "us" and "we," he is talking about the postdocs, Ph.D. students, and undergraduates who are part of his lab. But he is also talking about Assistant Professor Rong Yang, Tisch University Professor Nicholas Abbott, and all of the people in their labs, as well. All told, this "us" includes close to 50 people.

"It's people that matter," says Abbott. "I've always had an office that has been on the other side of the building from my research group. Now that we are all in one space it is so much easier to grab a couple of people and say 'why don't we try this together?' Collaborations and exchanges of information happen much more frequently and naturally now that we are in the Fleming Lab space."

"My lab uses a lot of customized instruments that we build ourselves," says Assistant Professor Rong Yang, "and that required a significant modification of the HVAC and the venting and the flow rate of the gases coming in. So Abe and I really worked together on guaranteeing the new space would have what I need for my work."

Abe, in this case, is Abe Stroock—the William C. Hooey Director of the Smith School. In an interview given as the Fleming Labs were still being constructed, Stroock said, "These faculty members represent a powerful cluster who truly engineer systems from the molecular scale. This laboratory space will allow them to continue to develop new

Rong Yang

chemical design principles, synthesize their own molecules and pursue a rich array of applications in biomedical and environmental contexts."

Alabi examines how the composition and order of the building blocks of a macromolecular chain affect its chemical and biological properties. The long-term goal of his work is to assemble new, sequence-controlled macromolecules that can be used in a variety of ways. Alabi sees these designer macromolecules being used to quantify intracellular processes, to deliver drugs to specific areas of the body efficiently, and to act as a new class of powerful antimicrobial and antiviral agents.

Yang is thrilled to share lab space with Alabi and Abbott and sees many places where their research is complementary. Yang has several research focus areas. One is using polymer vapor deposition techniques to create surfaces that allow the manipulation of bacteria-surface interactions via nanometer-scale heterogeneities. In this way, she hopes to control the interaction between surfaces and bacteria. Another thread of Yang's research is creating predictably uniform porous membranes for use in health care, water purification, and energy storage. A third focus of Yang's lab is developing material-based antibiotic treatments that disinfect by converting secreted metabolic products of pathogens to antimicrobials in situ.

"My long-term, shoot-for-the-moon goal," says Yang, "is to encode 'orders' for bacteria into the materials we create so that we can deploy bacterial biofilms for fouling prevention, disease treatment, and environmental preservation."

"Cornell has a strong cluster of people who really care about the problem of antibiotic resistance and enjoy working together to solve this problem," says Yang. "The work I do in this area can benefit greatly from working in such close proximity to Chris and his group. And I am excited to work with Nick on material innovations at the molecular level, which could enable unprecedented material properties."

"For me," says Abbott, "this new lab space is a wonderful means to an end. I like science and I like engineering and I like exploring. I was very grateful to have the opportunity to help design the new lab. It's going to let us discover, create and manipulate things at the molecular level in ways that have not previously been possible. And the proximity to Chris and Rong simply adds to those dimensions."

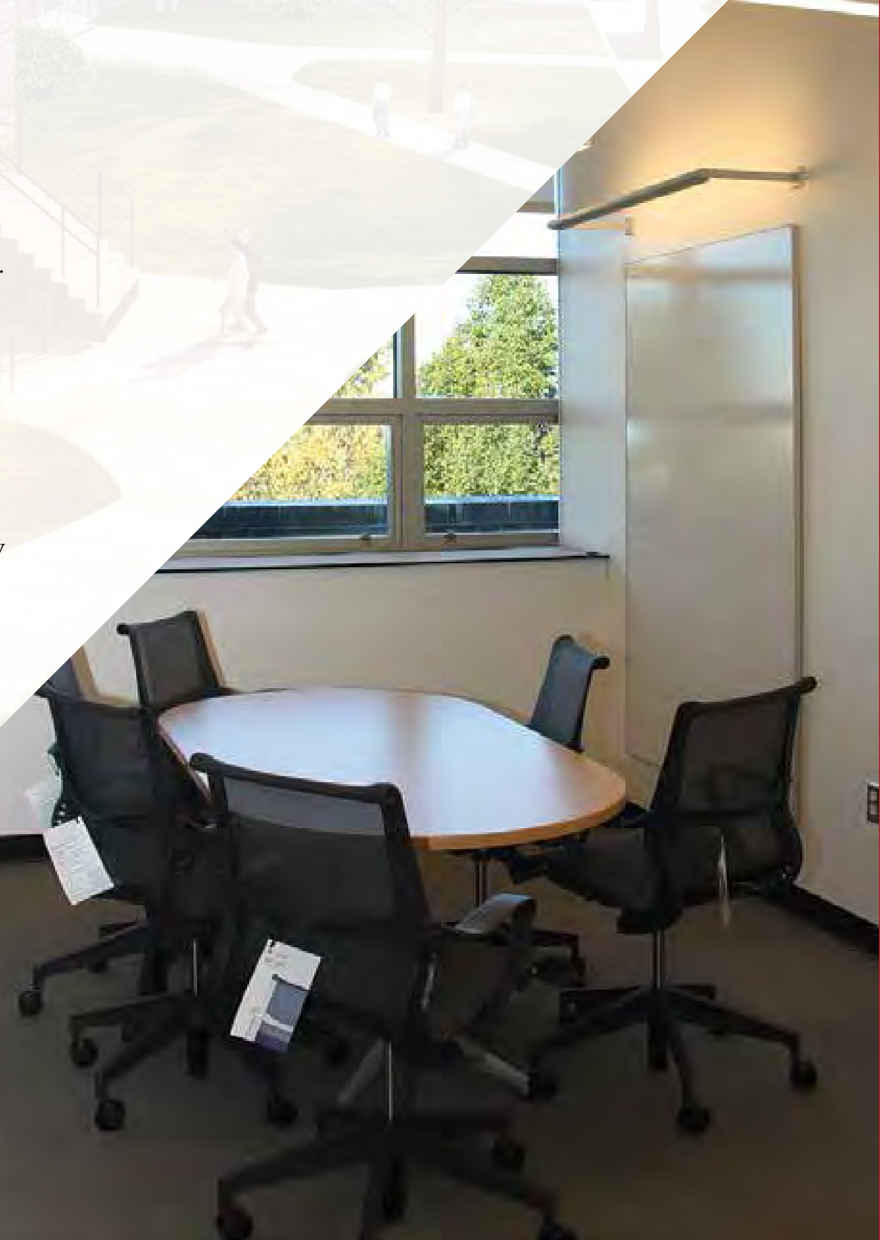
In separate conversations with Abbott, Alabi, and Yang all three bring up the idea of trying to consciously create a community of people focused on the theme of the Fleming Labs space—molecular engineering. It is clear that this community is already well-established. Even while Olin Hall was closed during the COVID-19 shelter-at-home decree, lab groups continued to meet virtually to create grant proposals, discuss papers in progress, talk about research, and simply make contact.

The work done and the innovations created will benefit just as much from the abundant human interactions the new spaces facilitate as from the new utilities, capacities, and technical equipment now available.

Nicholas Abbott

"NOW THAT WE ARE ALL IN ONE SPACE IT IS SO MUCH EASIER TO GRAB A COUPLE OF PEOPLE AND SAY 'WHY DON'T WE TRY THIS TOGETHER?' COLLABORATIONS AND EXCHANGES OF INFORMATION HAPPEN MUCH MORE FREQUENTLY AND NATURALLY NOW THAT WE ARE IN THE FLEMING LAB SPACE."

— Nicholas Abbott



BEHIND THE NAME

Samuel and Nancy Fleming

The gift that catalyzed the Samuel C. Fleming Molecular Engineering Laboratories and all of these interactions inside came in the form of $10 million from Sam '62 and Nancy Fleming. Sam Fleming earned his bachelor's degree in chemical engineering from Cornell in 1962 and an M.B.A. from Harvard in 1967. He had a long and successful career focused on the analysis of biopharmaceuticals and the management of health care networks. Fleming served on the Engineering College Council and was on Cornell's Board of Trustees and Weill Cornell Medicine's Board of Overseers.

He and his wife Nancy also supported the university's New Life Sciences Initiative. They endowed a professorship and three postdoctoral fellowships in the Weill Institute, and supported a fellowship to support collaborative research between the Ithaca campus and Weill Cornell Medicine. They also supported the McMullen Engineering Scholarship program, the Cornell Botanic Gardens, athletics and Greek life. The Fleming Molecular Engineering Laboratories was one of the last gifts to Cornell from Sam Fleming before he passed away in May 2019.

COMMERCIALIZATION

By Casey Verderosa

ENGINEERS REGULARLY SIMULATE TECHNOLOGIES WITH HIGH-IMPACT POTENTIAL IN THE LAB. FOR SOME, THE WAY TO GET THEIR TECH OUT INTO THE WORLD IS THROUGH THE OFTEN-UNFAMILIAR ROLLER COASTER RIDE OF COMMERCIALIZATION.

THE JOURNEY TO COMMERCIALIZATION AT CORNELL

Engineers regularly simulate technologies with high-impact potential in the lab. For some, the way to get their tech out into the world is through the often-unfamiliar roller coaster ride of commercialization.

Entrepreneurship can be full of ups and downs—learning that the target market you identified was all wrong, having to adapt your product to fit demand, and making hundreds of pitches before you obtain funding. It can be like running a marathon, getting to mile 15, and realizing you have to go back to the starting line and do it all over again.

Scientists who may not have entered their fields with entrepreneurial goals might feel like they're playing catch-up. In recent years, Cornell Engineering – and Cornell University as a whole – have developed a suite of commercialization resources so that Cornellians with great ideas can delve fully into the world of entrepreneurship, no matter their starting point.

PitchBook recently ranked Cornell sixth in the nation in its 2019 list of universities producing entrepreneurs backed by venture capital.

Within Cornell Engineering, undergraduates can begin with the Engineering Innovation Competition, where teams with physical prototypes vie for prizes to support the next step toward development of their business idea. Graduate students may also compete, as long as the majority of team members are undergraduates. Junior STEM students can apply to the Kessler Fellows program and engage in a semester-long immersion into entrepreneurship, followed by a summer experience with an existing startup.

A new entrepreneurship minor was launched in 2019 to meet the needs of doctoral engineering students seeking business acumen to complement the development of their advanced technologies. Also open to engineering Ph.D. candidates is the Commercialization Fellows program. Students in this program explore commercialization opportunities for their technology in partnership with a mentor over the course of a fully-funded semester and summer.

Cornell Engineering's Scale Up and Prototype Awards provides funding to Cornell students, postdocs, and faculty to create a functioning prototype or scale up an already-developed technology that is not quite ready for commercialization.

Cornellians who have taken advantage of these and other entrepreneurship opportunities on campus are out to change the world with innovative technologies. The paths they take on their journeys to commercialization are many and varied.

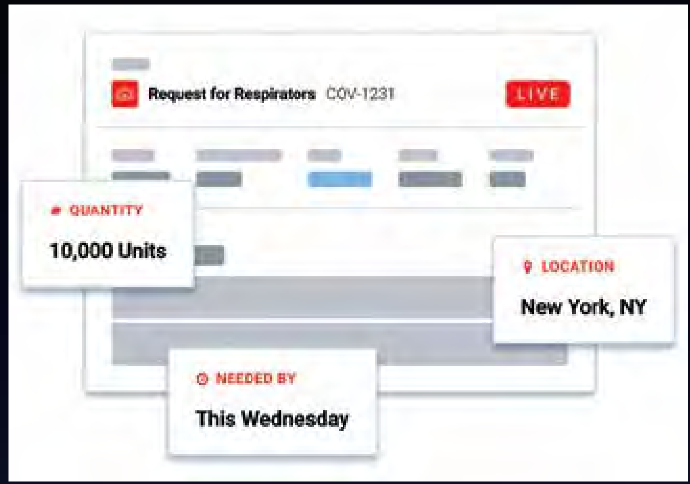
Founding a company before graduation

Kais Baillargeon '20, Nolan Gray '19, and Keivan Shahida '20 centered their academic careers on engineering and entrepreneurship. The three began working together during their sophomore year, when they participated in the Engineering Innovation Competition. At the time, they were developing a mobile app to improve communication between humanitarian-aid organizations and donors.

A summer business incubator experience through Cornell's student-run Life Changing Labs shifted the team's focus. "In the process of speaking with people in the humanitarian sector, they said the real challenges for them are in procurement—in how they spend that money raised," said Shahida. "We wanted to use our technical backgrounds to help these nonprofits."

Gray and Shahida, both computer science majors, and Baillargeon, studying operations research and information engineering, started laying the groundwork to digitize the procurement process for aid organizations. According to the team's interviews with humanitarian groups, procurement in this sector is focused on finding the best quality products for the best price, making efficient use of donated dollars. This monetary efficiency compromises efficiency in time, since finding the right product can take weeks on end. Further slowing the process down is the fact that it's also mostly done on paper and by email.

Conner Swenberg '21, left, and Nolan Gray '19 work together on their project, Response, which helps humanitarian organizations to quickly and efficiently buy supplies during emergency response.



Conceptual visualization of Response, a digital platform that automatically generates bid-offer forms and vendor questionnaires, evaluates bids instantly, and ensures compliant sourcing.

When a hurricane hits or drought causes a famine, it's important for aid groups to get supplies on the ground quickly. The trio's company, Response, hosts a digital platform that automatically generates bid-offer forms and vendor questionnaires, evaluates bids instantly, and ensures compliant sourcing.

In their junior year, the team joined Cornell's eLab accelerator for student businesses. There, they conducted another 100 customer interviews. With support from the university, they were able to travel to a humanitarian conference, AidEx, in Brussels, Belgium, attended by thousands of procurement officers. To date, the company has interviewed over 200 people from more than 40 countries.

"After eLab we were also fortunate to receive support from the Kessler program as well as the Beck Fellowship program, which enabled us to spend a summer in Washington, D.C., where many aid organizations are headquartered," said Gray.

As Response pilots its platform with humanitarian organizations, it has also identified a crisis where its product is uniquely positioned to provide assistance: the COVID-19 pandemic. The team has been busy creating a special platform to connect health care providers with medical suppliers to source items like gloves, face shields and ventilators.

Sometimes it takes a good butt-kicking

Electrical and computer engineering Ph.D. student Austin Hickman knew he wanted to get involved in some sort of business experience. He talked to his advisor and enrolled in a managerial finance course. From there, he took his academic research and springboarded into the Commercialization Fellows program.

Hickman's research is based on developing an aluminum nitride (AIN)-based power transistor with the ability to produce millimeter-wave-frequency signals at a higher power than what is currently used in amplifiers. This is significant for defense radar systems and telecommunications, since the signals can travel farther than what is possible with existing technology. The scale of application of AIN-based amplifiers may be largest in the global race to develop 6G (sixth-generation wireless) networks.

"Once I got the Commercialization Fellowship, from there things really took off," said Hickman. A key component of the fellowship is participation in the National Science Foundation Innovation Corps (I-Corps) program. Cornell is one of three universities that comprise the Upstate New York I-Corps Node.

A trademark of I-Corps is a customer discovery process in which aspiring entrepreneurs interview potential customers to learn how well their product meets demand in their target market. "You kind of get your butt kicked in that program but it helps you catch up really quickly in terms of what matters to businesses," said Hickman.

Hickman's technology has led to the establishment of a company, Soctera, where he is vice president of defense business. Through the course of customer interviews, he discovered that although there was interest from telecommunications companies in his product, they typically prefer to wait for production costs to come down before pursuing new technology. Because of this, the company is first focusing on the defense industry, which prioritizes emerging technologies, but would like to return to the telecommunications space in the future.

Romy Fain, Ph.D. '17, right, founder and CEO of Heat Inverse, a sustainable cooling technologies company, presents with the company's chief revenue officer, Franco Mora, MBA '12, during the 76West Clean Energy Competition, held Aug. 7-8 at Binghamton University.

Soctera recently won a Scale Up and Prototype Award, which it will use to ensure consistent performance across all manufactured products as it scales. The company was also the recipient of a Cornell Technology Acceleration and Maturation award, the funds from which it will put toward licensing a commercial amplifier.

Additional members of the Soctera team are doctoral student Reet Chaudhuri M.S. '16, as well as Huili Grace Xing, the William L. Quackenbush Professor of Electrical and Computer Engineering and Debdeep Jena, David E. Burr Professor of Engineering in Electrical and Computer Engineering and of Materials Science and Engineering.

Post-commencement, a startup is born

Romy Fain, Ph.D. '17, originally thought she would move back to San Francisco after earning her doctorate. While studying electrical and computer engineering at Cornell, she had developed a thin film that produces cooling temperatures without generating any waste heat. Realizing the technology would be a boon for the traditionally energy-intensive cooling and refrigerant industry, Fain started to work on commercializing her research. She remained in Ithaca, where she found that the entrepreneurial resources and incentives in New York's Southern Tier region made it "a fantastic place to start a business."

In the battle against climate change, Fain's tech startup, Heat Inverse, is aiming to revolutionize cooling technologies and reduce greenhouse gas emissions. The company was a semifinalist in the 2019 76West Clean Energy Competition hosted by the New York State Energy Research and Development Authority.

Through the customer discovery process her company underwent as part of an NSF I-Corps short course, she narrowed down her initial market to the refrigerated trucking industry. By applying Heat Inverse's films atop transport trailers, the company reduces carbon dioxide emissions and saves trucking companies 25% in fuel costs for refrigeration in transit.

Heat Inverse is also a member of Rev: Ithaca Startup Works, the city's business incubator that was co-created by Cornell, Ithaca College, and Tompkins-Cortland Community College. There, the company is part of the Prototype to Production cohort, enabling the scale up of its materials to large area format extrusions.

Fain will be participating in I-Corps a second time as part of a cohort of other NSF Phase I Small Business Innovation Research awardees, for a deeper investigation of markets relevant to her business in its current stage. "Cooling is something that can go in so many different directions," she said. "Everyone could be a customer."

Amid the COVID-19 crisis, however, Heat Inverse is focusing on other ways it can help. Fain is assisting the Ithaca community in its effort to cobble together resources (including "a small army of 3D printers") to produce more personal protective equipment for health care workers and is collaborating with other tech companies around the country in an endeavor to quickly manufacture a better N95 mask.

Entrepreneurship Roadmap

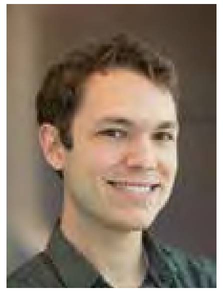
Aspiring business owners may want to begin planning with Cornell Engineering's Entrepreneurship Roadmap, a veritable *Choose Your Own Adventure* strategy. There is no "correct" path for engineers who want to commercialize their research. And it's never too late to start on one's entrepreneurial journey.

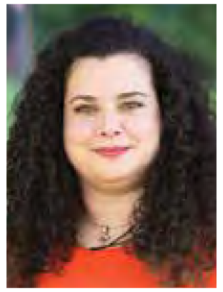
Cornell Engineering's Entrepreneurship Roadmap helps faculty and students identify which programs will best guide their journey to commercialization. Visit entrepreneurship.engineering.cornell.edu to get started.

AWARDS AND HONORS


Jayadev Acharya


Mark Campbell


Damek Davis


Christina Delimitrou


Nate Foster


Patrick Fulton

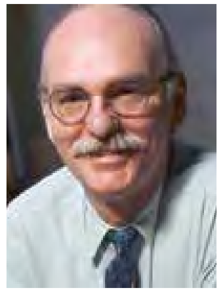

Debdeep Jena


Huili Grace Xing


Thomas Ristenpart

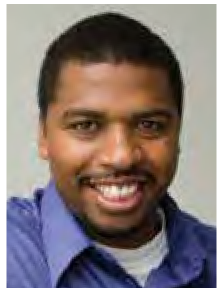

Hadas Ritz


Gennady Shvets


Harry Stewart


Zhiting Tian


Jane Wang


Hakim Weatherspoon


William White


Fengqi You

SCHOOL AND DEPARTMENT ABBREVIATIONS

AEP – Applied and Engineering Physics
BEE – Biological and Environmental Engineering
BME – Biomedical Engineering
CBE – Chemical and Biomolecular Engineering
CEE – Civil and Environmental Engineering
CS – Computer Science
EAS – Earth and Atmospheric Sciences
ECE – Electrical and Computer Engineering
MSE – Materials Science and Engineering
MAE – Mechanical and Aerospace Engineering
ORIE – Operations Research and Information Engineering

Jayadev Acharya, assistant professor (ECE), received the Best Paper Award at the 31st International Conference on Algorithmic Learning Theory (ALT 2020), held in San Diego, California, in February. The paper was co-authored by Ananda Theertha Suresh, a research scientist at Google. Titled "Optimal multiclass overfitting by sequence reconstruction from Hamming queries," it provides a resolution to the problem of overfitting in machine learning.

Mark Campbell, the John A. Mellowes '60 Professor (MAE), was elected as an AIAA Fellow by the American Institute of Aeronautics and Astronautics for his "notable and valuable contributions to the arts, sciences or technology"

Damek Davis, assistant professor (ORIE), has been selected as a 2020 Alfred P. Sloan Research Fellow in Computer Science, which aims to stimulate fundamental research by early-career scientists recognized for their distinguished performance and unique potential to make substantial contributions to their field. His selection highlights his work on the mathematics of data science, particularly in the interplay of optimization, signal processing, statistics and machine learning.

Christina Delimitrou, assistant professor and the John and Norma Balen Sesquicentennial Faculty Fellow (ECE), received a Google Faculty Research Award in the category of Systems. The awards recognize and support faculty pursuing cutting-edge technical research in computer science, engineering and related fields. She has also been selected as a 2020 Alfred P. Sloan Research Fellow in Computer Science for her work to apply data-driven machine learning approaches to large-scale systems problems. And she has received a Microsoft Research Faculty Fellowship for work focused on leveraging machine learning to improve the performance predictability, resource efficiency and security of large-scale data centers.

Nate Foster, associate professor (CS), received a Google Faculty Research Award in the category of Networking. The awards recognize and support faculty pursuing cutting-edge technical research in computer science, engineering and related fields.

Patrick Fulton, assistant professor and Croll Sesquicentennial Fellow (EAS), was elected to the RBR2020 Cohort by oceanographic instrument manufacturer, RBR. The cohort brings together scientists from around the world to enable innovative ocean measurements through workshops and programs.

Debdeep Jena, the David E. Burr Professor of Engineering (ECE, MSE), and Huili Grace Xing, the William L. Quackenbush Professor (ECE, MSE), received the cover of the journal *Physica Status Solidi (a)* for their study "Molecular Beam Epitaxy of Transition Metal Nitrides for Superconducting Device Applications."

Thomas Ristenpart, associate professor (CS, Cornell Tech), received a Google Faculty Research Award in the category of Privacy. The awards recognize and support faculty pursuing cutting-edge technical research in computer science, engineering and related fields.

Hadas Ritz, senior lecturer (MAE), won the 2020 American Society of Engineering Education (ASEE) St. Lawrence section Outstanding Teaching Award. Ritz has an exceptional record in student, project team and faculty advising, curriculum development, journal publications, and conference participation. She currently serves as the academic advisor for 22 undergraduate students.

Gennady Shvets, professor (AEP), was elected as an SPIE Fellow by the International Society for Optics and Photonics for his "achievements in optical metamaterials and nanophotonics and their applications, especially to life sciences."

Harry Stewart, associate professor (CEE), was approved for emeritus status.

Zhiting Tian, professor (MAE), was elected as a Fellow of the American Society of Mechanical Engineers for her contributions in the area of nanoscale thermal transport and energy conversion with a particular focus on phonon transport.

Jane Wang, professor (MAE), has been awarded a Simons Fellowship in Theoretical Physics and Mathematics by the Simons Foundation. The program extends academic leaves from one term to a full year, enabling recipients to focus solely on research for the long periods often necessary for significant advances. Wang's research centers on the physics of living organisms, with a special focus on the mechanistic explanations of insect flight.

Hakim Weatherspoon, associate professor (CS), won a Microsoft Investigator Fellowship to explore incorporating Microsoft's FarmBeats and Azure platforms into the research design of a 'Software-Defined Farm,' an end-to-end internet-of-things platform for agriculture that enables seamless data collection from various sensors, cameras and drones, along with data analytics and potential actuation.

William White, professor (EAS), was approved for emeritus status.

Fengqi You, the Roxanne E. and Michael J. Zak Professor in Energy Systems Engineering (CBE), has been selected to receive the 2020 Curtis W. McGraw Research Award by the American Society for Engineering Education, recognizing significant achievements of engineering researchers and educators with outstanding research abilities, trajectory, and potential. He also received the 2020 O. Hugo Schuck Award from the American Automatic Control Council in recognition of his work on a novel hybrid framework combining machine learning and mathematical programming methods for data-driven robust optimization of electric power systems control under renewable energy generation uncertainty.

Awards and honors from Feb. 13 to May 1, 2020.
Honors received outside of this timeframe appear online.

ALUMNI PROFILE

LINDA SCHADLER '85

INSPIRED BY THOSE BEFORE HER, LINDA SCHADLER '85 IS SHAPING THE NEXT GENERATION OF ENGINEERS

By Syl Kacapyr

She can trace her Cornell roots back more than 100 years, but Linda Schadler '85 is focused on the future, sowing engineers as dean of the University of Vermont's College of Engineering and Mathematical Sciences, and as a member of the Cornell Engineering College Council.

Long before she was a leader in engineering education, Schadler felt a deep connection to both Cornell University and science. Her Great Aunt Julianne Vaux spent time at the Ivy League university in the late 1800s, either as a student or a librarian, according to her family history. Her grandfather received his doctorate in plant pathology in the 1920s and started his career at what is now Cornell AgriTech. Her parents, uncle, cousin, and other extended family members also attended Cornell, so it's fair to say Schadler's blood is of the Big Red variety.

Linda Schadler '85

"My grandparents lived near Yale, so we would go to the Yale-Cornell football game and I loved the Big Red Band," said Schadler. "My father had been in the Big Red Band. I think that I was pre-dispositioned to like Cornell."

It was ultimately her love of science that drew her to Cornell. Her father an engineer and her mother a biology professor, Schadler considered studying biology and chemical engineering before growing fascinated with materials science.

"It was a mixture of the science and engineering that I was looking for, and there was a fantastic professor who made us all feel welcome," said Schadler, who also had the opportunity to join a research lab as an undergraduate at Cornell. "The department was a very personable place where the faculty really cared about giving the students opportunities."

Linda Schadler '85 at the University of Vermont's installation of President Suresh Garimella in fall 2019. Photo by Sally McKay.

From student to educator

Schadler remained busy outside of the classroom as well, playing basketball for two years, joining the Tri Delta sorority, and, of course, playing the clarinet and the bells as a member of the Big Red Band.

Schadler admits her extracurricular activities and busy social life prevented her from being what she describes as a model student, but after presenting on a materials science topic as part of a senior class assignment, she began to discover a passion for education.

"I realized during that year I wanted a job where I could combine interacting with students and research, which obviously leads you straight to higher education," said Schadler, who also spent a year teaching leadership as part of a Tri Delta field support program.

From there it was off to graduate school at the University of Pennsylvania before securing her first teaching position at Drexel University. Schadler would then spend 22 years at Rensselaer Polytechnic Institute, where her research lab produced several patents related to polymer nanocomposites, and she was named one of the top 100 Materials Scientists in the world by *Times Higher Education*. She also served as the associate dean of academic affairs in the School of Engineering, and vice provost and dean of undergraduate education for the university. In 2018, she was appointed dean at the University of Vermont.

Through it all, Schadler has received accolades for both her research and her role in creating educational opportunities for students. While at Rensselaer Polytechnic Institute, she won several teaching awards, expanded student services as an associate dean, and was one of the executive producers of Molecularium—a planetarium show and cinema experience translated into several languages for K-12 students.

Paying it forward

Even while leading the University of Vermont's College of Engineering and Mathematical Sciences, Schadler is helping to steer the direction of Cornell Engineering.

After winning the 2017 Distinguished Alumni Award from Cornell's Department of Materials Science and Engineering, Schadler was invited to join the department's advisory council and subsequently the Engineering College Council, which advises college administration on all aspects of long-range planning and development.

Schadler has also been involved with the President's Council for Cornell Women, has made contributions to the Big Red Band, and has established the Harvey '53 and Margaret '53 Schadler McMullen Scholarship in her parents' honor. The scholarship provides financial aid to students, including those who are the first in their immediate family to attend college.

"Both my father and my uncle were funded on McMullen Scholarships and could not have gone to college without them," said Schadler, "and so I'm happy to contribute in a small way to that overall funding pot to make sure that other first-generation students can have a Cornell education and the multigenerational successes that result from it."

Building toward the future

At the University of Vermont, Schadler is focused on creating a learning environment that is "a blend between the fundamentals that we know will support the students throughout their career, and the practical teamwork and communication skills" that come from a project-based course.

"I also think that unless we engage diversity fully—and I don't mean just gender balance—we are doing a disservice to society," said Schadler, adding that ethnicity and socioeconomics should be included in diversity initiatives. "So those are two big things that I'm focused on here."

Schadler's advice to students is to make the most of the college experience by getting to know the faculty.

"There are so many opportunities and the faculty are thrilled when you want to interact with them. Do research, have lunch, go to office hours," suggests Schadler, "because there's so much to be gained that you don't get from just sitting in a lecture."

Schadler also encourages students to get as much out-of-the-classroom experience as they can now, because those activities will serve them well in the future.

"Join a design team, do undergraduate research, get an internship. Whatever opportunities you can find that let you practice your trade before you graduate," said Schadler.

CornellEngineering

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LANCE COLLINS' LEGACY

10 YEARS!

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