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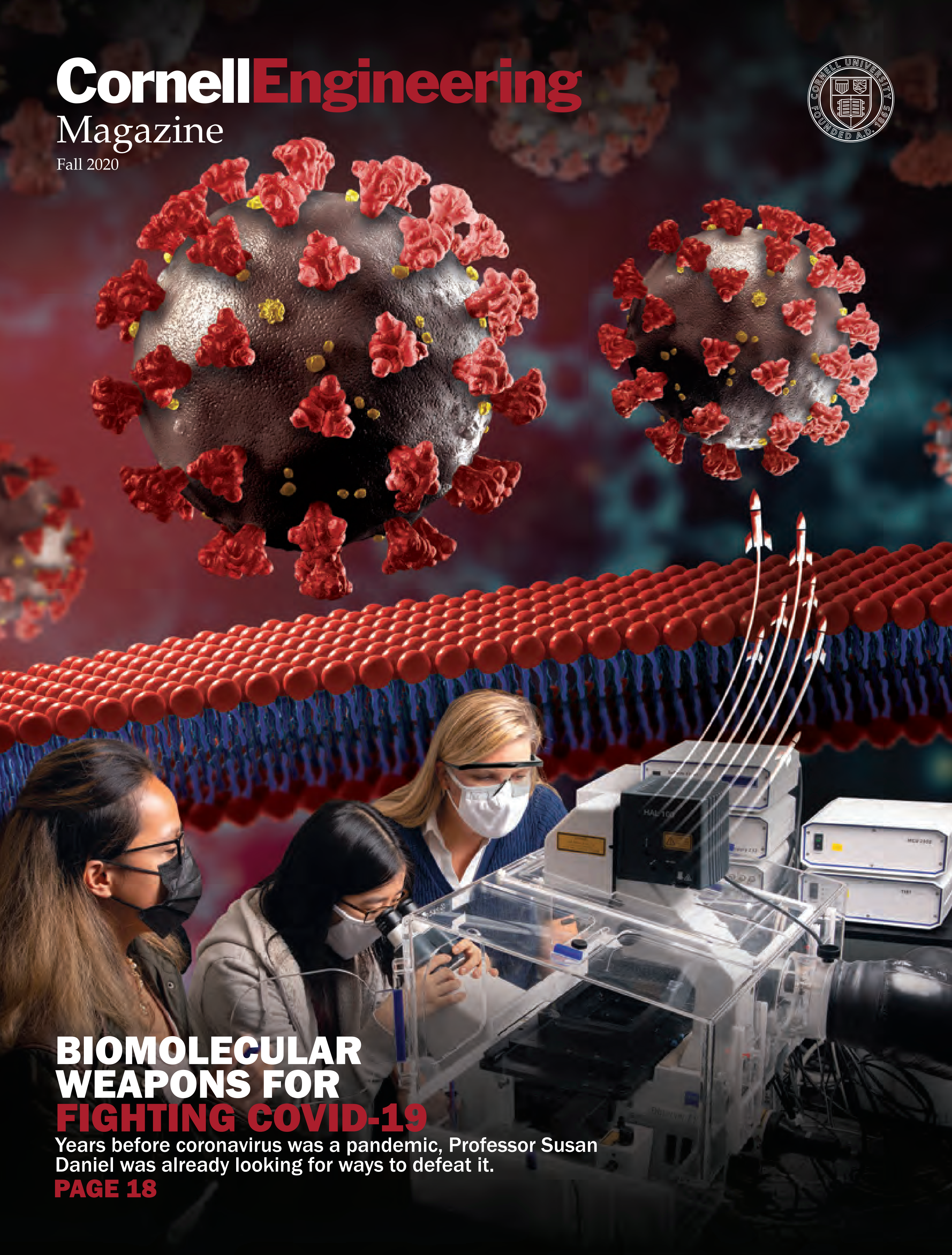
Fall 2020



BIOMOLECULAR WEAPONS FOR FIGHTING COVID-19

Years before coronavirus was a pandemic, Professor Susan Daniel was already looking for ways to defeat it.

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The Cornell COVID-19 Testing Laboratory at the College of Veterinary Medicine.

EPIDEMIOLOGICAL MODEL INFORMS CORNELL'S FALL SEMESTER

Developed by Cornell engineers, the epidemiological model used by university leadership to make decisions about reactivating and operating campus amid the coronavirus pandemic is receiving national attention as Cornell continues to limit the virus's spread.

The modeling has been led by Peter Frazier, associate professor in Operations Research and Information Engineering, who determined before the fall semester began that two to 10 times more people could be infected with COVID-19 during a semester conducted entirely online, with significantly higher numbers becoming seriously ill.

That's because surveys indicated a large percentage of Cornell students planned to return to off-campus housing in Ithaca even if all instruction was conducted remotely. In that scenario, Cornell would have had no authority to mandate testing or restrict students' behavior. Now, students living on-or-off campus are subject to follow public health guidelines and a requirement to comply with a testing program, also developed by Frazier.

Undergraduate students are required to be tested twice weekly, while graduate students, faculty and staff are tested once per week, all with the goal of identifying infected individuals and quickly isolating them. In order to test 5,000-7,000 Cornellians daily, a 'pooled testing' approach is used, in which samples of COVID-19 tests are grouped together and analyzed collectively. Using this approach, 4,900 samples can be processed using just 140 polymerase chain reaction tests performed at the College of Veterinary Medicine.

To proactively identify cases across campus, Cornell is testing everyone in the social circles of people infected with the virus, in addition to those who meet the definition of close contacts. The aggressive approach, known as adaptive testing, has already identified cases in a recently discovered cluster that would have otherwise gone undetected.

The modeling and testing efforts have received national attention from publications such as the *Wall Street Journal* and the *Washington Post*. Frazier has been quoted in media outlets such as *Bloomberg News* and *Inside Higher Ed*, and was featured on ABC's "Good Morning America."

Operations Research and Information Engineering faculty members Shane Henderson and David Shmoys, along with several students, played supporting roles in developing the modeling.

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LIQUID CRYSTALS GIVE RED BLOOD CELLS MECHANICAL SQUEEZE

In some diseases, such as sickle cell anemia and malaria, the elasticity and mechanical properties of red blood cells are compromised. Scientists hoping to understand these diseases can take heart: Researchers led by Nicholas Abbott, a Tisch University Professor in the Smith School of Chemical and Biomolecular Engineering, created a way of using synthetic liquid crystals to squeeze red blood cells and gain new insight into individual cells' mechanical properties. The process also illuminates minuscule differences between cells within a large population as each cell reacts to the same strain or force, revealing just how diverse the cells are.

Liquid crystals flow like a liquid but have the internal organization and long-range atomic order of a solid crystal. As synthetic materials, they have the potential to provide new functions when interacting with complex biological systems, like mammalian cells.

The research team found that, surprisingly, the red blood cells folded in different ways and displayed varying degrees of stiffness. Although the cells look alike before being placed into the liquid crystal, the liquid crystal reveals them to be highly variable in their mechanical properties.

"There's a lot of heterogeneity within the population," Abbott said. "If you want to understand the origins of disease, and you want to understand the effects of biological agents on cells, you have to consider that not every cell is the same as the one next to it."

An imaging process was used to analyze thousands of red blood cells within minutes, collecting data on the overall population and individual cells simultaneously. The method can also be applied to other cell types, and to differentiate between healthy and diseased cells.

ALGORITHM BOOSTS EFFICIENCY, NUTRITION FOR FOOD BANK OPS

Cornell systems engineers examined data from a busy New York state food bank and, using a new algorithm, found ways to better distribute and allocate food, and elevate nutrition among its patrons in the process.

Faisal Alkaabneh, Ph.D. '20, Cornell's first doctoral graduate in systems engineering, and his adviser, Oliver Gao, professor of civil and environmental engineering, reviewed data of the Food Bank of the Southern Tier, which serves six counties in upstate New York. In 2019, the food bank distributed 10.9 million meals to about 21,700 people each week. Nearly 19% of its patrons are seniors and about 41% are children, according to the group's data.

The algorithm Gao and his team used to determine how to allocate several food categories efficiently, based upon pantry requests, demonstrated a 7.73% improvement in efficiency from 2018 to 2019, compared to standard food bank allocation practices. Their calculations also showed a 3% improvement in nutrition using a wider variety of food, Alkaabneh said.

Most food banks face multi-dimensional complexities, as they coordinate several food categories to distribute finite resources such as canned goods, fresh produce, meats and dairy.

"One pound of beef is not the same as a pound of vegetables or a pound of bread," Alkaabneh said. "It's so challenging from a mathematical perspective. When you have more than one similar dimension, the problem becomes exponentially more difficult to solve."

Said Gao: "We hope our research is used as a baseline model for food banks improving practices and boosting nutrition and policies to help people at risk for hunger."

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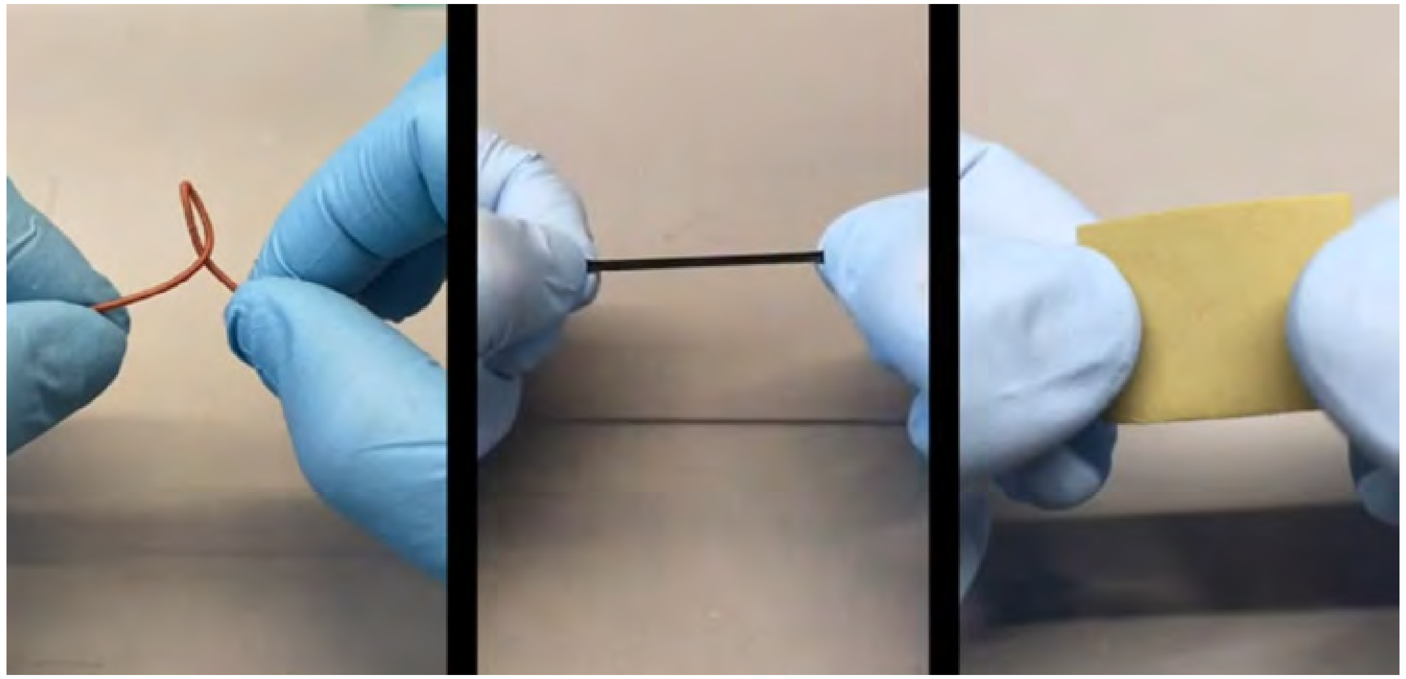
METAL-ION BREAKTHROUGH LEADS TO NEW BIOMATERIALS



The elasticity of a biodegradable, metal-ion elastomer is demonstrated. The first-of-its-kind material, developed by Cornell engineers, can be used to repair skin, blood vessels and other soft tissue.

Designing elastomers—a type of polymer with rubber-like properties—is a laborious process that yields a product with limited versatility. But Cornell engineers have developed a new framework that makes elastomer design a modular process, allowing for the mixing and matching of different metals with a single polymer.

The framework was conceived when researchers from Cornell's Biofoundry Lab sought to create an elastic vascular graft that could help repair heart tissue using copper. Yadong Wang, the McAdam Family Foundation Professor of Cardiac Assist Technology in the Meinig School of Biomedical Engineering, and postdoctoral associate Ying Chen wanted to incorporate copper into their graft because of its role in inducing angiogenesis—the process by which new blood vessels grow from existing ones.

Chen's key breakthrough was crosslinking her polymer with copper ions using chelating ligands—molecules that tightly bind a metal ion using two or more bonds. While chelation bonds are considered to be of moderate strength in chemistry, elastomers have many crosslinking molecules, so a multitude of chelating ligands can work together to form a strong molecule.

And because one ligand can bind multiple metal ions, it can yield a wide range of mechanical properties—such as stiffness and toughness—as well as biomedical properties. For example, a polymer's copper ions could be replaced with zinc, or a combination of copper and zinc could be used—a tandem that is present in an important enzyme for fighting human aging.

As proof of concept, Chen engineered six unique elastomers using one polymer and six different metals, and then made a seventh elastomer using a calcium-magnesium mix. It was the first time anyone had demonstrated a biodegradable metal-ion elastomer—let alone seven of them.

"When Ying showed me what she had done, I said, 'This material is amazing,'" Wang said. "There's so much you can do with just this one simple design. Using many different types of metal ions, one polymer can turn into eight, nine, 10 different elastomers."

Now that the framework has published in the journal *Advanced Materials*, Chen is focusing her research on the copper elastomer graft and its ability to repair blood vessels and heart tissue. In the meantime, she hopes other engineers will use her platform to create new materials for improving soft tissue reconstruction and regeneration.

TECHNIQUE COULD ENABLE BETTER CUSTOM CERAMIC FABRICATION

Ceramic structures filled with tiny macroscopic pores play an important role in industrial and biomedical products, but they're also notoriously difficult to fabricate. A Cornell researcher may have an answer, as a manufacturing technique she's developing has introduced a new level of precision to porous ceramic materials, opening a new realm of possibilities for their application.

The technique—created by Sadaf Sobhani, assistant professor of mechanical and aerospace engineering, in the Sibley School of Mechanical and Aerospace Engineering—uses a combination of computational modeling, porous structure design and 3D printing to precisely customize the porous network.

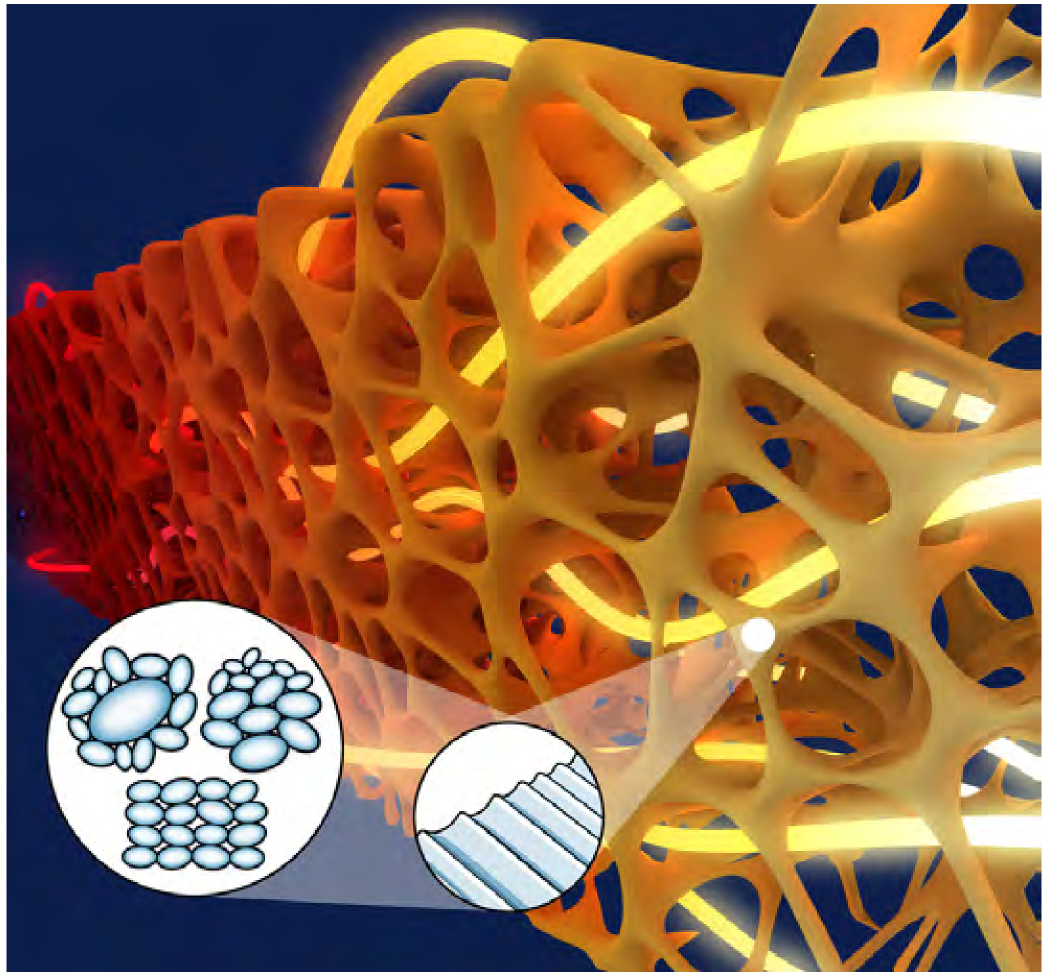
Digital light processing lithography is a type of 3D printing that, unlike other ceramic 3D-printing techniques that deposit material across a build platform, projects light patterns onto layers of a photocurable resin. The resin then solidifies where it has been exposed to light, retaining the pattern projected onto each layer.

Sobhani uses lithography with a ceramic-loaded resin. Once the resin has been treated by blue light, the ceramic particles remain suspended where the resin has solidified. The printed object is then placed into a series of furnaces that burn off the resin and cure the remaining ceramic.

"The technique enables you to make things that you just couldn't make with a mold or other traditional ceramic manufacturing methods," said Sobhani.

As a proof of concept, Sobhani fabricated two samples of alumina porous ceramics, with different pore geometries. She and her colleagues then studied the samples in a combustion experiment and assessed the flame stability inside the porous structure. The samples, both made from the same resin-ceramic mix, produced dramatically different results due to their distinct porous structure designs.

Sobhani's future research will also focus on identifying new applications that can take full advantage of the fabrication technology. She has acquired a high-density ceramic lithography printer for her lab—the first on campus—and said she is looking forward to collaborating with researchers who have innovative ideas for everything from energy and thermal-management systems to biomedical applications.



An artist's rendering of fluid strategically guided through a ceramic structure's pores. Using a manufacturing technique researched by Cornell's Sadaf Sobhani, tailored porous structures hold new opportunities for applications in thermofluidic systems.

ENGINEERED BACTERIA CHURN OUT CANCER BIOMARKERS

Pity the glycan. These complex sugar molecules are attached to 80% of the proteins in the human body, making them an essential ingredient of life. But this process, known as glycosylation, has been somewhat overshadowed by flashier biomolecular processes such as transcription and translation.

"Glycosylation is absolutely essential for life on this planet. And yet, we still know relatively little about it," said Matthew DeLisa, the William L. Lewis Professor of Engineering in the Smith School of Chemical and Biomolecular Engineering. "We need new tools to advance the field forward."

DeLisa's lab has created these very tools by commandeering simple, single-celled microorganisms—namely E. coli bacteria—and engineering them to explore the complex process of glycosylation and the functional role that protein-linked glycans play in health and disease.

Previously, DeLisa's team used a similar cell glyco-engineering approach to produce one of the most common types of glycoproteins—those with glycan structures linked to the amino acid asparagine, or N-linked. Now the researchers have turned their attention to another abundant glycoprotein, namely O-linked, in which glycans are attached to the oxygen atom of serine or threonine amino acids of a protein.

The O-linked glycans are more structurally diverse than their N-linked cousins, and they have important implications in the development of new therapeutic treatments for diseases such as breast cancer.

When a cell turns cancerous, it expresses certain biomarkers, including abnormally glycosylated surface proteins, that indicate the presence of cancer. DeLisa's group equipped E. coli with the machinery to produce such proteins, including one that closely resembled a prominent cancer biomarker, mucin 1 (MUC1).

"The glycosylated version of MUC1 is one of the highest-priority target antigens for cancer therapy. It's been very challenging to develop therapies against this target," said DeLisa. "But by having a biosynthetic tool like the one we've created that is capable of replicating the MUC1 structure, we're hopeful that this could provide glycoprotein reagents that could be leveraged to discover antibodies or employed directly as immunotherapies, all of which could help in the fight against certain types of cancer."

Both O-linked and N-linked glycans have also been discovered in one of the surface proteins of the SARS-CoV-2 virus, which causes COVID-19. DeLisa is hopeful his group's method of bacterial cell glyco-engineering will open the door for creating glycosylated versions of this S-protein that could lead to therapeutic antibodies against the coronavirus, or the development of a subunit vaccine.

RESEARCHERS CREATE NANOCLUSTERS THAT MIMIC BIOMOLECULES

Biological systems come in all shapes, sizes and structures. Some of these structures, such as those found in DNA, RNA and proteins, are formed through complex molecular interactions that are not easily duplicated by inorganic materials.

A research team led by Richard Robinson, associate professor of materials science and engineering, discovered a way to bind and stack nanoscale clusters of copper molecules that can self-assemble and mimic these complex biosystem structures at different length scales. The clusters provide a platform for developing new catalytic properties that extend beyond what traditional materials can offer.

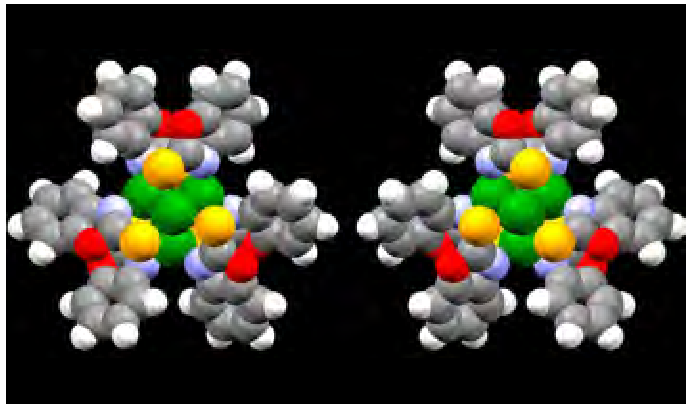
"Just to be able to create inorganic clusters and precisely locate the atomic positions is a relatively new area because inorganic clusters don't easily assemble into organized crystals like organic molecules do. When we did get these to assemble, what we found was this strange, hierarchical organization that was completely unexpected," said Robinson. "This work could provide a fundamental understanding of how biosystems like proteins assemble themselves to create secondary structural organization, and it gives us an opportunity to start creating something that could imitate a natural living system."

The nanoclusters have three levels of organization with an interlocking, chiral design. Two copper caps are fitted with special binding molecules, known as ligands, that are angled like propeller blades, with one set tilting clockwise and the other counterclockwise (or left-handed and right-handed), all connecting to a core. The copper clusters are bridged with sulfur, and have a mixed oxidation state, which makes them more active in chemical reactions.

The clusters' flexible, adaptive nature makes them potential candidates for metabolic and enzymatic processes, as well as accelerating chemical reactions through catalysis. For example, they may be able to reduce carbon dioxide to alcohols and hydrocarbons.

"We'd like to develop catalytic materials with features that mimic natural enzymes," said Jin Suntivich, associate professor of materials science and engineering. "Because our cluster has only 13 copper atoms, the tunability is more controllable than a nanoparticle with hundreds or thousands of atoms. With this higher level of control, we can think about building the clusters in a systematic manner. This can help reveal how each atom participates in reactions and how to rationally design a better one. We see it as a bridge to enzymes, where the atoms are assembled in a precise way to enable highly selective catalysis."

Said Robinson: "Material scientists and chemical scientists have been trying to mimic these complex hierarchical structures in the lab, and we think we finally have something that nobody else has seen, and that we can build off of for future research."



The nanocluster core, shown here, connects to two copper caps fitted with special binding molecules, known as ligands, that are angled like propeller blades.

SMILE: ATOMIC IMAGING FINDS ROOT OF TOOTH DECAY

A collaboration between researchers from Cornell, Northwestern University and University of Virginia combined complementary imaging techniques to explore the atomic structure of human enamel, exposing tiny chemical flaws in the fundamental building blocks of our teeth. The findings could help scientists prevent or possibly reverse tooth decay.

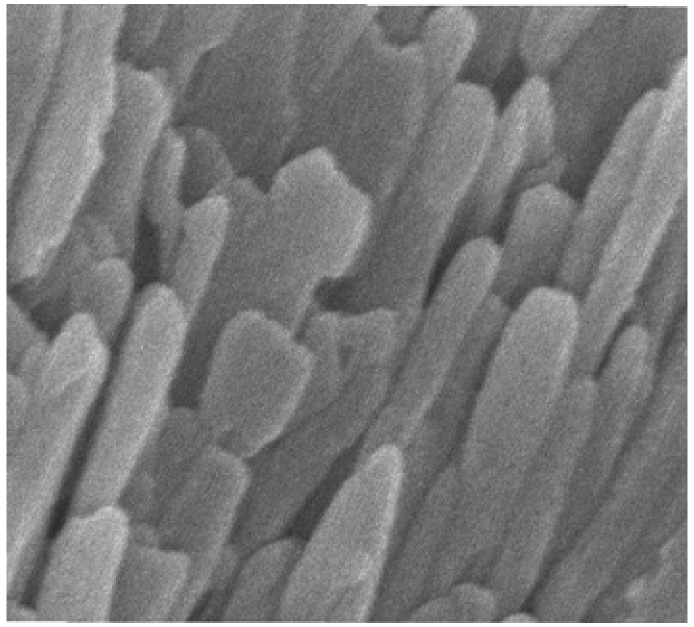
"Enamel is mechanically a very, very strong material, but when you put it in the electron microscope, it's very sensitive to the electron beam," said Lena Kourkoutis, associate professor in applied and engineering physics. "So compared to the crystalline materials that you find in electronics, for example, you can only put a fraction of the number of electrons into an enamel crystal. Normally, pushing down to the atomic scale means you have to put more electrons into the material. But if it damages the material before you get the information out, then you're lost."

Cornell researchers at PARADIM (Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials), a National Science Foundation-supported user facility, have advanced a form of low-temperature electron microscopy that can image the atomic structure of radiation-sensitive samples. The technique can also safely map a sample's chemical composition by measuring how much energy is lost when the electrons interact with the atoms.

By combining their complementary techniques, the researchers were able to image an enamel crystallite and its hydroxylapatite atomic lattice. But all was not crystal clear: The lattice contained dark distortions—caused by two nanometric layers with magnesium, as well as sodium, fluoride and carbonate ion impurities near the core of the crystal.

Additional modeling confirmed the irregularities are a source of strain in the crystallite. Paradoxically, these irregularities and the enamel's core-shell architecture may also play a role in reinforcing the enamel, making it more resilient.

The researchers say the findings could lead to new treatments for strengthening enamel and combating cavities.



Enamel is made up of tightly bunched, oblong crystals that are about 1,000 times smaller in width than a human hair.

$7.2M GRANT FUNDS EXPLORATORY RESEARCH INTO EARTH SOURCE HEAT

Cornell has secured a U.S. Department of Energy grant, expected to total about $7.2 million, which will fund exploratory research—in the form of a 2-mile-deep borehole—to help verify the feasibility of using a novel geothermal energy system to heat its campus buildings.

Earth Source Heat (ESH) has been part of Cornell's Climate Action Plan since 2009 as a potential means of moving toward carbon neutrality on campus by eliminating fossil fuels for campus heating. ESH is an ambitious proposal to heat most buildings on the Ithaca campus using a deep geothermal system that would draw thermal energy stored deep within the Earth.

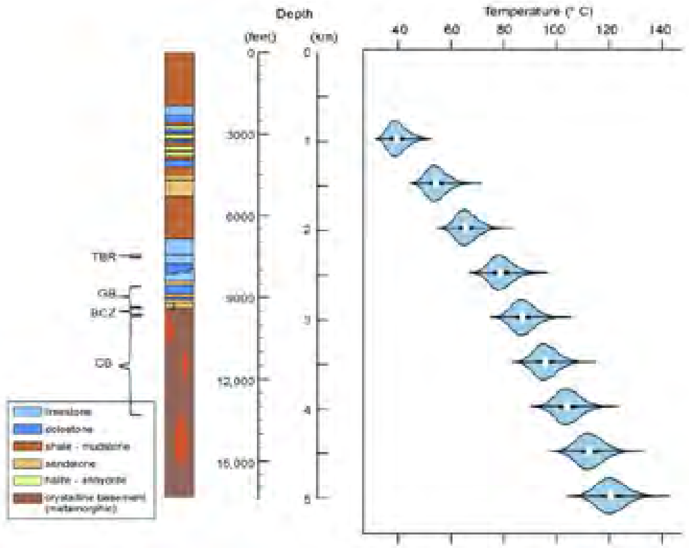
The project would help eliminate Cornell's carbon footprint while demonstrating a geothermal technology that may be applicable in much of the northern United States.

The research borehole, to be 4 inches in diameter in its deepest section and located on Cornell-owned property, will complete the testing necessary to verify geological conditions deep under campus, according to Jefferson Tester, the David Croll Sesquicentennial Fellow and Professor in the Smith School of Chemical and Biomolecular Engineering, chief ESH scientist and principal investigator for the research borehole.

"The DOE's support puts us on path to demonstrate geothermal's potential as a major, sustainable source of clean, decarbonized energy that the region and much of the country urgently need in order to transform the way we heat our communities and cities," Tester said. "The Earth Source Heat project will also demonstrate the feasibility of seasonal thermal storage to increase the performance and lifetime of geothermal reservoirs."

The project will be subject to an environmental review and a permitting process.

Its start date is to be determined, but Tester and other project leaders estimate that it will take up to a year to establish detailed drilling plans and permitting. The actual drilling and sample extraction will take about three months; laboratory and computational analyses of materials and data will take another 18 months.



Sedimentary rock layers and corresponding temperatures Cornell researchers expect to find within a two-mile-deep exploratory borehole, to be drilled on Cornell-owned property. Researchers hope to validate optimal conditions for the proposed Earth Source Heat geothermal system within the Trenton-Balck River (TBR), Galway-Potsdam (GP), Basement Contact Zone (BCZ) or deep Crystalline Basement (CB) layers.

PEROVSKITE MINERAL SUPPORTS SOLAR-ENERGY SUSTAINABILITY

Tandem solar cells that combine different light-absorbing materials are a relatively new and promising development for cheaply and efficiently converting light into electricity, and now a Cornell study finds that these tandems—particularly tandems made from a class of materials known as perovskites—can outperform state-of-the-art silicon cells when it comes to overall environmental impact.

In addition to offering a faster return on the initial energy investment than silicon-based solar panels, all-perovskite solar cells mitigate climate change because they consume less energy in the manufacturing process, according to research conducted by Fengqi You, the Roxanne E. and Michael J. Zak Professor in Energy Systems Engineering in the Smith School of Chemical and Biomolecular Engineering.

Producing perovskite-only tandem solar cells leaves a smaller carbon footprint than silicon or perovskite-silicon tandem solar cells. You described making silicon-only cells for solar panels as an energy-intensive process, requiring extreme pressure and heat, and leaving a large of carbon footprint.

Perovskite need less processing, and much less of the heat or pressure, during the fabrication of solar panels, You said.

Silicon photovoltaics require an expensive initial energy outlay, and the best ones takes about 18 months to get a return on that investment. A solar cell wafer with an all-perovskite tandem configuration, according to the researchers, offers an energy payback on the investment in just four months. "That's a reduction by a factor of 4.5, and that's very substantial," You said.

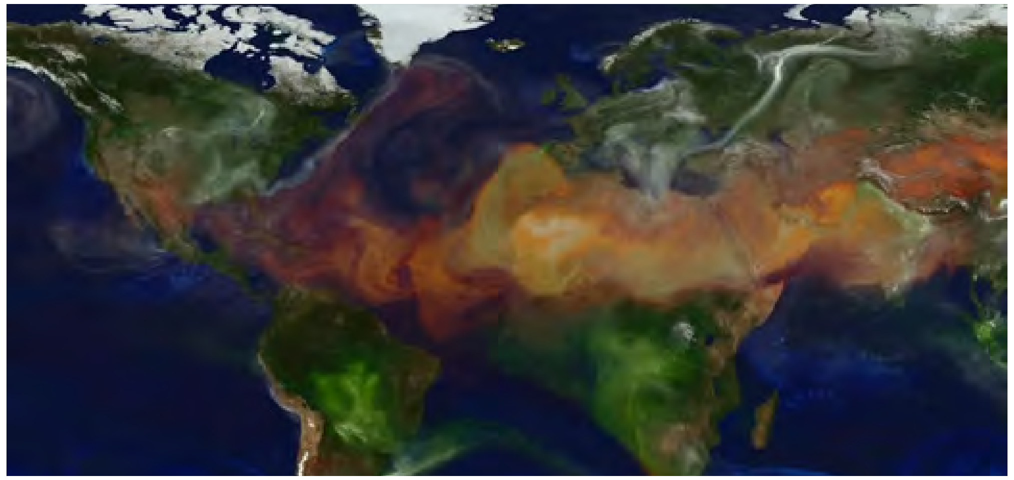
But solar panels don't last forever. After decades of service, silicon solar panels become less efficient and must be retired. And as in the manufacturing phase, breaking down silicon panels for recycling is energy intensive. Perovskite cells can be recycled more easily.

Adopting materials and processing steps to make perovskite solar cell manufacturing scalable is also critical to developing sustainable tandem solar cells, You said.

"Perovskite cells are promising, with a great potential to become cheaper, more energy-efficient, scalable and longer lasting," You said. "Solar energy's future needs to be sustainable."

A solar cell made with perovskite, shown here, show promise as an energy-efficient, scalable and longer-lasting way to create solar panels.

SCIENTISTS TRACK PLANT DISEASES RIDING ACROSS GLOBE WITH DUST



NASA remote sensing satellites will help Cornell University faculty members Katie Gold, assistant professor of plant pathology, and Natalie Mahowald, professor of Earth and atmospheric sciences, study the effects of soilborne plant pathogens which can travel in dust clouds from Africa to the Western Hemisphere.

At the end of June, the largest dust cloud ever observed by satellites crossed the Atlantic from the Sahara in North Africa to the Americas. Undoubtedly, that cloud carried plant pathogens that hitched rides with dust particles.

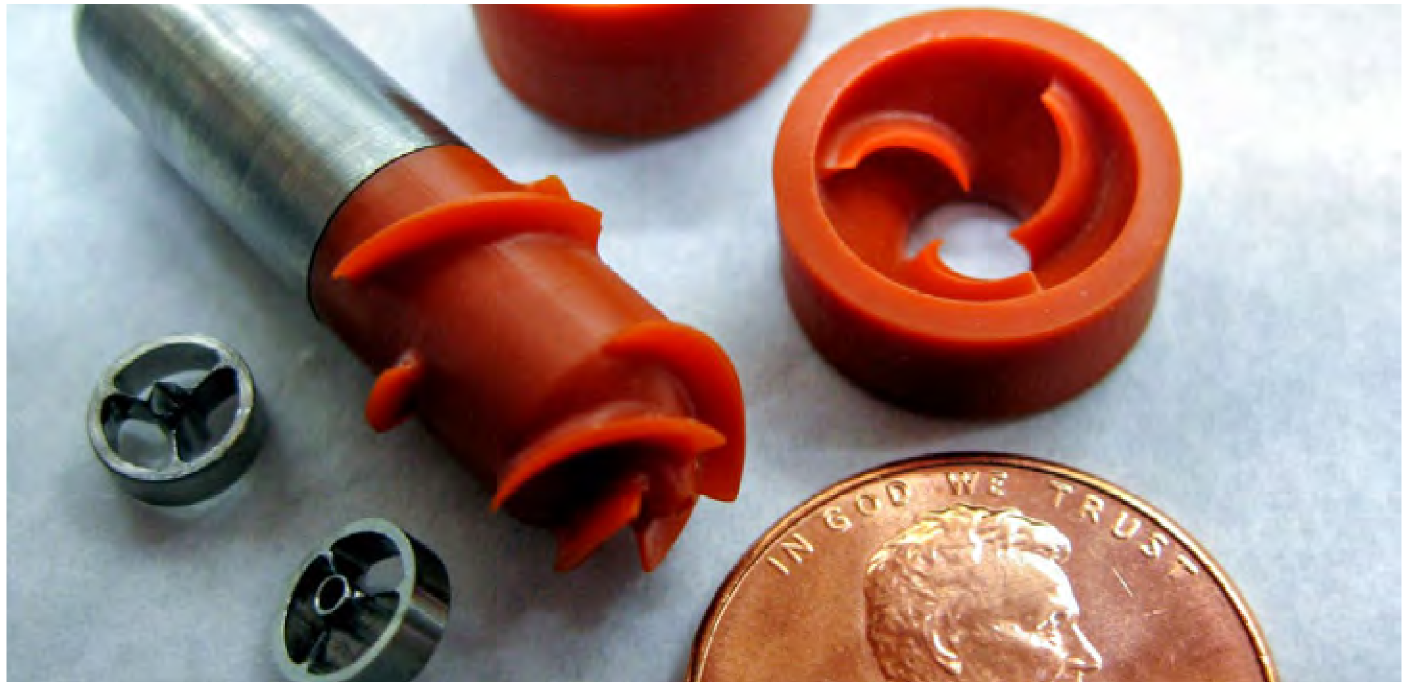
A multidisciplinary, Cornell-led team of scientists has been selected for a $750,000 NASA grant to combine their expertise in remote sensing, climate and earth system computer modeling, plant pathology and genomics to better understand how plant pathogens that travel the globe with dust particles might put crops at risk, especially in places where people struggle to eat.

It's well documented that plant pathogens in the soil become airborne; infectious spores have been found in dust samples that travel on intercontinental winds. The team will use Earth-observing satellites to identify areas of potential disease and track plumes of dust that traverse the globe. They will also use earth system modeling to predict how regions will change over time and how that may influence disease dispersal with dust.

NASA's Release of Research Opportunities in Space and Earth Science Interdisciplinary Science grant is for three years, which will allow the team to lay the foundation for a global surveillance system to assess risk and track and potentially prevent the global spread of plant diseases.

If the origins and landing spots of specific pathogens can be better predicted, farmers can be advised on how to avoid practices that would increase its spread, such as those that kick up dust from farm fields, and perhaps grow less susceptible crops where such dust falls.

"It's just a fascinating combination of cross-disciplinary work that's going to allow us to address things that no one has been able to address before," said co-investigator Natalie Mahowald, the Irving Porter Church Professor in Engineering in Earth and Atmospheric Sciences and an expert in atmospheric modeling.



Various components of the PediaFlow infant heart-assist device.

INFANT HEART-ASSIST DEVICE GETS NEW LIFE WITH $4.7M GRANT

After being defunded by a company with rights to its intellectual property, development of a pediatric heart-assist device has been revived at Cornell with the help of a $4.7 million grant from the U.S. Department of Defense.

Development and preclinical validation of the PediaFlow heart-assist system will be led by James Antaki, the Susan K. McAdam Professor of Heart Assist Technology at Cornell's Meinig School of Biomedical Engineering.

PediaFlow is an alternative to a heart transplant for infants with congenital heart failure. The device is based on the world's smallest magnetically levitated rotodynamic blood pump, which was invented by Antaki and colleagues. Implantation of the device—about the size of a AA battery—can potentially rehabilitate an infant's heart by stimulating recovery of the muscle.

The system also includes a battery-operated external control unit and peripherals for diagnostics and maintenance.

Antaki began work on the device in 2002, when the National Institutes of Health (NIH) issued a call for proposals for pediatric circulatory support because none existed at the time. By 2013, Antaki had found a commercial partner for PediaFlow, as required by the NIH, and was ready to move the device into the next phase of development.

But the research came to an abrupt end when the partner was acquired by a company with no interest in pediatric heart pumps. The project was shelved and the government grant money that had been funding it was returned.

Antaki did some research into the Bayh-Dole Act, which allows federal contractors who acquire ownership of inventions made with federal funding to retain that ownership. Two large government contracts from the NIH had made the PediaFlow device possible, yet a private corporation had acquired the license for the technology for the purpose of preventing anyone from developing it further.

In March 2016, Antaki wrote to the act's sponsor, former Republican Sen. Robert Dole of Kansas, who had taken a position at a Washington, D.C., law firm following his retirement from the Senate. Dole arranged an introduction to intellectual property lawyers from the firm; by November 2018, Antaki had won the right to develop the PediaFlow.

The grant awarded by the U.S. Department of Defense's Peer Reviewed Medical Research Partnership is allowing Antaki to reassemble the team of collaborators that designed the PediaFlow's original prototypes.

Said Antaki: "It is a new lease on life for this device for children who have no other alternative."

CLIMATE CHANGE FORCES FARMERS TO PICK LOW YIELDS OR INSTABILITY

Climate change will leave some farmers with a difficult conundrum, according to a new study by researchers from Cornell and Washington State University: either risk more revenue volatility or live with a more predictable decrease in crop yields.

As water shortages and higher temperatures drive down crop yields in regions that depend heavily on seasonal snow, the choice to use more drought-tolerant crop varieties comes at a cost, according to model projections detailed in a study conducted by Patrick Reed, the Joseph C. Ford Professor of Engineering in Civil and Environmental Engineering.

The study examined the Yakima River Basin in Washington, where a complex combination of snow, reservoirs and water rights controls the availability of irrigation water. That water dictates the success of some of the largest producers of wheat, corn, potatoes, pears, cherries, grapes, apples and hops in the U.S. With proper snowfall and melt, total agricultural productivity in the basin can reach more than $4 billion a year.

The research team sought to quantify climate change's direct and indirect effects on irrigated agriculture in the basin. Researchers also wanted to know if drought-resistant crop varieties could help recover productivity during times of drought.

Reed's group built on prior research at Washington State University that developed a modeling platform connecting crop growth and development, land-surface hydrology and river-system processes. The model framework simulates dam operations and prioritizes the allocation of water among different sectors within the Yakima River Basin.

The team found that higher water stress and temperatures led to lower crop yield, as anticipated, said Keyvan Malek, a postdoctoral researcher in Reed's group and lead author of the study.

"However, the models show that year-to-year variability in expected crop yields goes down because the difference between the best and worst case yields is reduced," said Malek. "While this is not a positive result, year-to-year fluctuations in crop yield revenue are strongly important in how crop insurance programs balance revenue fluctuations."

The team then used its model to explore the potential of new drought-tolerant crop varieties, which are expected to improve annual yields under climate change. The results showed that although those varieties could significantly improve the average yield, farmers could also experience much higher revenue volatility from crop production.

The researchers argue that the best outcomes for crop yield and revenue volatility must be through a simultaneous improvement in crop varieties—for example, by preserving agrobiodiversity—and in water systems, such as through improvements in water-governing institutions and infrastructure.

The Roza Irrigation District within the Yakima River Basin in Washington state.

$1.5M GIFT LAUNCHES COLLINS FELLOWSHIP SUPPORTING DIVERSITY

Cornell Engineering has established the Lance R. Collins Fellowship, created to support engineering graduate students from traditionally underrepresented populations, and to honor Lance R. Collins, who for 10 years was the Joseph Silbert Dean of the College of Engineering.

Alumni of Cornell Engineering raised $1.5 million to fund the fellowship. Members of the Engineering College Council were instrumental in the success of the effort, including council chair Elissa Sterry '79, M.Eng. '80.

"The council is honored to have worked closely with Dean Collins in his tireless effort to make Cornell Engineering a leader in diversity and inclusion," said Sterry. "This fund will contribute to ensuring his legacy lives on."

When his second five-year term as dean of Cornell Engineering ended June 30, Collins became the inaugural vice president and executive director of Virginia Tech's new Innovation Campus.

The first African American dean at Cornell, Collins prioritized diversifying the College of Engineering's faculty and student body. He more than doubled the proportion of undergraduate students from underrepresented communities, from 8% to 19%, and increased the enrollment of undergraduate women from 33% to 50%, while keeping graduation rates and average GPA equal among genders.

For his work on diversity, Collins received the inaugural Mosaic Medal of Distinction in 2017 from Cornell Mosaic—an alumni organization founded to increase engagement from alumni of all backgrounds—and the 2018 Edward Bouchet Legacy Award from Howard University and Yale University, which recognizes educators and advocates who promote diversity and inclusion.

"Cornell's diversity efforts lead the nation," Collins said, "and I am incredibly proud of the fact that the engineering alumni chose this way to recognize my contribution to those efforts. I look forward to meeting the fellowship awardees in the future and offering my services as a mentor to those who are interested. This is a legacy that I will cherish forever."

In addition to his success diversifying the student body and faculty of the college, Collins led one of the largest capital campaigns in Cornell Engineering's history, and helped secure its two largest gifts, which established the Nancy E. and Peter C. Meinig School of Biomedical Engineering and the Robert Frederick Smith School of Chemical and Biomolecular Engineering. Collins also prioritized experiential learning within the college, launching the Engineering Leadership Program and developing new entrepreneurship initiatives, such as the Commercialization Fellowship and the Scale-Up and Prototyping Awards.

Lance Collins, vice president and executive director of Virginia Tech's Innovation Campus

Jami Joyner, director of Diversity Programs in Engineering at Cornell, and José F. Martínez, associate dean for diversity and academic affairs at Cornell Engineering, will play a large role in creating the qualification and application process for the Collins Fellowship.

"The Collins Fellowship reaffirms Cornell's founding principle of '… any person… any study' as it further fortifies Cornell Engineering's commitment to institutionalizing access, inclusion and excellence across STEM disciplines," Joyner said.

"This fellowship is a beautiful way to culminate Lance's 10-year effort to make Cornell Engineering one of the most diverse, elite engineering schools in the nation, Martínez said. "The Lance R. Collins fellows will further strengthen an outstanding cohort of Sloan, Colman, GEM and other graduate fellows in engineering."

$5M GIFT ESTABLISHES DUFFIELD FAMILY CORNELL PROMISE SCHOLARSHIP

A $5 million gift from David A. Duffield '62, MBA '64, to the College of Engineering has established the Duffield Family Cornell Promise Scholarship, providing financial assistance to undergraduate engineering students in response to the COVID-19 pandemic.

The gift is the largest single contribution to the Cornell Promise initiative, which upholds Cornell's founding commitment of "an institution where any person can find instruction in any study," by addressing the ability of Cornell students and their families to afford an education despite financial hardships brought by the pandemic.

"Cornell has been important to me and my companies, and the Cornell Promise initiative gave me the chance to say thank you," said Duffield, an entrepreneur and philanthropist who is the founder of six companies, including two successful public software firms, PeopleSoft and Workday.

He is currently the chairman of Workday and founder/CEO of Ridgeline, an enterprise software company building products for investment managers. Both Workday and Ridgeline recruit from Cornell Engineering on a regular basis.

Duffield's fund will provide 200 term scholarships that will be disbursed over the next three academic years and will help the College of Engineering meet the dramatically expanding financial needs of students. The college had budgeted $36 million for student aid in the 2020-21 academic year, but that number is now expected to reach more than $50 million.

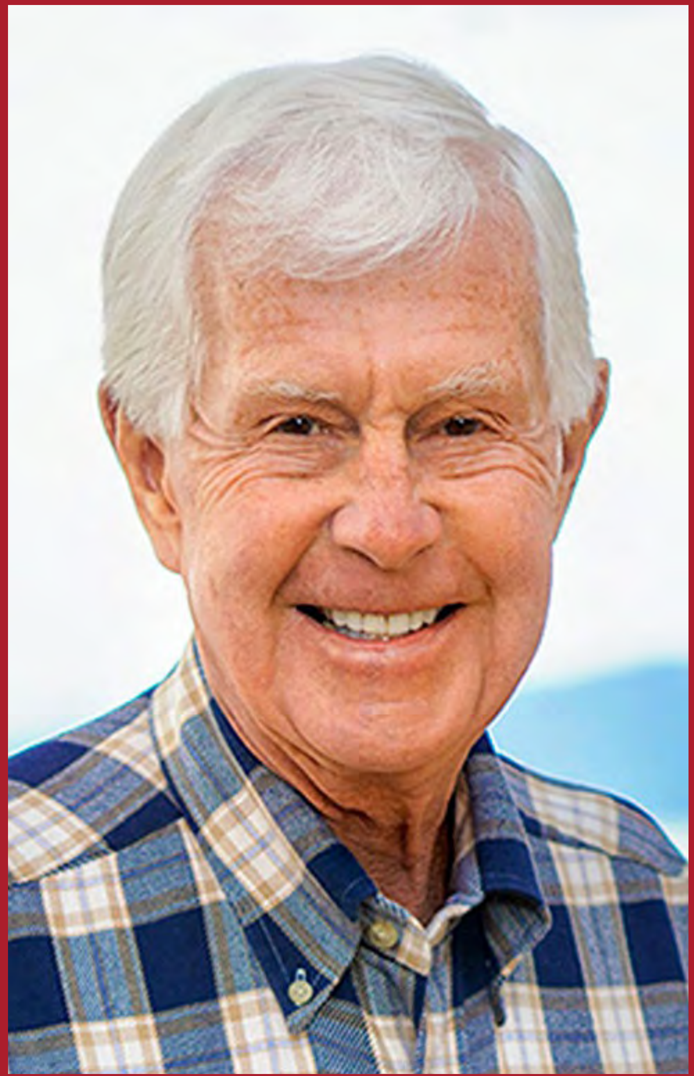
"Dave has played an outsize role in strengthening the College of Engineering as a place that shapes the leaders and innovators of tomorrow," said Cornell President Martha E. Pollack. "We are incredibly fortunate to have someone who immediately recognizes what Cornell Engineering needs and is willing to step forward to make it happen."

"Solving the grand engineering challenges of our time requires educating every talented student, regardless of financial circumstance," said Lynden Archer, the Joseph Silbert Dean of Engineering. "Dave's support comes at a critical moment for the next generation of engineers and problem solvers, and I am grateful for his leadership."

One of the College of Engineering's most successful alumni, Duffield's support for nearly three decades enabled the construction and ongoing maintenance of Duffield Hall, which houses some of the world's most sophisticated research and teaching facilities for nanoscale science and engineering. He also funded the Workday Atrium in Gates Hall and Workday Labs in Phillips, Rhodes and Sage Halls.

Duffield and his wife Cheryl founded Maddie's Fund, which supports companion animal welfare and promotes no-kill animal shelters across the country, including Maddie's Shelter Medicine Program at Cornell's College of Veterinary Medicine.

Among other honors, Duffield was named Cornell Entrepreneur of the Year in 1996 and received the Cornell Engineering Distinguished Alumni Award in 2018.



David A. Duffield '62, MBA '64, chairman of Workday and CEO of Ridgeline

Max Zhang, professor of mechanical and aerospace engineering

Stephen Wicker, professor of electrical and computer engineering

DESIGNING NY'S FIRST STATEWIDE 'INTERNET OF THINGS'

By Eric Laine

The 'internet of things' (IoT) is an ever-growing catalogue of devices designed to connect to an array of available services. Refrigerators, thermometers, doorbells and cameras have become data collection points for home users looking to automate shopping lists or monitor energy usage.

Businesses and municipalities in urban and suburban areas have been quick to see the benefits of collecting data from individual sensors networked into a new kind of public infrastructure. They monitor and optimize industrial equipment, water and heating systems, automobile fleets and traffic lights, taking advantage of ubiquitous internet connectivity and reliable signal strength.

IoT can play a vital role in rural economic development as an enabler of a wide range of applications such as automated crop, soil, and livestock monitoring, smart water irrigation control and community health indicator monitoring. Rural areas, however, have been unable to capitalize on the efficiencies promised by the internet of things due to historically poor cellular connections and general lack of broadband access. This digital divide results from the reluctance of telecommunication companies to invest in remote areas, citing high installation costs and a lack of customers.

Led by Max Zhang, professor of mechanical and aerospace engineering (MAE), and Stephen Wicker, professor of electrical and computer engineering (ECE), Cornell researchers are teaming up to bridge the digital divide in New York by designing the nation's first statewide IoT public infrastructure. Collaborating with community partners in each county through Cornell Cooperative Extension (CCE), the team will set up networks based on low-power wide-area network (LPWAN) technology, a form of low-frequency radio. The National Science Foundation has funded the effort with a $1.5 million grant.

Designing and deploying the network across the state may not be the biggest challenge. The team will need to show communities how they can benefit from this new public infrastructure and inspire the next generation of engineers to do the same.

"We have to make technology available in a way that others will adopt it and get the most out of it," said Wicker. "We're trying to improve municipal infrastructure in rural communities through telecommunications technology, but we have to understand local needs to have real impact."

Communities will be able to take advantage of this infrastructure even in areas with poor broadband coverage. Multitudes of low-cost sensors can connect to a single gateway using LPWAN. Only the gateway, which could be miles away from the sensors, is connected directly to the internet.

"It opens up many more opportunities," Zhang said. "If each device had to be internet connected, that really limits us in terms of power, cost and range, especially for rural areas. Even if you don't have internet, you still can have your devices connected."

The broader effort started three years ago with a single gateway and antenna mounted on the roof of the CCE-Tompkins County building, providing LPWAN coverage to the city of Ithaca. To demonstrate the concept, Zhang led a team that used the public network to gather data from sensors monitoring pollutants in wood smoke and measuring building energy efficiency. In 2018, Zhang and Wicker received an award from the Academic Venture Fund of Cornell's Atkinson Center for Sustainability to start collaborating on LPWAN research.

"Tompkins County is our first pilot, but we want to try a

"WE HAVE TO MAKE TECHNOLOGY AVAILABLE IN A WAY THAT OTHERS WILL ADOPT IT AND GET THE MOST OUT OF IT. WE'RE TRYING TO IMPROVE MUNICIPAL INFRASTRUCTURE IN RURAL COMMUNITIES THROUGH TELECOMMUNICATIONS TECHNOLOGY, BUT WE HAVE TO UNDERSTAND LOCAL NEEDS TO HAVE REAL IMPACT."
— Stephen Wicker

few other different places to see, if we deploy this and come up with some applications or solutions, whether people will use it or like it," Zhang explained. "Hopefully that will generate valuable lessons for us before we present a plan to cover the entire state."

Planning public IoT networks requires a detailed level of design, precise placement and sizing with respect to both bandwidth and coverage. David Shmoys, the Laibe/Acheson Professor of Business Management and Leadership Studies in the School of Operations Research and Information Engineering (ORIE), joined the team to focus on optimization.

"Optimization models studied in ORIE provide the means to balance cost with coverage and resilience in these networks, and investigate algorithms that find near-optimal solutions for these models," Shmoys said. "Our research aims to transform these tools, building on advances in data science, and provide designs at much greater scales and finer degrees of resolution that allow for greater resilience and robustness."

Rural communities provide opportunities for developing new networked technologies which can leapfrog traditional wired broadband. The project is using a co-design process between academic researchers and community partners, which will create living laboratories for research, education and community engagement. Zhang and Wicker have received letters of collaboration from every county, but they know simply building the infrastructure is not sufficient. To have a real impact on life in rural communities, people have to use it.

"We can't assume we know everything," Zhang said. "We have to work with communities and find out what will be the appropriate applications. That's really the most exciting piece."

Understanding what communities need and communicating how they could use a public IoT infrastructure to address those needs is a major part of the project. Lee Humphreys, professor in the Department of Communication, joined the team to help this effort, Wicker explained.

Alex Coy '21, Engaged IoT hardware lead, assembling IoT-enabled energy and environmental measuring devices.

Alfredo Rodriguez, Ph.D. student and Engaged IoT project lead, collaborates with building managers to ensure the safe and proper installation of IoT metering equipment.

As a social scientist, Humphreys is concerned with how people's prior experiences shape their motivations to use tech innovations. Her research will help to integrate the needs of users into the design of the networks, and then analyze the impact of these networks on organizations and communities once implemented.

"When we design and implement new IoT technologies for organizations and communities, it's important to realize how their expectations can and should shape the implementation of these networks," Humphreys said. "Rural technology innovation, development and adoption are an exciting area of both technological and social research because they have received far less attention than urban technology."

The outreach efforts include a new engineering student project team—Cornell Engaged IoT—which has been working directly with organizations in Tompkins County to utilize the IoT infrastructure. The broad scope of the work requires collaborators in a range of fields, from understanding the physical factors of energy and environmental monitoring, to designing the devices and sensors as well as the software dashboards.

Alfredo Rodriguez, Ph.D. candidate in MAE, is leading the Engaged IoT team which is currently providing users with a feedback system for energy efficiency in buildings and local air quality data. "This project requires expertise in many disciplines in order to make a meaningful impact toward bridging the digital divide," he said. The project team is supported by the Shen Fund for Social Impact, created by David Shen '89 to address significant social challenges through novel engineering solutions.

CORNELL ENGAGED IoT
ENGAGED INTERNET OF THINGS

Alex Coy '21 is an undergraduate in ECE working on the team, primarily in radio frequency and embedded device research. "We provide efficient user interfaces so that our audiences can understand important trends in the data," he said, "and possible steps to conserve energy, improve air quality, or otherwise help the Earth."

Navin Ramsaroop '21, an undergraduate in computer science, has been a researcher in the group for six semesters. He said the ultimate goal of his group is to help lower electricity usage across New York state by measuring usage in buildings, analyzing readings, and providing actionable advice on how to lower power consumption. "Our project also gathers many other metrics," he said, "such as air quality readings, temperature and humidity, giving us the ability to connect and compare buildings throughout New York using numerous metrics, and accurately identify any anomalies building managers might find useful to know about."

Rodriguez set the project team's immediate goals. "Before the end of this academic year," he said, "we are hoping to further expand our building electricity metering project and our woodsmoke measurement and alert system project throughout New York state to provide more users with real-time building energy performance and local air quality data."

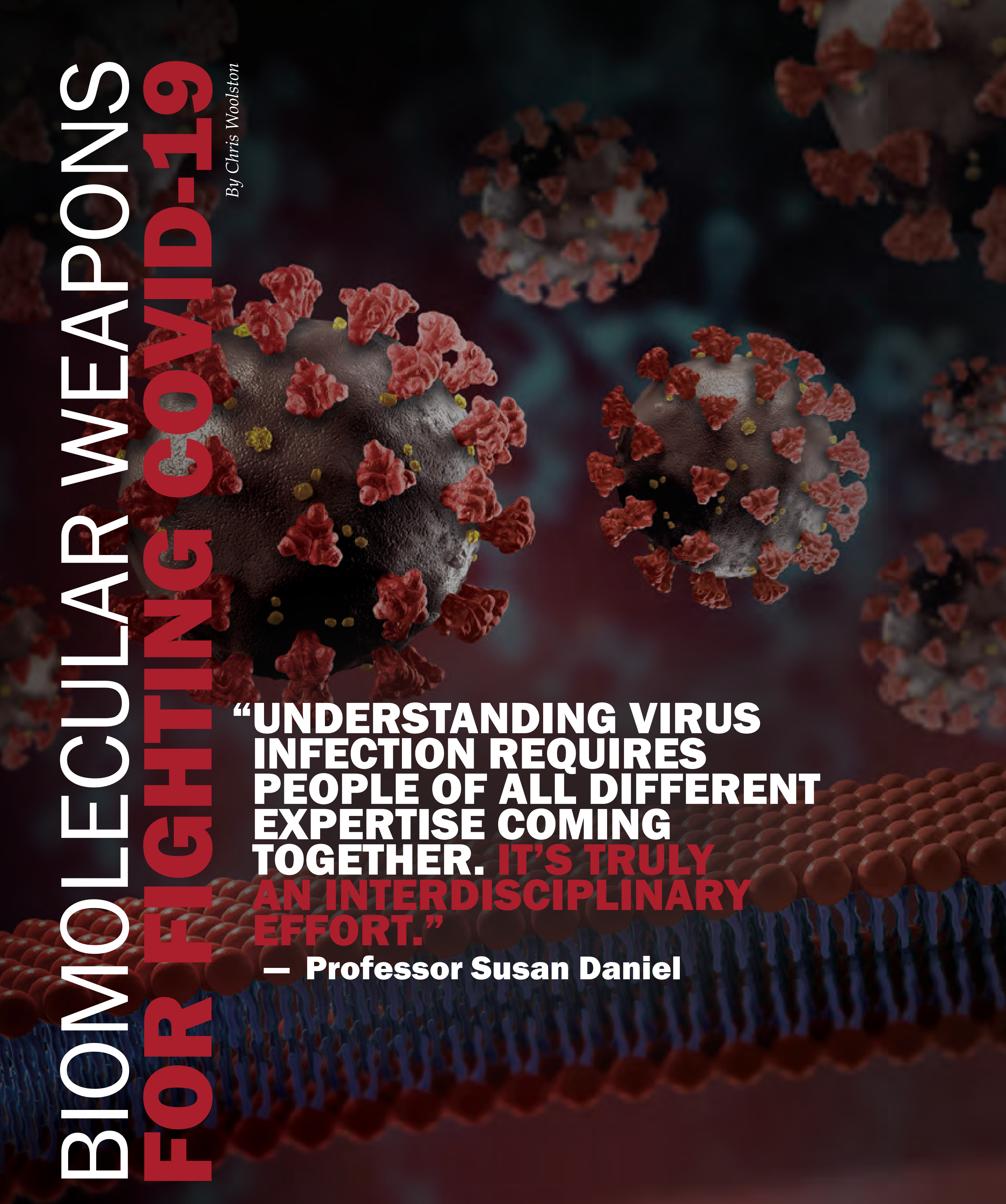
Wicker and Zhang are also working to expand interest in a public IoT infrastructure by creating Cornell's first introductory IoT course, in which students will engage with community partners to tackle social, economic and environmental problems using the technology. In conjunction with the NSF effort, students will learn how to develop IoT-based technological solutions and how to communicate about the responsible use of IoT technology to create positive societal impact. The Cornell Engineering Information Technology Service Group is providing support to the efforts.

Cornell's Office of Engagement Initiatives, whose mission is to support community-engaged learning, is another partner in the project. Ashlee McGandy, online education initiative content strategist, said: "We've directly supported the IoT work in two ways: through a supplemental grant that allowed the Atkinson team to add undergraduates to the research team, and through an Engaged Curriculum Grant to help develop the introductory IoT course."

"The whole idea of IoT is so broad that there's not a single person who can handle this," Zhang said about the multi-disciplinary collaboration. "That's why having Steve with wireless communication, data security and privacy expertise, combined with my application-oriented approach will give a much broader, much more comprehensive view at the introductory level."

Wicker agrees. "Years ago, we [in ECE] used to share courses that focused on microcontroller-based applications because that's a natural thing for mechanical engineering. This is the first time we'll actually have a course that's co-taught between an ECE and an MAE professor, actually trying to blend communication technology with real applications and infrastructure. It's a great opportunity and a model for future engagement."

Navin Ramsaroop '21, Engaged IoT software lead, presenting IoT device users with real-time data visualization and recommendations to improve energy efficiency.



BIOMOLECULAR WEAPONS FOR FIGHTING COVID-19

By Chris Woolston

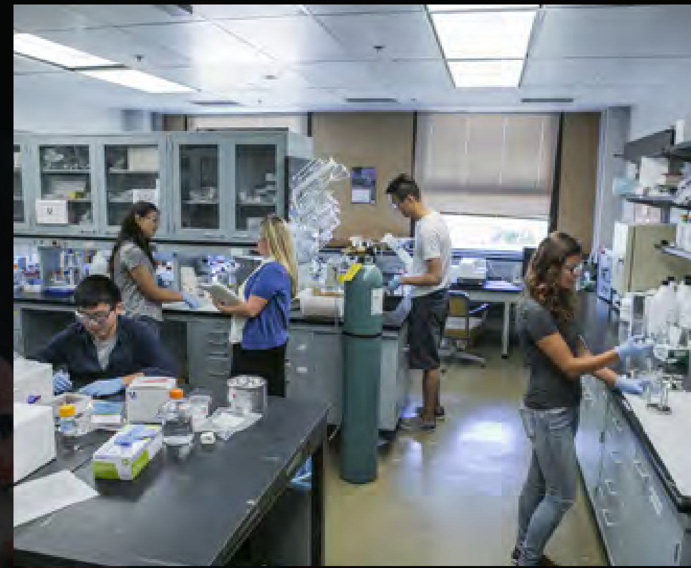
Years before the novel coronavirus turned into a global pandemic, Susan Daniel was already looking for ways to defeat it. Daniel, a professor in Cornell's Robert Frederick Smith School of Chemical and Biomolecular Engineering, had created models of the host membrane to gain new insights into the virus SARS-CoV. Now referred to informally as SARS-CoV-1, the virus is a precursor and close relative of the new coronavirus, SARS-CoV-2 or SARS 2.

A dangerous virus in its own right, SARS 1 infected more than 8,000 people around the world in an outbreak in 2002 and 2003. That particular outbreak has long faded, but Daniel was intrigued by this virus and wanted to know exactly how it enters its host's cells, a crucial step toward infection. The work was scientifically interesting—these viruses have a lot of tricks—but the arrival of the novel coronavirus suddenly put her work at the center of a global crisis. "Never has my research been so relevant to the world," she says.

The new virus wasn't a complete surprise, says Tiffany Tang, a fifth-year Ph.D. student in Daniel's lab. She notes that new strains of coronavirus tend to emerge every decade or so, and the latest version was overdue. "When we heard there was a new virus in December, we figured it was about time," she says. Of course, nobody could have anticipated the new virus's devastating spread. "Part of me is still in shock over the impact," she says.

The novel coronavirus is far more contagious and deadly than its predecessor, but the two viruses also share much in common. The strains look alike under a microscope—picture tiny spheres bristling with spikes—and the similarities go deep down into the genome. By studying SARS 1, Daniel was learning much about unique features of coronaviruses that would help her understand SARS 2, even before it emerged.

"It was an easy pivot," she says. "We could essentially deploy all of the techniques that we were already using." With a new sense of urgency, Daniel and her team are collaborating with other Cornell researchers to expand their coronavirus studies in an effort that blends engineering with virology and data science. "Understanding virus infection requires people of all different expertise coming together," she says. "It's truly an interdisciplinary effort."



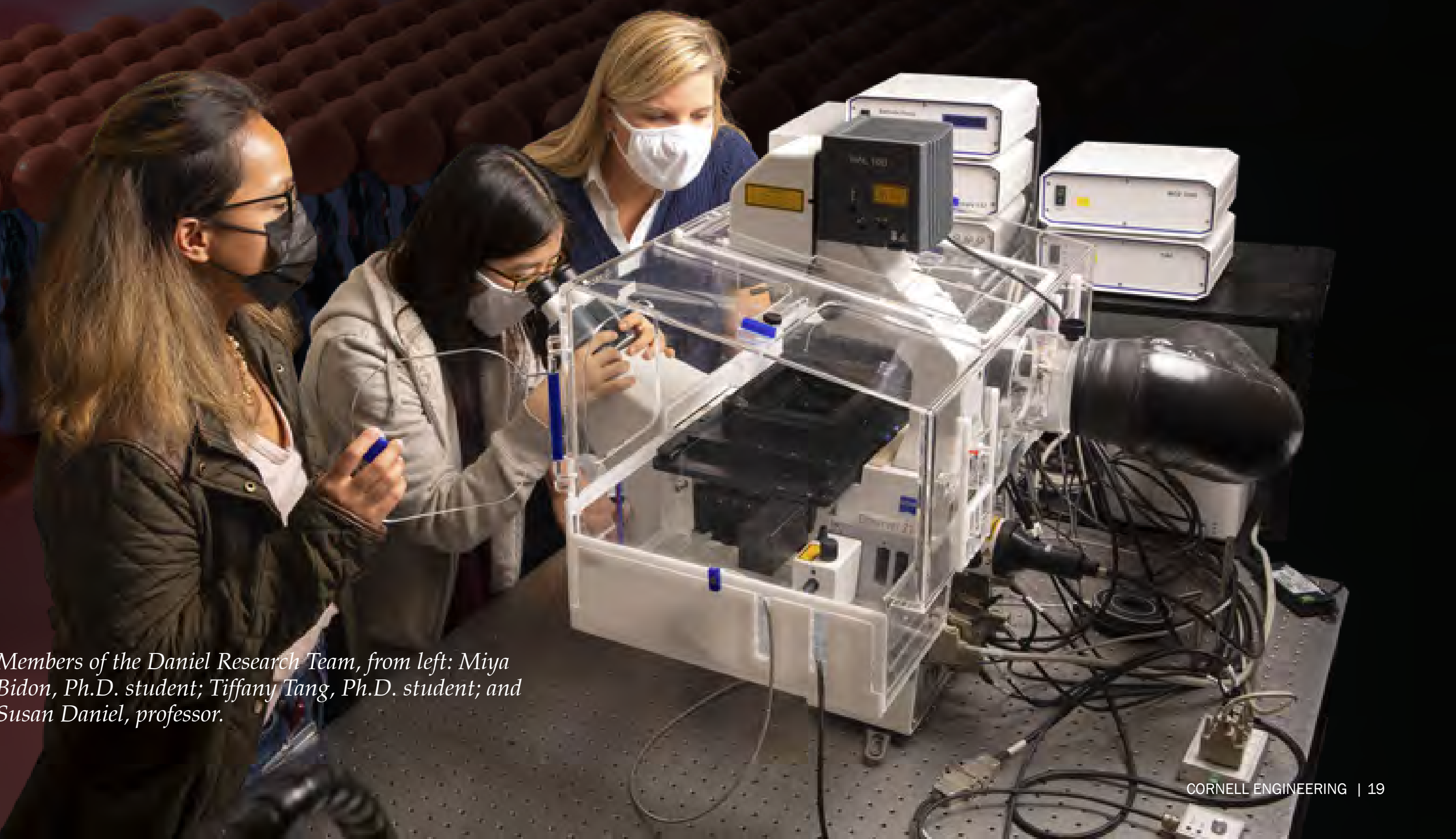
Members of the Daniel Research Team work in their Olin Hall laboratory.

"UNDERSTANDING VIRUS INFECTION REQUIRES PEOPLE OF ALL DIFFERENT EXPERTISE COMING TOGETHER. IT'S TRULY AN INTERDISCIPLINARY EFFORT."

— Professor Susan Daniel

Discovering coronavirus's vulnerability

Much of the work in Daniel's lab looks at the spiky projections—appropriately called spike proteins—that give coronaviruses their tell-tale appearance. These pointy proteins reach out to grab nearby cells (Daniel calls it "harpooning"), the



Members of the Daniel Research Team, from left: Miya Bidon, Ph.D. student; Tiffany Tang, Ph.D. student; and Susan Daniel, professor.

first step towards an infection. Once the spikes have snagged a cell, the virus can deliver its genetic payload, essentially turning the infected cell into a virus factory. If there was a way to stop these spike proteins from doing their job, the virus would be essentially disarmed. "If the virus doesn't fuse with the cell, the genome is never transferred, and the infection doesn't proceed," she says.

Daniel and her team believe they may have identified a potential vulnerability in the spike proteins. Studies of the original SARS 1 virus showed that the spikes depend on the mineral calcium to effectively do their job. As Daniel explains, calcium ions fit neatly within a particular region of the spike that controls the harpooning process. That extra fortification seems to help make the spike tips strong and rigid, qualities that are important for attaching to a cell. Without calcium, the spikes tend to be floppy, potentially making it more difficult for the virus to infect a cell. In theory, reducing calcium levels at the point of virus entry could stop infections before they start. Daniel and colleagues discussed the role of calcium in coronavirus infection in a paper published online in *Antiviral Research* in April 6, 2020.

When the new virus first arrived on the scene, Cornell researchers knew where they wanted to look. Daniel—along with her frequent collaborators Gary Whittaker, professor of virology at the College of Veterinary Medicine, and Nicholas Abbott, the Tisch University Professor of chemical and biomolecular engineering—received a $200,000 "rapid" grant from the National Science Foundation in April to study the spike proteins of the new virus. The team brings different skills and viewpoints. Whittaker's lab had been studying the spike proteins in coronaviruses, including varieties that infect dogs, cats, pigs and horses. Abbott's lab studies a type of interaction—called a hydrophobic interaction—that coronaviruses use to harpoon cells.

The researchers are paying particularly close attention to the section of the protein, called the fusion peptide, that actually initiates a process called membrane fusion, where the host and viral surfaces merge, forming an opening where the genome escapes into the cell. After comparing the sequences for the fusion peptides in SARS 1 and SARS 2, they quickly realized that this novel threat was in many ways surprisingly familiar. "They are nearly an identical match," Daniel says. "And because we knew that calcium was crucial for SARS 1 entry, we posited that SARS 2 would require it too."

If the new coronavirus really does need calcium to infect a cell, an arsenal of FDA-approved calcium-blocking drugs could potentially be called into action. The drugs, often prescribed to treat high blood pressure and heart issues, work by reducing the concentration of calcium ions around the cell. If Daniel's theory about calcium and spike proteins is correct, those drugs at the right concentrations in the right patients could slow or even prevent infection of the novel coronavirus.

As a first test of the hypothesis, Daniel and her team have been studying the effects of calcium-blocking drugs on lung cells and kidney cells that are exposed to the new coronavirus in the laboratory. The findings are not yet published, but Daniel is already excited. "We've had phenomenal results," she says. "In some cases, we've had undetectable levels of infection."

Turning to big data, nature

Daniel is quick to point out that there's a huge gulf between showing that drugs work in a petri dish and showing that they work in real patients. For that reason, she cautions that it's far too soon for people to take such medicines for the purpose of fighting or preventing coronavirus infection. As a next step, she's hoping to build on ongoing collaborations with other Cornell researchers to test the theory in more realistic models. "I would love to team up with researchers in the clinic and veterinary school to see how this treatment works in mice and guinea pigs," she says.

There may be another way to test the possible effects of calcium-blocking drugs on COVID-19 infection. Daniel notes that many people already take such drugs for other conditions. By mining data in medical records, it might be possible to find out of if those patients are any less likely than others to succumb to the infection. The comparison would be complicated by the fact that people taking the drugs are by definition already somewhat unhealthy. But if there's any benefit to calcium-blocking drugs, the numbers should tell the story. "We'll need to turn to someone with the right computational toolbox to tease that out," she says, "Luckily, we know some great people down at Weill Cornell Medicine."

Susan Daniel, professor of chemical and biomolecular engineering

"NEVER HAS MY RESEARCH BEEN SO RELEVANT TO THE WORLD"

— Professor Susan Daniel

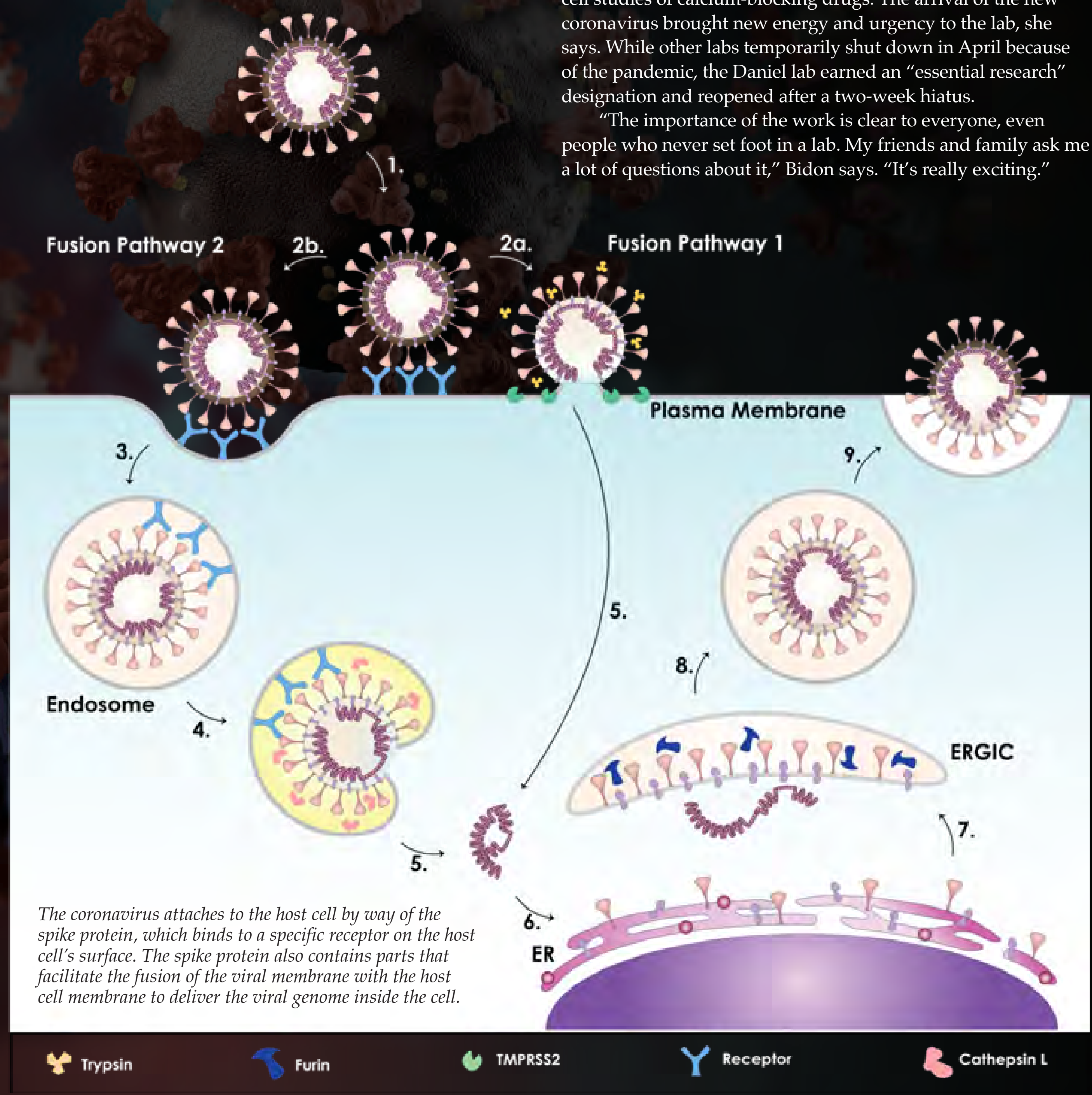
In another line of investigation, Daniel and team are looking at the interaction between spike proteins and antibodies produced by the immune system. So far, they've managed to show that mere fragments of the spike protein were enough to trigger the production of antibodies in mice. What's more, some of those antibodies seemed to zone in on the fusion peptides of invading viruses. In a sense, the immune system seems to be targeting the same parts of virus that scientists have in their own sights. Understanding how nature fends off coronaviruses could offer important insights for researchers who are trying to accomplish the same goal, Daniel says.

Rising to the challenge

After building her career on bioengineering techniques, including the cell-free membranes that she developed to study the infection mechanisms of SARS 1, Daniel had to move slightly beyond her comfort zone to a more clinical world of cell cultures and animal studies. She embraced the challenge. "If I were to focus solely on the technology that I developed, I'd be missing the bigger picture," she says. "As an engineer, my role is bringing my toolbox to the field of virology, and then to help synthesize the information from all inputs to better understand these viruses."

The ongoing collaborations with Whittaker, Abbott and other researchers have been a great experience, says Miya Bidon, a third-year Ph.D. student in Daniel's lab. "We're learning all sorts of different techniques," she says. Bidon continues to work on her original project—studying fusion peptides in SARS 1—but like everyone else, she has also turned her attention to SARS 2, too. Among other things, she's participating in the cell studies of calcium-blocking drugs. The arrival of the new coronavirus brought new energy and urgency to the lab, she says. While other labs temporarily shut down in April because of the pandemic, the Daniel lab earned an "essential research" designation and reopened after a two-week hiatus.

"The importance of the work is clear to everyone, even people who never set foot in a lab. My friends and family ask me a lot of questions about it," Bidon says. "It's really exciting."



The coronavirus attaches to the host cell by way of the spike protein, which binds to a specific receptor on the host cell's surface. The spike protein also contains parts that facilitate the fusion of the viral membrane with the host cell membrane to deliver the viral genome inside the cell.

CORNELL ENGINEERING 2030 AND BEYOND

By Syl Kacapyr

Lynden A. Archer,
Joseph Silbert Dean of Engineering

What could one of the world's most prestigious engineering colleges look like a decade from now? Cornell Engineering's new leader details his vision.

"WE BUILT THIS FANTASTIC INSTITUTION AT A TIME WHEN IT WAS NEEDED AND WE ARE AT EXACTLY THAT SAME TIME AGAIN, A FOURTH INDUSTRIAL REVOLUTION, WHEN DATA, INFORMATION TECHNOLOGY AND MACHINE LEARNING ARE BRINGING TECHNOLOGY INTO EVERY ASPECT OF LIFE."
— Dean Lynden Archer

The Second Industrial Revolution forever changed the world at the turn of the 20th century, and at the center of it all were the engineers who conceived one technological advance after another. Those advances dramatically changed the way products were manufactured, information was communicated, and people and goods were transported.

At the time, Cornell Engineering was making its own mark on the world. Robert Henry Thurston, a renowned inventor and educator who became director of what was then the Sibley College of Mechanical Engineering and the Mechanic Arts in 1885, transformed engineering from a shop-based, practical profession into one based on scientific design and academic training. It was this educational vision that put Cornell's engineering program on the map and enabled its faculty and students to have greater impact on the world.

"We built this fantastic institution at a time when it was needed," said Lynden Archer, who became the Joseph Silbert Dean of Engineering earlier this year, "and we are arguably at exactly that same sort of turning point again, a Fourth Industrial Revolution, when data, information science, machine learning and bioengineering are bringing technology into every aspect of life."

A century and a half after Cornell Engineering's founding, the college finds itself immersed in developing the people, programs and innovations that will drive this latest revolution, and with an opportunity to again play a leadership role in solving society's grand challenges.

"Access to massive amounts of data and the tools to use such data are what's going to define our age. We are then obliged to think about the role of Cornell Engineering in influencing the direction and pace of change," said Archer, who described the opportunity as a call to service for all faculty, students, alumni and staff to reimagine the college and how it will have a lasting impact on the decades to come.

"It is clear that to get from here to there, Cornell Engineering will need to excel in what it is already good at— knowledge creation and dissemination— and must also quickly

Lynden A. Archer, Joseph Silbert Dean of Engineering

develop mastery of new domains—translating research discoveries into commercial practice, expanding opportunity, and developing people to reach their greatest potential," Archer said.

"How do we build a comparable infrastructure of buildings and people and pedagogies that allow us to continue the outstanding tradition of leadership defined by our predecessors?" asked Archer, who plans to spend his first year in office working with others to formulate a new strategic vision for the college. This vision will be built around four main pillars: strength in research, teaching excellence, research translation, and a renewed focus on collaboration, particularly between the college and Cornell's two New York City campuses.

Integrated within each pillar is a focus on leveraging the college's success in recruiting populations traditionally underrepresented in engineering—particularly women, minorities and first-generation students—to develop a climate of true belonging in which students are able to thrive.

"This is our time," said Archer, "to add enduring values to this college that we all love."

Strength in Research

Archer joined the Cornell faculty in 2000 and established a research group broadly considered a leader in the materials physics of organic polymers and their composites with inorganic nanomaterials. Inspired by a call from the National Science Foundation for functional nanomaterials, he discovered a novel type of nanoscale organic hybrid material that combines the best of its organic polymer and inorganic particle components to enable access to low-cost, but high-energy batteries that use metals as anodes.

A member of the National Academy of Engineering, Archer has the distinction of being named four times to the "World's Most Influential Scientific Minds" list compiled by Thompson Reuters, and in 2019 he was named one of the most influential researchers of the decade by Web of Science.

But just because Archer is a decorated researcher, doesn't mean he wants to tell others how they should be running their laboratories, in fact, quite the opposite. As Cornell Engineering's schools and departments think about how they will position themselves for leadership in their fields, Archer is taking a decidedly bottom-up approach to planning strategy. It begins by challenging departments to define what constitutes excellence in research, teaching and technology translation in their specific domains, and then by asking what investments are required to achieve such excellence.

"One of the only rigorously philosophical aspects to my leadership style stems from a deep belief that to lead is to serve, and the people I serve are the departments and students they educate," said Archer, "and so this entire exercise of strategic planning is about me learning and formulating a strategy that is rooted in the aspirations of the departments and completely guided by their priorities."

Part of that strategy will be to invest in the college's infrastructure by modernizing its buildings and laboratories. The recent reconstruction of Upson Hall, along with renovations to Kimball, Olin and Weill halls, serve as a model for future projects.

Another key element involves investments in faculty—to recognize, nurture and reward excellence in research, and to strategically hire new faculty who can bridge engineering disciplines by uniting researchers across the college, campus and university.

"The idea is to recruit superstars—people who are vetted not just for their ability to be intellectual leaders, but who can bring other faculty together in areas where Cornell Engineering has emergent technical strength, to win large multi-investigator grant proposals that will accelerate our rise to national prominence in these areas," said Archer.

A recent example of how success in recruiting talented researchers can lead to new opportunities is that set by the recruitment of Debdeep Jena and Huili Grace Xing in 2015 from the University of Notre Dame. As professors in both the School of Electrical and Computer Engineering and the Department of Materials Science and Engineering, the two researchers were attracted to Cornell because of Duffield Hall's world-class infrastructure for nanoscience research and by the university's deep tradition of collaborative research.

As established researchers with leadership skills, Jena and Xing have been key members of PARADIM—a $25 million National Science Foundation research platform—and founders of the Air Force Research Laboratory Cornell Center for Epitaxial Solutions—a $3 million center uniting researchers who aim to discover the atomic secrets of beta-gallium oxide, a promising new material that has piqued the interest of engineers for its potential to allow electronic devices to handle dramatically more power.

"Once we recruit outstanding faculty to the college and give them the recourses they need, they not only allow us to rapidly add strength in priority areas, but also help define the culture of excellence required to sustain such strength," said Archer. "The hope is that more junior faculty and perhaps even the senior faculty colleagues participating in their successes will then be inspired to excellence, lifting us all."

Archer also hopes star faculty can champion Cornell's campus as a 'living laboratory,' where buildings, utilities, and transit systems serve as a platform for translating research into demonstrated technologies with real-world impact.

Examples include the Lake Source Cooling system that transports water from the depths of nearby Cayuga Lake to sustainably cool all buildings on campus, and more recently, the Earth Source Heat project led by Jefferson Tester, professor of chemical and biomolecular engineer and David Croll Sesquicentennial Fellow. The project proposes heating most buildings on campus using a novel, deep-geothermal system.

Another example is the ongoing work to prevent the spread of COVID-19 on campus, modeled by Peter Frazier, associate professor of operations research and information engineering. The approach has been a hallmark of Cornell's plan to keep campus operational and can be applied elsewhere to scale up testing efforts.

Teaching Excellence

Much of Archer's passion for science and education stems from his experience growing up in the South American nation of Guyana. His interest in materials science derives from one of the country's largest exports at the time—an ore used to make aluminum—and some of his first experiments were conducted at a young age when a tip from a chemistry book led him to improve his mother's livestock using brewer's yeast as a feed supplement.

But it was Archer's experience as an 18-year-old high-school teacher in Guyana that greatly influenced his philosophy on the importance of teaching.

"I'm still in touch with some of the students I taught and an enduring lesson is that if you go beyond the call of duty and do something that is selfless, it uplifts students in a way that you could never imagine," said Archer. "It is remarkable what stories my students tell about their 18-year-old teacher, even 30 years later."

Archer said it's Cornell's reputation for combined excellence in research and teaching that first attracted him to the Ivy League university, and it's a value he has carried with him during his 20-year career at Cornell, in which he has mentored more than 40 Ph.D., 20 masters, and 2,000 undergraduate students.

"I think that is an important legacy that we've got to preserve and strengthen," said Archer, who added that one way to do this is through endowed faculty positions specifically focused on teaching. He points out that among the nearly 200 full-time faculty in Cornell Engineering, only three such positions exist, and only one recognizes a member of the faculty—Michael Duncan, the Raymond G. Thorpe Teaching Professor of Chemical and Biomolecular Engineering.

Archer hopes to expand teaching-focused appointments to one or two per department over the next decade, although he is still examining how the initiative could be structured for maximum impact.

"The intention is to create a cohort of faculty who excel as teachers, who bring creativity to developing content and defining teaching spaces that facilitate learning, and who are committed to mentoring faculty to make us more effective teachers," said Archer.

Archer points to the work of Kathy Dimiduk, director of the James McCormick Family Teaching Excellence Institute, who collaborates with faculty in developing new teaching methods, improving course design, and modernizing teaching spaces for improving student learning.

"The institute and Kathy are good examples of the long-term impacts even small investments can have in improving the quality of the education we provide," said Archer, who also points to the work of the Engineering Leadership Program to illustrate the influence creativity in engineering education can have.

The expectations of engineers have grown considerably over the past few decades, and many are now expected to start

Duffield Hall seen from the Pew Engineering Quad.

or manage a company, among other leadership functions. The Engineering Leadership Program—run by Erica Dawson, the Nancy and Bob Selander Director and professor of practice—helps prepare students for this future through classes, seminars, and a leadership certificate program, all of which teach professional skills such as working in diverse teams, communication, decision making, managing conflict, ethics, networking and organizational culture, among other topics.

"As former director of the Smith School, I had opportunities to meet alumni at a range of career points. This provided a useful distillation of thought about what is most valuable in terms of what we teach," said Archer. "It is remarkable how often the 'I wish I learned this or that while at Cornell' intersect with the sorts of instruction the Engineering Leadership Program provides."

Archer aims to expand the leadership program so that it's deeply integrated into the experience of all Cornell Engineering students. He also hopes to expand Diversity Programs in Engineering, which facilitates the development of faculty and students from backgrounds historically underrepresented in engineering.

"With the college's most recent class at 51% women and 24% underrepresented minorities, one has to begin to ask, how do we begin to transform the college so that these students are able to thrive at Cornell and beyond?" said Archer.

One Cornell Engineering

At the dawn of the Second Industrial Revolution, when Cornell's founder, Ezra Cornell, famously proclaimed his vision for the university as a place for "…any person…any study," he articulated what was a radical idea at the time—a university with few academic boundaries, in which faculty and students would have the freedom to pursue their intellectual interests.

More the 150 years later, that founding principle has endured.

"Exciting advances in science and engineering always appear to happen at the intersection of fields," said Archer, who added that Cornell Engineering must build upon the success of the university's Radical Collaboration initiative—which aims to foster collaboration between colleges—and the One Cornell campaign—which aims to strengthen ties between Cornell's various campuses. Archer is particularly focused on identifying opportunities that will leverage the strengths of Cornell Engineering with Cornell Tech and Weill Cornell Medicine, both of which are based in New York City.

Archer argues that the division between Cornell Engineering in Ithaca and its presence in New York City remains too visible to the outside world. He views a push to strengthen those ties as a way to spark creative, interdisciplinary research, and to enhance recruiting efforts. As many researchers will profess, Cornell's interdisciplinary nature is what attracted them to the university, Archer included.

"I moved to Cornell because I saw an emerging knowledge gap in the electrochemistry field that required access to world-class collaborators interested in polymer physics, materials engineering and fluid dynamics," said Archer. "I've benefitted immensely from this culture of collaboration developed by my predecessors."

In recent years, Cornell engineers have had success building multidisciplinary centers with Weill Cornell Medicine. In 2015, Uli Wiesner, the Spencer T. Olin Professor of Materials Science and Engineering, stressed collaboration as key to the successful launch of the MSKCC-Cornell Center for Translation of Cancer Nanomedicines—a $10 million center he co-directs with Michelle Bradbury, director of intraoperative imaging at Memorial Sloan Kettering Cancer Center (MSKCC) and associate professor of radiology at Weill Cornell Medical College.

And in 2016, researchers from the College of Engineering and Weill Cornell Medicine announced the Center on the Physics of Cancer Metabolism—led by Claudia Fischbach, the Stanley Bryer 1946 Professor of Biomedical Engineering, and Dr. Lewis Cantley, the Meyer Director of the Sandra and Edward Meyer Cancer Center at Weill Cornell Medicine.

And while Archer sees more opportunity for Ithaca-Weill partnerships, he describes Cornell Engineering's relationship with Cornell Tech, which officially opened its Roosevelt Island campus in 2017, as full of largely unrealized promise. While Cornell Engineering does have two non-computer-science master's degree programs based on the tech campus, Archer points to Cornell Tech's Urban Tech Hub as a prime example of untapped potential for impactful collaboration.

The Urban Tech Hub is Cornell Tech's academic umbrella for the emerging study of how to make cities and urban spaces livable and efficient, encompassing civil engineering, electrical and computational engineering, sustainability, transportation, policy and the social sciences, among other areas of study.

"Recruitment of good faculty and graduate students is essential for activating these partnerships," said Archer, "and if we're able to develop programming that leads to deep engagement between the two campuses, I predict that when one thinks of Cornell Engineering, opportunities in New York City won't be an afterthought. We'll have departments that are closely connected with Cornell Tech and Weill Cornell Medicine in meaningful ways."

Uniting researchers and programs across schools and campuses is just one way Archer said he will monitor progress towards his goal of expanding Cornell Engineering's influence during his tenure as dean. In the end, "my success is really about the success of the people who I serve," said Archer, who explained this means developing a collective vision for the college that amounts to more than just building upon existing achievements.

"We're dreaming together and making a plan from the bottom up to play our part in the emergent Fourth Industrial Revolution," said Archer. "That is the part I'm most excited about."

"THIS IS OUR TIME TO ADD ENDURING VALUES TO THIS COLLEGE THAT WE ALL LOVE."
— Dean Lynden Archer

The Cornell Mars Rover student project team.

POWERFUL DESIGN SOFTWARE BRINGS STUDENT IDEAS TO LIFE

By Jackie Swift

Ronald Heisser, graduate student in mechanical and aerospace engineering, wants to change the way car chassis are designed. Rather than metal parts welded and screwed together, he reasons, why not echo the way bones, muscles, and tendons work and use organic shapes connected by cables? Instead of the front end crumbling in a collision, a car with this flexible chassis design should spread out the force of the impact and protect its human occupants better.

Heisser came up with the idea for a flexible chassis as part of his Ph.D. work in theoretical and applied mechanics but later decided to set it aside to work on other projects. Then he received an invitation from Autodesk, an international software design company that has partnered with Cornell, to attend an informational meeting about the company's Fusion 360 software. When Heisser met with Autodesk representatives, they suggested he come up with ways to use the generative design element of the software, and he was back to thinking about that chassis again.

Generative design allows engineers to create dozens of design variations with a few clicks of a button. By defining a project's size, weight, materials and budget, among other constraints, users supply the software's artificial intelligence algorithms with a set of specifications to work with. In return, users receive design proposals optimized for their goals.

"My initial idea didn't even involve generative design," he says. "But I thought it would play into the concept because generative design is partially about making structures lightweight. So if I can make these organic shapes that I'm connecting with cables more lightweight, the car will have less mass. If you get into an accident, then it's a lighter structure undergoing impact, so there will be less kinetic energy to transfer to the driver."

Left: Part of the Cornell Mars Rover's robotic arm was optimized for computer numerical control machining, thanks to an alternate design developed using Autodesk software. Right: Vicky Hsu '21 and Chris Draikiwicz '21, members of the Cornell Mars Rover student project team.

Innovation drives Autodesk-Cornell partnership

Fusion 360 software subscriptions, which include generative design capabilities, are available to Cornell students like Heisser, as well as to faculty, as part of the Autodesk-Cornell partnership first initiated in 2013. At that time, Autodesk donated software to Cornell valued at $51.4 million, among the largest in-kind donations in the university's history. "Cornell was on a targeted list of schools that we wanted to build a better relationship with," explains Amy Bunszel '89, Autodesk senior vice president, Architecture, Engineering and Construction Design Solutions Group. "A huge number of entrepreneurs have come out of Cornell, and the university's way of thinking about innovation and entrepreneurship aligned with ours and spoke to us. We were also drawn to Cornell's emphasis on diversity in the STEM fields and the priority given to interdisciplinary education."

Bunszel knows first-hand the type of education students receive at the university. A startup founder with a B.S. from Cornell in electrical and computer engineering, she is just one of many Autodesk leaders who are also Cornell alumni. That connection goes back to the early 1990s when Autodesk purchased Ithaca Software, a company based on a 3D graphics system created at Cornell. At that time Ithaca Software founder Carl Bass '83, joined Autodesk and went on to hold a number of positions there, including president and chief executive officer. "With so many of our leaders coming from Cornell, we were really excited to be able to support the university's students and the whole education curriculum with our software," Bunszel says.

Autodesk products have evolved since that first software gift, and Cornell has continued to benefit from the partnership. Students in mechanical, manufacturing, chemical, civil and biomedical engineering use Autodesk software for a broad range of courses and projects, as do students in the College of Art, Architecture and Planning, and those studying business and entrepreneurship. Faculty also teach using Autodesk tools in a variety of undergraduate and graduate classes.

Mars Rover modified

These days, Autodesk is emphasizing Fusion 360, a single platform that unifies design, engineering, electronics and manufacturing. As part of their outreach to the Cornell community, company representatives regularly visit labs and extend invitations to students to take part in informational meetings like the one Heisser attended.

That was how Chris Draikiwicz '21, mechanical and aerospace engineering senior and member of the suspension team for Cornell Mars Rover, first heard about the benefits of generative design. Since 2010, the Cornell Mars Rover program has offered students the chance to design and build a fully-autonomous rover to send to the annual University Rover Challenge competition hosted by the Mars Society. Draikiwicz and fellow team members Stephanie Terhaar '22 and Mikayla Lahr '23 were responsible for designing the suspension for the 2019-20 rover, named Argos.

The Cornell Cup team showcases its C1C0 robot at Maker Faire 2017.

"We started the design cycle by analyzing the previous year's system, and we identified it as being very heavy and over spec," Draikiwicz remembers. "So our driving goal behind the suspension design for Argos was to lighten it. There's a lot of ways you could do that, but we ultimately chose to manufacture generative design linkages."

Draikiwicz and the other suspension team members—along with Vicky Hsu '21, a member of the drivetrain sub team—spent time getting up to speed on generative design before applying it to the rover. "To use generative design right, you have to get all your loading conditions correct, so we actually conducted some rough accelerometer experiments to get ballpark numbers," Draikiwicz says.

Once the team had the loading conditions, they input them into the program. "Fusion 360 gave us a design for the main suspension arm," Draikiwicz continues. "It took us a while to tailor it to something we could machine in-house, but our end deliverable was actually two designs. One was a simplified 2D geometry version, which we made in November of 2019. But we also had an organic-shaped, 3D suspension linkage that we had ready to go for machining in March."

Unfortunately, the temporary lock-down of the Ithaca Cornell campus caused by the COVID-19 pandemic meant that the students weren't able to make the organic version. They did utilize the first 2D version however. "We were able to save .8 kilograms across our 50-kilogram rover, which is pretty significant in terms of mass savings," Draikiwicz says. "The 3D design that I didn't get a chance to machine would have shaved a further .2 kilograms. If you're looking at our big goal of cutting mass, all those one-tenths of a kilogram matter."

A robot's reach

Reducing mass was also one of the main concerns of Cornell Cup team members who decided to use Fusion 360 generative design capabilities to lighten the arms of their robot known as C1C0 (pronounced Kee-ko). As the hosts of Cornell Cup, a nationwide, embedded systems competition, the Cornell team doesn't compete, but they do engage in an overall education and awareness campaign aimed at children and teens, and C1C0 serves as their ambassador.

"We've heard from a lot of engineers on our team and in the College of Engineering in general that the robots they grew up seeing depicted in the media made them think that STEM fields are interesting," says Natalia Zeller MacLean '21, senior in mechanical and aerospace engineering, overall Cornell Cup team leader, and leader of the Cornell Cup mechanical systems division. "We wanted to make a robot which can provide that kind of inspiration, but in real life. C1C0 shows kids that you can make a cool robot that actually works in the real world."

C1C0 looks like R2D2 from the Star Wars franchise, except it has arms, and is actually autonomous. "Obviously, that R2D2 shape is not meant to have arms," Zeller MacLean says. "That means it's really important for us to make sure the weight of the arms when they're moving around doesn't tip the whole thing over or cause steering problems."

Cornell Cup works closely with Autodesk representatives, who often visit the lab. A few years ago Autodesk suggested that the students come up with ways to use generative design on their robots, and Zeller MacLean and her team mates saw the problem with the arm weight as the perfect application for the software. "Generative design is really good at only putting material in the places where it's needed," she says. "Optimizing for less material equals a lighter robot arm."

At the same time, the students wanted to ensure that the lighter arm still maintained its strength. Team member Samuel Lemma '20 took the lead in using generative design for the task. "He used the software to inform the most important structural locations where we actually needed to have pieces of material," Zeller MacLean says. "He took the original design and ran a generative design study on it and ended up with a 3D model of what was important to keep in and what we could take out. Then he was able to project that down to a 2D sketch."

Design and manufacturing simplified

The side plates for C1C0's arm are water jet cut, Zeller MacLean explains, which means essentially cutting holes out of a big sheet of metal. Lemma carried out that manufacturing task, as well, by superimposing the generative design 2D projection onto a sheet of metal plate. "It helped him figure out where to make cuts," Zeller MacLean says. "It's informed the overall shape of all the structural portions on the stronger of our two robotic arms."

Heisser echoes that experience. He had a rough idea of what he wanted for his flexible chassis, he says. "I just sketched where I wanted stuff to go," he explains. "When it came down to actually making the parts, when it came to designing the structure itself, the software just took care of that for me. In so many ways it simplifies the design process."

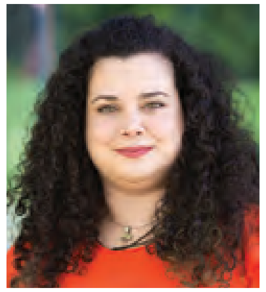
Hearing about Cornell students' real-life experiences with generative design is music to Bunszel's ears over at Autodesk. "These students are our future customers, and their feedback is really important to us," she says. "Making sure our products are relevant to the next generation is a priority."

Graduate student Ronald Heisser prototypes part of a vehicle chassis. Credit: Michael Suguitan.

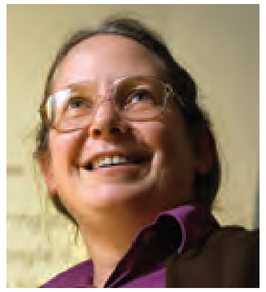
AWARDS AND HONORS


Lynden Archer


Ilana Brito


Christina Delimitrou


Louis Derry

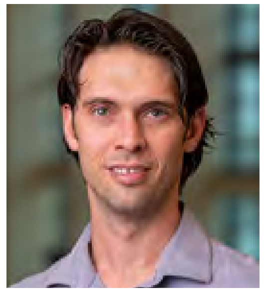

Kathy Dimiduk


Hadas Ritz


Jeff Moses


Traci Nathans-Kelly

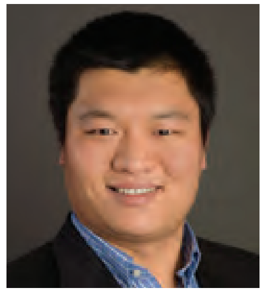

Silvia Ferrari

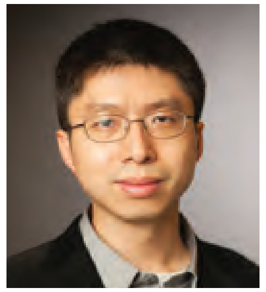

Ziv Goldfeld


Peter McMahon


Patrick Reed


Meredith Silberstein


Fengqi You


Zhiru Zhang

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**

Lynden Archer, the Joseph Silbert Dean of Engineering (CBE), was featured on the Wikipedia homepage on June 2 as part of the website's "Did You Know" series. The entry read: "Did you know that in 2016, *Scientific American* listed one of Lynden Archer's discoveries among their top-10 'world changing ideas' for that year?"

Ilana Brito, assistant professor and Mong Family Sesquicentennial Faculty Fellow (BME), received an Accelerator Award from the Lupus Research Alliance and sponsoring partner Bristol Myers Squibb for her work looking at the specific effects of bacteria in the gut on the immune system of lupus patients. This research will help identify new markers of lupus that could serve as targets for treatment and possibly diagnosis.

Christina Delimitrou, assistant professor and the John and Norma Balen Sesquicentennial Faculty Fellow (ECE), was named this year's TCCA Young Computer Architect by the IEEE Computer Society, recognizing her outstanding research contributions to the field of computer architecture.

Louis Derry, professor (EAS), was elected a fellow of the Geological Society of America, an honor that recognizes exceptional members of the geoscience community. Derry's research includes studying biogeochemical processes at multiple time scales. His recent work includes elemental speciation and cycling in soil-plant-water systems, and the role of atmospheric deposition, among other projects.

Kathy Dimiduk, director of the McCormick Teaching Excellence Institute (MTEI), Hadas Ritz, senior lecturer (MAE), Orlay DeJesus Santa, MTEI coordinator, and Lesa Carter, MTEI service professional, had their paper, "Mid-semester Course Feedback Surveys Extend the Reach of an Engineering Teaching Center," sweep the 2020 Section Best Paper Awards at the American Society for Engineering Education St. Lawrence Section Conference, winning both the Best Diversity Paper Award and the Best Paper Award.

Rick Evans, director of the Engineering Communications Program, Jeff Moses, assistant professor (AEP), and Traci Nathans-Kelly, senior lecturer, received the "DELOS" Best Paper Award at ASEE 2020 in the Division of Experimentation and Laboratory-Oriented Studies. The paper is titled "Developing Best Practices for Teaching Scientific Documentation: Toward a Better Understanding of How Lab Notebooks Contribute to Knowledge-Building in Engineering Design and Experimentation."

Silvia Ferrari, the John Brancaccio Professor (MAE), was elected an Associate Fellow for the Class of 2021 in the American Institute of Aeronautics and Astronautics and a Fellow of the American Society of Mechanical Engineers. Ferrari is the director of the Laboratory for Intelligent Systems and Control and director of the Veho Institute for vehicle intelligence.

Ziv Goldfeld, assistant professor (ECE), received an IBM 2020 University Award, which is intended to promote curriculum innovation to stimulate growth in disciplines and geographies that are strategic to IBM. Goldfeld received the award for the theoretical machine learning research he is doing jointly with collaborators from the IBM-MIT Watson AI Lab.

Peter McMahon, assistant professor (AEP), was named a CIFAR Azrieli Global Scholar, a program that supports outstanding early-career researchers through mentorship, a global network, professional skills development, and $100,000 in unrestricted research support for two years. CIFAR's community of fellows includes 20 Nobel laureates and more than 400 researchers from 22 countries.

Patrick Reed, the Joseph C. Ford Professor (CEE), won the top 2020 Gold Medal prize in the global "Humies" competition hosted by the Association for Computing Machinery Special Interest Group in Genetic and Evolutionary Optimization, awarded for the top evolutionary algorithm derived breakthrough that exceeds prior human benchmarks. Reed's research determined the right combination of factors that would enable a four-satellite constellation to maintain nearly continuous 24/7 coverage of almost every point on Earth.

Meredith Silberstein, associate professor (MAE), received a 2020 DARPA Young Faculty Award for her proposal "Theory and Realization of Bioinspired Polyelectrolyte-Based Soft Matter Circuits," which will lead to a new approach for ionic circuit design that will capitalize on the intrinsic properties of soft matter.

Fengqi You, the Roxanne E. and Michael J. Zak Professor (CBE), was selected for recognition by the journal *Industrial & Engineering Chemistry Research* in its 2020 Excellence in Review Awards, his fifth consecutive year of recognition. The journal used more than 6,000 reviewers during the last 12 months, but only 35 were selected for the number, quality and timeliness of their reviews. He also won the Young Investigator Award for Innovations in Green Process Engineering from the American Institute of Chemical Engineers. The award was given for You's outstanding research in system engineering analysis of product life cycles and sustainable engineering.

Zhiru Zhang, associate professor (ECE), received a $50,000 award from Facebook Research for his proposal titled "Algorithm-Systems Co-Optimization for Near-Data Graph Learning." The project aims to improve the efficiency of machine learning on graphs, which are being adopted in a new generation of recommender systems.

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

ALUMNI PROFILE

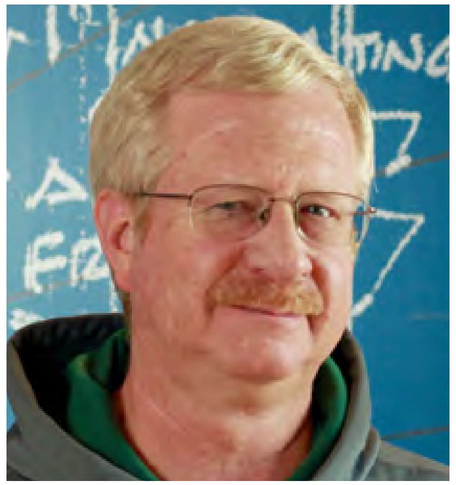
GREG GALVIN, M.S. '82, PH.D. '84, MBA '93

ALUMNUS COMPANY RAMPS UP PRODUCTION OF RAPID COVID-19 TEST

By Syl Kacapyr

With 22,000 pounds of assembly line equipment sitting outside his company headquarters, Greg Galvin, M.S. '82, Ph.D. '84, MBA '93, quips that he forgot to factor the global pandemic into his business plans for this year.

Galvin is the founder and CEO of Rheonix, an Ithaca-based biotechnology company that is ramping up production of its fully-automated, same-day test for SARS-CoV-2, the virus that causes COVID-19. Since February, Rheonix has grown from 50 to 125 employees and doubled most of its manufacturing equipment. It is now installing an automated assembly line to meet the national demand for rapid testing.



Greg Galvin, M.S. '82, Ph.D. '84, MBA '93, founder and CEO of Rheonix.

The simple-to-use diagnostic system consists of the Rheonix COVID-19 MDx Assay, a biomolecular analyzer that detects genetic material from a person's respiratory sample. Up to 24 assays can be processed at once after being loaded into the Encompass MDx workstation, which does not require a technician or advanced knowledge to operate.

Production of the assay and workstation has mostly been at the mercy of a crippled supply chain, according to Galvin, but Rheonix has been meeting as much of the demand as possible ever since the FDA authorized emergency use of their assay in April.

Rheonix's early entry into the coronavirus testing market came as the company was already seeking FDA approval of a similar assay for rapid testing of sexually transmitted infections. The technology needed to produce a coronavirus test was so similar, Rheonix had a working prototype in February, just three weeks after the CDC published the virus's genetic sequence. Galvin said it was just a matter of altering the system to detect a different genetic target—a business move that not only made sense financially, but also virtuously.

"The sense of urgency was apparent and the need was personal for everyone at the company," said Galvin. "But also this ability to develop a product, put it out in our local community and create immediate benefits, I think it really helped motivate people."

Among the first organizations to receive the test were Cayuga Health in Ithaca and United Health Services in Binghamton, New York. The assays enabled Cayuga Health to open one of the first drive-through testing stations in the state. With the recent installation of additional Rheonix instruments health officials say they can now process around up to 2,000 samples per day while providing same- or next-day results.

When it comes to the accuracy of rapid testing, Rheonix is scoring high marks. Comparative data released by the FDA in September show that of 58 molecular assays compared, Rheonix's scored the fourth highest in its ability to detect a small amount of viral material in a given sample.

The COVID-19 MDx Assay is a biomolecular analyzer that can detect COVID-19 using genetic material from a respiratory sample. Credit: Nancy J. Parisi.

"We were very pleased to see the results," said Galvin. "We knew our test was very sensitive, but what really surprised me out of that data was how wide the disparity between the different tests actually is. I really didn't expect the tests to be that different."

While Rheonix ramps up production of its COVID-19 assay, it will also be seeking FDA approval of a newly developed assay that can target four viruses at once: influenza A, influenza B, respiratory syncytial virus, and COVID-19.

"The physical symptoms of COVID and the flu are very similar, so distinguishing between the two diseases is clinically important because the treatment protocols are completely different for them," said Galvin.

Amid all the success of Rheonix, Galvin reflected on his time at Cornell and his education's influence on the company. Unlike Kionix—a manufacturer of microelectromechanical systems sold by Galvin in 2009—Rheonix is not based on Cornell technology. However, Galvin said that doesn't mean it's not a Cornell-inspired company.

"Rheonix is an example of the much, much greater number of startup businesses that are created by Cornellians that don't necessarily use Cornell intellectual property," said Galvin. "The university is fostering a lot more entrepreneurial activity than just the number of startups that use Cornell technology. Whether it's Cornell intellectual property or a Cornell alum, it's still a Cornell creation."

Galvin is a former member of the Cornell University Board of Trustees and also serves on the advisory councils for Cornell Engineering and the Department of Materials Science and Engineering. He is a frequent speaker on campus and has created a graduate fellowship to support engineering students. In 2014, he was named Cornell Entrepreneur of the Year. Galvin is also the proud father of three Cornellians, Thomas ENG'19, Kristen A&S'21 and Andrew ENG'23.

A Rheonix employee uses the Encompass MDx workstation. Credit: Nancy J. Parisi.

CornellEngineering

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