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04
FEATURE
04 HOME Away from Home
06 NASA Invests in 3D Printing for Aviation

08
RESEARCH
08 Breakthrough in Mind-Controlled Robotic Arm
10 A New Route for Plant Nutrient Delivery
12 Anticipating Change
16 CMU Among First To Pilot Supercomputer
18 Could Wildfires Be Contributing to Heart Disease?
20 Flyovers Aid Agriculture
21 Are Strawberries the Key to an Insulin Pill?
22 Calling All Nano-makers!
24 Magnetic Materials for Motors of the Future
26 Communications Technologies for Monitoring the Great Outdoors
28 Securing the Energy Grid with Blockchains
29 Electronic Tattoos for Wearable Computing
30 6 Things You Should Know About AI

34
INSIDE THE COLLEGE
34 Safety Lights
36 Pileggi Named ECE Department Head
38 Qian Awarded Inaugural Chair
39 In Memoriam

32
DEPARTMENT NEWS

41
STUDENT NEWS
41 EEG and Student Innovation
42 Animal Kingdom 2.0
43 Lungs From Scratch

44
ALUMNI
44 Connecting Native Alaskan Villages to Sanitation Infrastructure
46 Where the Action Was
48 Gift To Advance Mechanical Engineering
50 Shoot for the Stars
CMU's competitive hacking team has won DefCon more than any other team in history.

**AN UNPRECEDENTED WIN**

Carnegie Mellon University's competitive hacking team, the Plaid Parliament of Pwning (PPP), won its fifth hacking world championship in seven years at this year's DefCon security conference, widely considered the “World Cup” of hacking. The championship, played in the form of a virtual game of “capture the flag,” was held August 8-11 in Las Vegas. PPP now holds two more DefCon titles than any other team in the 23-year history of DefCon hosting the competition. The CMU hacking team began competing at DefCon in 2010, and since then they have won the contest in 2013, 2014, 2016, 2017, and now 2019.

The winning team included Tim Becker, Corwin de Boor, Jay Bosamiya, Susie Chang, Ryan Goulden, Erye Hernandez, Sam Kim, Benjamin Lim, Tyler Nighswander, Brian Pak, Jenish Rakholiya, Matthew Savage, Max Serrano, Artemis Tosini, Wong Wai Tuck, Zach Wade, Andrew Wesie, Ned Williamson, Robert Xiao, Ricky Zhou, Richard Zhu, and Carolina Zarate.
It has been incredibly rewarding to serve as interim dean this year. As I look across the College, I have deep appreciation for the way we drive research. Riveted by the expertise of our faculty, I can confidently say that we are in a strong position to provide thought leadership on emerging topics, whether it is restoring the vitality of our infrastructure, engineering better medicines, or realizing the economic benefits of advanced manufacturing, among many others. The extent to which we collaborate with colleagues outside of the university is what magnifies our influence in the world. Here are several recent examples of how the company we keep broadens the College’s footprint.

Mill 19 at Hazelwood Green celebrated its grand opening on September 4. Located less than three miles from Carnegie Mellon, Mill 19 is an extension of campus that allows us to take on more large-scale projects with industry. Mill 19, which houses the Manufacturing Futures Initiative (MFI) and Advanced Robotics for Manufacturing (ARM), is intended to transform manufacturing and catalyze economic development in Pittsburgh and beyond. We are looking forward to other partners joining us in the future.

On September 19-20, the 2nd annual Carnegie Mellon Forum on Biomedical Engineering was held on campus. Endorsed by the International Academy of Medical and Biological Engineering, approximately 300 people from more than 20 universities attended the Forum to explore the grand challenges in biomedical engineering and other salient topics.

With regard to education, three years ago, ANSYS, Inc. and Carnegie Mellon University announced a partnership to educate the next generation of engineers. And now on October 31, 2019, we will celebrate the grand opening of ANSYS Hall. The new 36,000 square-foot building is where students, faculty, and collaborators will innovate and interact in a spacious maker facility with cutting-edge simulation and fabrication tools.

As you can see, great things happen when we collaborate with industry and others. This proclivity for collaboration is in our DNA, and it is what keeps us at the forefront of engineering research and education.

Sincerely,
Jonathan Cagan
Interim Dean, College of Engineering
If we intend to explore the Moon or Mars, astronauts need smart habitats that will support life and remain operational when they are vacant. To advance the design of autonomous systems for space habitats, NASA is funding a multi-university Space Technology Research Institute called Habitats Optimized for Missions of Exploration or more fittingly, HOME.

Mario Bergés, associate professor of Civil and Environmental Engineering (CEE), is leading the Carnegie Mellon University (CMU) research team working under the auspices of the center. Their task is to enable complete situational awareness in the habitat by providing it with capabilities to process and interpret its own data and make decision recommendations that can be passed on to robotic systems or suggested to human occupants.

“Space is harsh and errors can be catastrophic, so we need autonomous systems that are very good,” says Bergés. One idea the team is exploring is the application of artificial intelligence (AI) to analyze equipment data to understand electricity use in the habitat. If we know how power is consumed, we could learn the status of all the electric-powered systems in the habitat.

We have experience conducting data analysis for equipment on Earth, but we have to learn how to translate this knowledge to the context of space and specifically to the systems in these habitats.

For example, on Earth we have a variety of air-conditioning systems, and we can figure out where potential faults are and how they happen. But in the new habitats, all the systems will be one-offs. “How do you conduct automated fault detection and diagnosis without a lot of system data? This is where AI comes in,” says Bergés. “We have machines that learn by themselves if you give them enough data, but we don’t have a lot of machines that can reason by using existing engineering knowledge, which can reduce the amount of data they need.”

To rein in the amount of data needed to detect equipment faults throughout the habitat, the team will collect electrical measurements. This data will be shared with robotic systems that will process it and act on the physical environment, and in theory enable the habitat to maintain itself.

The CMU team is comprised of Bergés, an expert in sensing and data analysis for infrastructure, and Burcu Akinci, a CEE professor and expert in information modeling. Rounding out the team is Stephen Smith and Artur Dubrawski from CMU’s Robotics Institute, who will lead research on machine learning and robotic systems. CMU’s research will feed into other projects underway in the institute.

HOME is funded for five years for approximately $15 million, and NASA may apply recommendations spinning out from the institute before the funding period ends. According to Bergés, CMU’s research could potentially inform the design of a gateway station that will orbit the Moon as part of NASA’s deep-space exploration plans.

Bergés believes that civil engineers will play a role in space exploration. “Since the beginning, civil engineers have been the stewards of the infrastructure that supports modern life. If humanity is moving into space, it makes sense for civil engineers to be part of that.”
ILLUSTRATION OF THE INTERIOR OF A DEEP SPACE HABITAT

SOURCE: NASA
Additive manufacturing (AM) is a promising new technology for all areas of aviation manufacturing. Additive manufacturing’s flexibility in design and customization, cost reduction, and speed in delivering finished parts make it a perfect fit for creating parts used in aviation contexts.

At the leading edge of this new frontier in aviation is Carnegie Mellon University’s Next Manufacturing Center and Manufacturing Futures Initiative (MFI). Carnegie Mellon has been selected by the National Aeronautics and Space Administration (NASA) to lead a research team dedicated to examining new ways to build and power aircraft of the future, through NASA’s University Leadership Initiative (ULI). As part of the Transformative Aeronautics Concepts Program, Carnegie Mellon will help solve the nation’s most pressing problems in aviation.

Carnegie Mellon’s project will be led by Tony Rollett and Jack Beuth, faculty co-directors of Next Manufacturing, and will include additional engineering faculty Erica Fuchs, Elizabeth Holm and Kenji Shimada. The team will receive nearly $7 million over three years.

“We are truly honored to be selected for this NASA ULI,” said Rollett, a professor of materials science and engineering. “Over the last eight years, metals AM has had a significant impact on aviation manufacturing for jet engine components, airframe structural elements, and other applications. We believe this project will continue to substantially advance U.S. manufacturing capabilities in the aerospace and aviation industries.”

The research team—which will include partners from Argonne National Laboratory, ANSYS, Lockheed Martin, Trumpf, Eaton, General Electric, Pratt & Whitney, Northrop Grumman, Metal Powder Works, Siemens, Materials Solutions and The Barnes Group—will explore new methods for using additive manufacturing to reduce costs and increase the speed of mass-producing aircraft without sacrificing quality, reliability and safety.

Studies and testing will be carried out in Carnegie Mellon’s new advanced manufacturing facility in the
Hazelwood neighborhood of Pittsburgh. The building is being constructed entirely within the enormous skeleton of the historic steel mill known as Mill 19, located on the Hazelwood Green development site. Mill 19 will be a central hub for advanced collaboration in the manufacturing space, housing MFI, industrial scale activities of the Next Manufacturing Center, and the Advanced Robotics for Manufacturing (ARM).

“Process qualification is one of the most important challenges for additive manufacturing over the next five to 10 years. This project, our university-industry team, and the facilities at Mill 19 are coming together at just the right time,” said Beuth, professor of mechanical engineering.

The successful implementation of the project’s qualification framework for laser powder bed fusion 3D printing will bring down the cost of manufacturing, particularly for short production run parts and replacement parts, as well as boost economic growth through enabling small contractors to qualify their AM processes and equipment.

The NASA ULI program was created to initiate a new type of interaction between the Aeronautics Research Mission Directorate (ARMD) and the university community, where U.S. universities take the lead, build their own teams and set their own research path. This initiative seeks new, innovative ideas that can support the NASA ARMD portfolio and the U.S. aviation community.

Carnegie Mellon faculty Holm (materials science and engineering), Shimada (mechanical engineering), and Fuchs (engineering and public policy) will bring expertise in machine learning, robotics and commercialization to the project. Other partners on this project include the University of Pittsburgh, Case Western Reserve University, Worcester Polytechnic Institute, Colorado School of Mines, the University of Texas at El Paso, and the Air Force Research Laboratory’s Materials and Manufacturing Directorate.
A team of researchers from Carnegie Mellon University, in collaboration with the University of Minnesota, has made a breakthrough in the field of noninvasive robotic device control. Using a noninvasive brain-computer interface (BCI), researchers have developed the first-ever successful mind-controlled robotic arm exhibiting the ability to continuously track and follow a computer cursor.

Being able to noninvasively control robotic devices using only thoughts will have broad applications, in particular benefiting the lives of paralyzed patients and those with movement disorders.

BCIs have been shown to achieve good performance for controlling robotic devices using only the signals sensed from brain implants. When robotic devices can be controlled with high precision, they can be used to complete a variety of daily tasks. Until now, however, BCIs successful in continuously controlling robotic arms have used invasive brain implants. These implants require a substantial amount of medical and surgical expertise to correctly install and operate, not to mention cost and potential risks to subjects. As such, their use has been limited to just a few clinical cases.

A grand challenge in BCI research is to develop less invasive or even totally noninvasive technology that would allow paralyzed patients to control their environment or robotic limbs using their own “thoughts.” Such noninvasive BCI technology, if successful, would bring such much-needed technology to numerous patients and even potentially to the general population.

However, BCIs that use noninvasive external sensing, rather than brain implants, receive “dirtier” signals, leading to lower resolution and less precise control. Thus, when using only the brain to control a robotic arm, a noninvasive BCI doesn't stand up to using implanted devices. Despite this, BCI researchers have forged ahead, their eye on the prize of a less- or non-invasive technology that could help patients everywhere on a daily basis.

Bin He, department head and professor of biomedical engineering at Carnegie Mellon University, is achieving that goal, one key discovery at a time.

“There have been major advances in mind controlled robotic devices using brain implants. It’s excellent science,” says He. “But noninvasive is the ultimate goal. Advances in neural decoding and the practical utility of noninvasive robotic arm control will have major implications on the eventual development of noninvasive neurorobotics.”

Using novel sensing and machine learning techniques, He and his lab have been able to access signals deep within the brain, achieving a high resolution of control over a
robotic arm. With noninvasive neuroimaging and a novel continuous pursuit paradigm, He is overcoming the noisy EEG signals leading to significantly improve EEG-based neural decoding, and facilitating real-time continuous 2D robotic device control.

Using a noninvasive BCI to control a robotic arm that's tracking a cursor on a computer screen, for the first time ever, He has shown in human subjects that a robotic arm can now follow the cursor continuously. Whereas robotic arms controlled by humans noninvasively had previously followed a moving cursor in jerky, discrete motions—as though the robotic arm was trying to “catch up” to the brain's commands—now, the arm follows the cursor in a smooth, continuous path.

In a paper published in Science Robotics, the team established a new framework that addresses and improves upon the “brain” and “computer” components of BCI by increasing user engagement and training, as well as spatial resolution of noninvasive neural data through EEG source imaging.

The paper, “Noninvasive neuroimaging enhances continuous neural tracking for robotic device control,” shows that the team's unique approach to solving this problem not only enhanced BCI learning by nearly 60% for traditional center-out tasks, it also enhanced continuous tracking of a computer cursor by more than 500%.

The technology also has applications that could help a variety of people, by offering safe, noninvasive “mind control” of devices that can allow people to interact with and control their environments. The technology has, to date, been tested in 68 able-bodied human subjects (up to 10 sessions for each subject), including virtual device control and controlling of a robotic arm for continuous pursuit. The technology is directly applicable to patients, and the team plans to conduct clinical trials in the near future.

“Despite technical challenges using noninvasive signals, we are fully committed to bringing this safe and economic technology to people who can benefit from it,” says He. “This work represents an important step in noninvasive brain-computer interfaces, a technology which someday may become a pervasive assistive technology aiding everyone, like smartphones.”

This work was supported in part by the National Center for Complementary and Integrative Health, National Institute of Neurological Disorders and Stroke, National Institute of Biomedical Imaging and Bioengineering, and National Institute of Mental Health.
A NEW ROUTE FOR PLANT NUTRIENT DELIVERY

Agriculture across the globe needs new solutions for food and water sustainability. With more frequent climate extremes, growing populations, increased food demand, and global crop threats, environmental engineers are searching for solutions to manage food production for the future, starting at the tiniest level.

With current practices, up to 95% of applied micronutrients and 99.9% of applied pesticides never reach their destinations and are wasted. They accumulate in the soil or run off into the ground water and cause collateral environmental damage, degrade soil, and waste the water and energy used in their production and application.

The researchers sprayed gold nanoparticles with a polymer coating onto the leaves of young wheat plants. Plants don't need gold, but since gold doesn't exist anywhere in the plant, they were able to easily identify where it traveled. They used wheat plants because they are an important crop in the United States and susceptible to nutrient deficiencies.

Once the nanoparticles are sprayed onto the leaf, they move through the cuticle, which is the waxy outer layer covering the leaf. Then, it crosses the epidermis. The cuticle and epidermis are layers that protect the leaf from harm, prevent water loss, and allow gas exchange for the plant to breathe. The nanoparticle then makes its way into the inner leaf tissue, or mesophyll. Finally, it moves into the vasculature of the plant, or the plant's veins. From there it can travel all the way down the stem and into the root, or up to higher leaves.

The researchers demonstrated that once reaching the roots, nanoparticles can be exuded into the soil, adhering to the microenvironment that sticks to the roots called the rhizosphere. The rhizosphere is where the plant interacts with the soil, takes in nutrients, releases small acids, carbon dioxide, and proteins, and where bacteria and fungi can enter the plant. The only methods currently available to
treat an unhealthy rhizosphere are mixing agrochemicals in the soil or applying water with the chemicals. In both cases a large amount of chemicals are lost. What the researchers have shown is 100% efficient delivery that can decrease the amount of chemicals needed, lower the cost, and limit environmental contamination.

These tiny particles—which are smaller than 50 nanometers—could be one very important key to sustainably feeding the 10 billion people projected to be on the planet by 2050. For example, wheat plants growing in zinc-deficient soil turn yellow and crop production decreases as plants start to die. But if you could deliver zinc oxide nanoparticles through the leaves to reach the root, they could exude into the soil and make both the soil and the plant healthy.

Farmers could also deliver antibiotics to the plant. Once a plant gets bacteria into its vasculature, there’s little that can be done to save it. But if antibiotic nanoparticles could be delivered through the leaves to get into the vasculature, they could prevent or treat systemic bacterial diseases.

Nanoparticles are also more effective than chemicals because engineers can design them to have specific properties. For example, they could design a nanoparticle that will stick to a leaf without dripping off when it rains. Or they can engineer the coating on the outside of the particle to respond to moisture or light. It is also possible to design nanoparticles that will be used in fewer quantities and are better for both the environment and human health than the conventional agrochemicals used currently. The possibilities are endless, and this is an important first step.

Delivering nanoparticles on plants in a 100% efficient way is part of Lowry’s larger goals of atom-efficient agriculture (where every atom put on crops is used and not wasted) and combatting societal challenges such as food insecurity.

“We’re at this point where we’ve got to grow 80% more food, on the same amount of land, with less pollution resulting from it,” said Lowry. “That’s going to take a paradigm shift of the way we do agriculture, and that’s what we’re trying to help.”

**How Agrochemical Delivery Works**

1. The engineered nanoparticle, coated in a polymer, is sprayed onto the leaf.
2. It moves through the cuticle, or the waxy outer layer that protects the leaf from harm.
3. Then it crosses the epidermis, another protective layer that prevents water loss and allows gas exchange.
4. Once in the epidermis it moves through the mesophyll, which is the inner leaf tissue.
5. From the mesophyll it enters the vasculature, or the plant’s veins.
6. It travels through the phloem down to the roots.
7. From the roots it can be exuded into the soil.
Anticipating Change
The buildings of today may not be fit for the weather of tomorrow. The increasing rapidity at which our climate is changing means that many designers must now build with the expectation that significant environmental change within the lifetime of a building could become the norm. In order to ensure the safety and stability of our infrastructure this must be taken into consideration, but to design for every possible threat could be prohibitively expensive. The question then—how do we plan for the unknown?

Matteo Pozzi and Peter Adams of the Department of Civil and Environmental Engineering are helping lay out a road map for designers faced with these tough decisions. Their decision-making model combines infrastructure and climate data readily available, but also takes into account the information expected to be available in the future.

They posit that if projected learning rates could provide a better understanding of the effects and threats of climate change, it may be more sensible to provide a greater degree of flexibility in design. Though more costly than “fixed” designs, this could allow future building or other infrastructure managers more options in adapting infrastructure to the expected changes in climate conditions. Conversely, if there is little reasonable expectation of more climate information being available in the future, designers can more confidently invest in cheaper, fixed designs.

Through modeling the relationship between flexibility in infrastructure design and the rate at which we expect to learn about climate change, this project will provide a valuable tool for urban planners, architects, engineers, and many other infrastructure stakeholders. By trying to provide an accurate vision of the future, they can lower the risk of wasting resources on over-designing against every possible outcome, while limiting the dangers of under-designing. They also plan to assess the value of gathering additional information and how that affects our expected learning rates.

By providing a barometer for our current and expected knowledge, Adams and Pozzi are helping infrastructure designers create more resilient, long-lasting infrastructure for an uncertain future.
Has the city where I live gotten hotter? Does it rain more or has it gotten drier? Are there more days of extreme heat? In short, what’s going on with climate change in my specific location?

“That is actually a very difficult question to answer,” according to Dave Dzombak, professor and head of the Department of Civil and Environmental Engineering (CEE).

The big picture of global climate change has been close to unanimously agreed upon by the scientific community, and, increasingly, by a majority of Americans: Earth is heating up, sea-levels are rising, and weather events are becoming more frequent and extreme. And while these broad patterns are well understood, the story of local climate change is more varied.

For instance, the average annual temperature today in New York City is more than four degrees warmer than at the beginning of its climate record in 1869. But just 300 miles west in Pittsburgh, on the other hand, things are actually cooler now compared to the late 19th century. And while Baltimore has seen an increase in precipitation, a short drive down I-95 in Washington D.C., environmental conditions are drier now compared to the beginning of climate records in those cities. When you zoom in past broad regions to focus on individual cities, “there are a lot of interesting stories,” says Dzombak.

In an article in the Journal of Climate, CEE Ph.D. student Yuchuan Lai and Dzombak published the climate histories for more than 100 U.S. cities, constructed from daily measurements of temperature and precipitation dating back as far as 150 years.

Despite the long existence of climate measurements at weather stations across the U.S., records at any single station can be spotty (missing data over long stretches) or only cover limited periods of time. And data from different weather stations are spread out across disparate databases, making it difficult (or impossible) to find a complete record for a particular city.

Moreover, large-scale climate assessments aggregate temperature and precipitation data across many different stations. This approach alleviates issues related to spotty data, and is useful for assessing regional climate changes (e.g. there is more precipitation today in the Northeastern U.S.). But, it inherently glosses over the climate histories of specific places.

Driven by the question “what’s going on with the climate in particular locations?” Lai and Dzombak used data science tools to compile records for as many places in the U.S. as they could. Using National Weather Service databases from the National Oceanic and Atmospheric Administration, they systematically combined data across different time periods and closely located weather stations to create a composite climate history for each location. Now, the question above can be answered readily for more than 100 U.S. cities.

Such city-level climate records are of interest to civil and environmental engineers, as well as urban planners and infrastructure managers, as location-specific information informs design choices for future projects. For example, drainage systems for highways must be built to accommodate rain deluges, and heating-cooling systems for buildings need to anticipate both the coolest and hottest days. Despite broad patterns, specific places have had their own unique changes in climate, and the future will be no different.

Moving forward, Lai and Dzombak are working on extrapolating their city-level climate records to make near-term projections (1-20 years). This is a different approach from physics-based climate models, which are intended to be useful for broad areas and longer time periods, but do not capture differences between cities with great accuracy. “We’re proposing an alternative,” said Lai, by “making projections based on the historical data.” These statistical models, the focus of Lai’s current work, will help engineers make infrastructure design and management decisions tailored to meet a city’s unique future climate demands over the coming decades.

“As an engineer, I need climate information for the specific place where I’m working. I’m not interested in average climate change across North America,” said Dzombak. “I’m interested in Pittsburgh, or Phoenix, or wherever my project is located.”
The modern city is a wonder of technological innovation, but the massive collections of infrastructure that allow our urban centers to function also causes disruption to many natural processes. Man-made materials trap and hold heat and disrupt air flow, causing the urban heat island effect, while the abundance of hard surfaces prevent water from infiltrating and dispersing through the soil.

In 2005, to help alleviate problems like these, future head of Carnegie Mellon’s Civil and Environmental Engineering Department Dave Dzombak helped create the university’s first green roof. Situated on a sub-roof of Hamerschlag Hall, that first green roof has now become one of many dotting CMU’s campus, including on Gates Hall, Doherty Hall, the Cohon University Center, and the Tepper Quad building. Some even collect excess water to use for other purposes, such as in waste disposal. The original green garden still remains, virtually untouched since a study in 2011. Now, almost a decade later, graduate student Marissa Webber is returning to that original garden to analyze its efficacy today.

Green roofs are meant to soak up water which would otherwise flow into storm drains as runoff, and to provide an extra layer of insulation to reduce energy usage. They are one form of green infrastructure, a developing field that has only existed for the past few decades. The idea at the center infrastructure design mirrors that which spurs Webber’s interest in environmental engineering: “understanding what natural systems are able to do and how we can incorporate either that functionality, or the natural system itself, into our design.”

Part of the challenge of working in this nascent field is the scarcity of information available—thus, the need for follow-up work, like Webber’s. By taking measurements of weather conditions like temperature, relative humidity, rainfall, wind speed, wind direction, and pressure, her project will help show how effective green roofs are over time and how maintenance may affect their lifespan.

Data collection at the Hamerschlag Hall roof will continue for the foreseeable future, providing information as the green roof ages. Although still in its infancy, research suggests that climate change is already shaping the green infrastructure space; green roofs like those at CMU are designed to help mitigate runoff from regular rainfall events, and are less effective at handling the increasingly severe weather we see brought on by climate change. Green engineers like Webber inherit a field that, like a growing number of infrastructure stakeholders, will continually have to adapt to meet the challenges posed by our changing climate.
In 1964, the CDC 6600 was the fastest supercomputer in the world. Designed by Seymour Cray, widely considered the “father of the supercomputer,” it was an integral driver of some of the most innovative research of the day, making its way into the operations of the Lawrence Berkeley National Laboratory, CERN, and many others. The CDC 6600 operated at a frequency of 40 MHz, and could perform three million floating point operations per second (FLOPS). The iPhone X, on the other hand, tops out at 100 billion FLOPS. And while it’s not surprising that today’s smartphones can run circles around yesterday’s supercomputers, it does beg the question: If the original supercomputers were able to drive so much innovation, what could we do with the supercomputers of today?

In early 2020, the National Energy Research Scientific Computing (NERSC) Center will celebrate the arrival of the Perlmutter supercomputer, designed by none other than Cray Inc. It boasts the ability to hit a whopping 100 million billion FLOPS. And Carnegie Mellon’s Zachary Ulissi will be one of the first to use it.

“When this machine comes online, it will be one of the largest open-science machines in the U.S.,” says Ulissi, an assistant professor in chemical engineering. “Our day-to-day work uses machine learning methods and high throughput calculations, but in the past, these tasks often had to be done in separate locations due to limited computational resources. The Perlmutter supercomputer will greatly accelerate both the data generation and the machine learning model development, allowing us to compute many more iterations of our models much, much faster.”

According to NERSC, Perlmutter is the first supercomputing system designed to enable both data analysis and simulation. Participants in this first round are encouraged to explore applications of the Perlmutter’s capabilities in three ways: simulation of complex physical phenomena, real-time data analytics through the supercomputer’s GPU architecture, and cutting-edge machine and deep learning solutions.

Ulissi and his research team will be using Perlmutter’s expanded computing power to accelerate their search for new materials that can serve as active catalysts for renewable energy chemistries. His project was chosen as part of the NERSC Early Science and Application program, and as such, the team will work with high performance computing experts at NERSC to develop and tune GPU-accelerated machine learning methods for this new machine. The project will then be used to demonstrate to future users the impact of the new machine, and to verify that it runs according to its targeted specifications.

“We do hundreds of expensive calculations every day to search for catalysts that can more efficiently split water to produce renewable hydrogen, directly convert waste CO$_2$ into a valuable feedstock chemical, and improve the efficiency of hydrogen fuel cell vehicles,” says Ulissi. “All of these technologies are important in an increasingly electrified chemical economy.”

As the quest for more efficient electrified vehicles gains steam, research must accelerate to keep up with demand. As the market grows, so must our fuel cell technology. Researchers like Ulissi are on the cutting edge of this drive, but they can only do so much on their own. With current computing technology, it takes a lot of time and money to analyze each catalyst, in search of which will provide fuel cells with greater efficiency and capacity. With supercomputing technology like Perlmutter at their disposal, however, Ulissi and his team will be able to perform more of these calculations much faster, enabling them to develop technologies that will bring us closer to a zero-emissions transportation sector—just as CDC 6600, way back in 1964, helped shape the world as we know it today.
The College of Engineering’s Behind the Researcher series explores the talents of our faculty outside of the classroom and the lab. The series illustrates that our collective versatility starts with unique and passionate individuals who make up our diverse and multi-talented community. From an organist to a glass-blower to a competitive cyclist, get to know the researchers shaping the future of engineering.

Visit the College’s YouTube channel for the latest Behind the Researcher videos.
U.S. WILDFIRES POSE A SERIOUS THREAT TO HUMAN HEALTH—

AND NOT JUST IN THE AREA OF THE BURN.
The destructive force of wildfires in the U.S. is well documented. Every year, on both the east and west coasts of the country, and due to both environmental and man-made factors, fires rage, and homes and habitats are destroyed. But beyond the obvious dangers, these fires cause other, more invisible damages. Certain nanoscale particles in the atmosphere known as organic aerosols—particles released when organic materials like trees and other plant matter are burned—have been linked to an increased risk of heart disease, and even death.

These particles don’t just pose a threat to the region where the fire burns. Until now, most models of atmospheric particle movement have made certain assumptions about how these organic aerosols will affect human health based on how they react with the atmosphere. But in their recent paper published in *Atmospheric Environment*, authors Spyros Pandis, research professor of chemical engineering; Allen Robinson, head and professor of mechanical engineering; and Laura Posner, chemical engineering Ph.D. alumna, are challenging those assumptions, and revealing just how dangerous organic aerosol emissions can be.

“Biomass burning is a major global source of organic aerosols,” the authors write in the paper. “Biomass burning organic aerosol can contribute significantly to organic aerosol concentrations both locally and far downwind of fires.”

Traditionally, organic aerosols are divided into two categories, based on how they enter the atmosphere: primary organic aerosol (POA), and secondary organic aerosol (SOA). POA is directly emitted into the atmosphere as particles, while SOA is formed when some of the products of volatile organic compound oxidation condense in the atmosphere. Current chemical transport models, which track the movement of particles in the air, focus on POA emissions from fires, but neglect those from SOA.

Because of this assumption, these chemical transport models only account for the damages caused by POA, which are mostly in the burn’s immediate vicinity—the local area around the fire. This new research suggests, however, that only taking POA into account is only telling half the story—and that the effects of SOA can pose a threat to the health of people much further from the fire’s source.

The team used a three-dimensional transport model to understand how much these emissions from wildfires contributed to the total organic aerosol concentrations in the continental U.S. for three representative months during spring, summer, and fall. The model showed that while POA remained the most severe contributor to organic aerosol concentrations near the burned area, incorporating SOA into those measurements made the transport model much more accurate when compared to the observed levels of organic aerosol than other predictive models—at least for the spring and summer. In the fall, on the other hand, the model had a tendency to over-predict the levels of organic aerosol, suggesting a correlation between the temperature and the proliferation of these emissions.

“Atmospheric chemistry acts as a booster,” says Pandis, “producing additional particulate matter as the plume moves away from the fire one or two days later. The effects, of course, get smaller as one gets away from the fire, but it can remain significant up to six hundred miles away—even if it’s no longer visible as thick smoke. This enhancement is stronger during warm sunny days.”

The authors hope that this research will help expand the public’s understanding of the severity of these wildfires and the importance of limiting them in the future, just as we try to limit other sources of harmful emissions.

“The evidence suggests that these emissions are just as bad for our health as that of other combustion sources, such as vehicle and industrial emissions,” says Pandis. “The emissions from wildfires contain thousands of complex organic compounds, some of them carcinogenic.”
Kenji Shimada, professor of mechanical engineering, and his team of engineers are using drones to detect damage in agricultural water canals in a town in Niigata, an agricultural district on the northwest coast of Japan. These canals that total approximately 40,000 kilometers throughout Japan are essential for the rice farming economy.

Damage to the canals accumulates due to age, earthquakes, and extreme weather. They can only be analyzed and repaired during the annual two-month dry season. Of these two months, one and a half are devoted to laborious inspections by technicians who walk along the canals to manually identify, measure, and record damage. This leaves only two weeks for repairs.

“Forty thousand kilometers are equivalent to the equatorial circumference of Earth, and the manual labor for inspecting and evaluating the condition of water canals is enormous. We automate the work by flying autonomous drones equipped with high-resolution cameras that detect cracks and wear with machine-learning algorithms,” said Shimada.

Shimada and his team have developed a systematic framework with a fleet of drones and cars to effectively assess the canals, extending the coverage area and minimizing inspection time. Di Deng, a Ph.D. candidate in mechanical engineering, works on the coverage planning aspect of the project. Last year, she traveled to Japan to conduct field tests.

“Over the summer, we flew our autonomous drone and tried different sizes of water canals, so the system can automatically decide the position of the drone inside the water canals,” said Deng. “We tried out canals that go from 2.4 to 5 meters in width. We could clearly see a lot of stone exposed, so these were the places we needed to repair.”

Using public maps and research data, the researchers formulated an algorithm to plan the drones’ path along the canals. They can fly along different sized canals in multiple directions to record video of the walls for crack detection. The commercial drone they used is limited to thirty minutes in the air and it must stay within a range of a few kilometers from the remote controllers. This makes it impossible for the drones to cover all of the canal in one flight.

To ameliorate these limitations, the drones are paired with cars that are strategically parked to provide batteries and pick up the drones when needed.

Once the drones have recorded video of the entire canal, the data from the images is fed into a neural network to detect damaged areas and map them in CAD models. To plan paths for the drones, a scaled map of a canal is converted to a graph. This graph is then divided into subgraphs, which represent the areas they will cover. The team also graphs the roads to generate a route for the car that is within communication distance of the drones. The cars are programmed to automatically find alternative routes if faced with traffic.

The team presented their research at the International Conference on Intelligent Robots and Systems (IROS) last October. In the future, they plan to tackle potential road blocks. Additional challenges to this project include potential vehicle collisions, aerial constraints (such as flying zones, aerial traffic, and other regulations), and inaccurate maps and measurements. A long-term goal is to develop large-scale automated vehicle planning.

“We believe that this type of technology is critical to keeping the aging infrastructures healthy and safe—it enables faster, cheaper, and more regular inspection and monitoring,” said Shimada.
ARE STRAWBERRIES THE KEY TO AN INSULIN PILL?

KATHRYN WHITEHEAD HAS MADE A BREAKTHROUGH IN THE DEVELOPMENT OF AN INSULIN PILL TO TREAT DIABETES.

According to a 2015 Centers for Disease Control and Prevention (CDC) study, 30.9 million Americans suffer from diabetes. On average, individuals with diabetes inject themselves with insulin two to four times per day. This means that every single day, Americans are injecting anywhere from 61,800,000 to 123,600,000 doses of insulin. It’s not surprising, then, that there’s a high demand for new, less painful methods of administering insulin.

For many years now, researchers looking into new modes of insulin delivery have focused on the oral method—in other words, an insulin pill. And while great strides have been made toward this effort, after decades of trying, some researchers have declared such a method of insulin delivery impossible. But chemical engineering professor Kathryn Whitehead and her team have now shown that such a feat is possible.

Not only is oral insulin delivery possible, but its secret lies in an unlikely place: strawberries.

“The problem with insulin,” says research assistant Nicholas Lamson, “is that it’s a protein. The human stomach is very adept at breaking down proteins—such as with food. But in order for insulin to be therapeutic, it needs to be absorbed intact by the small intestine. This requires the insulin to be protected as it passes through the stomach.”

Researchers have developed many ways to encapsulate insulin molecules so that they can make it to the small intestine. But it’s what to do with them once they’re there that has been the biggest sticking point in this field. Allowing the proteins to pass into the small intestine fully undigested means the insulin is too large to be absorbed through the intestine and into the blood stream. And while compounds already exist that can open the pores of the small intestine, few can do it without lasting damage.

This is where Whitehead’s strawberries come in.

“We took around 110 fruits and vegetables and screened them for an ability to open up the gaps between the cells of the intestine wide enough to allow the insulin to pass through,” Whitehead says. “It turns out that the same chemical that makes strawberries red—pelargonidin—can also dilate these intestinal pores in a nontoxic way that later allows them to shrink back to normal.”

Combine this molecule with an encapsulated insulin package and voila—an insulin pill that can help diabetics manage their blood sugar with no negative side effects. But though the research team has proven the pill’s efficacy in mice, there is still a long way to go before an insulin pill is made available to human diabetic patients.

“A number of challenges must still be addressed,” says Lamson, “one of the biggest being the necessity of variable dosage. Diabetics must test their blood sugar throughout the day and administer an insulin dose appropriate for their blood sugar levels. This is easy to do with an injection, but much more difficult to do with a pill. This is the next challenge we’ll have to overcome.”

While this research can help make the oral delivery of insulin in diabetic patients a reality, that’s not all it can do. Whitehead’s lab is interested in the oral delivery of proteins in general, and her team plans to extend their strawberry technology to proteins other than insulin. That means this technology can potentially be used with other protein therapies, many of which are used to treat conditions like leukemia, osteoporosis, and autoimmune disease.

Such an advance would revolutionize healthcare as we know it, removing the pain of injections and improving the daily lives of millions of patients.
CALLING ALL NANO-MAKERS!

The Claire and John Bertucci Nanotechnology Laboratory at Carnegie Mellon is a premier nano-manufacturing hub dedicated to the invention and demonstration of micro- and nanosystems. Our mission is to provide best-in-class services and high-tech equipment to innovative nano-makers. To deliver this, the “Nanofab” houses approximately 100 processing tools in a 14,000-square-foot nanofabrication research facility located in Sherman and Joyce Bowie Scott Hall. Note the growing and diversified set of users and research areas that the “Nanofab” supports.

PIEZOELECTRIC NANOELECTROMECHANICAL RELAYS

Our vision for a connected world proliferated with sensor networks has generated a need for low-energy electronics that traditional transistors simply cannot meet alone. One example of work in this area is the development of a new form of switch called the piezoelectric nanoelectromechanical relay. This device could be the key to replacing semiconductor transistors in many applications.

These relays utilize mechanical energy—rather than changes in electronic characteristics, like transistors—to initiate a change in state. They also exhibit lower current leakage, cutting both energy usage and excess heat.

These two combined characteristics mean that devices utilizing these relays could potentially consume less energy than traditional electronics by multiple orders of magnitude. The relays’ low-energy demands mean that embedded sensors and implants may not necessarily require a battery and could instead harvest the small amount of energy they require from the environment around them or from the body, respectively.

With the last half a century of computing architecture design having been driven by Moore’s Law and built around the traditional semiconductor transistor, the long-term effects of these developments are poised to revolutionize the field of computing.

POLYMER NANOWIRES TO DISSIPATE HEAT

We are exploring ways to improve energy efficiency by more quickly dissipating the heat generated by devices, such as through the use of polymer nanowires. In their bulk form, polymers cannot transfer heat efficiently because they are made from long chain molecules that are random in their bulk form. However, researchers in the Nanofab are experimenting with drawing and aligning the molecules in polymers to give them a high thermal conductivity and make them far stronger. These drawn polymer nanowires have the potential for use in electronic equipment and other applications to help dissipate heat quickly and easily.
The nanofab has recognized a growing demand from corporate, government, and academic researchers, as evidenced by a 5x growth in customers over the past three years.

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MAGNETIC MATERIALS FOR MOTORS OF THE FUTURE

Currently motors are typically made from silicon steels. MANCs provide an alternative to silicon steels and, because of their high resistivity (how strongly they oppose an electrical current), they don't heat up as much and can therefore spin at much higher speeds.

“As a result, you can either shrink the size of the motor at a given power density or make a higher power motor at the same size,” said McHenry.

McHenry’s group, in collaboration with the National Energy Technology Laboratory (NETL), NASA Glenn Research Center, and North Carolina State University, are designing a two and half kilowatt motor that weighs less than two and half kilograms. Most recently, they’ve benchmarked it at 6,000 rotations per minute and are looking to build bigger ones that will spin even faster. The design, which is funded by the Department of Energy (DOE) Advance Manufacturing Office, combines permanent magnets with the MANCs.

To synthesize MANC materials, McHenry and his team rapidly solidify liquid metals at about a million degrees per second. Since they work at the lab scale, they look at 10-gram samples and screen them for their magnetic properties. Through various partnerships with partner research institutions and industry, they can take these MANCs and scale up the fabrication process for use in real-world applications.

During the power transformation process in a conventional motor, the magnetization of the motor materials switches, often resulting in power loss. But with MANCs, the losses associated with switching of the magnetization are greatly reduced because they are a glassy metal rather than a crystalline metal. The structural difference is at the atomic level: when the material is melted, then rapidly cooled, the atoms don't have time to find positions in a crystalline lattice.

McHenry’s group and collaborators are some of the few demonstrating the use of MANCs in motors. Their design
also uniquely uses their own patented materials—a combination of iron and cobalt, and iron and nickel, mixed with glass formers. The efficient MANCs also enable the use of lower cost permanent magnets, which do not require critical rare earth materials, in the motor design.

While the researchers test in smaller proportions at the lab scale, collaborations with companies in industry and other research labs can bring these metals to scale for use in industry.

“Eventually we can go to higher speeds and higher powers with these designs,” said McHenry. “Right now we’re benchmarking a smaller motor, and then we’ll try and build bigger ones. Motors have aerospace, vehicle, and even vacuum cleaner applications—motors are important in any number of applications. In aggregate, motors represent a huge use of electrical power, so they are one area where efficiencies can make a big difference.”
Along a flowing creek nestled in the rolling hills of Pepperwood Preserve in Sonoma County, California, Carnegie Mellon University (CMU) researchers are adapting internet of things technologies to alert authorities when flooding is imminent.

This research at a main watershed of the Russian River is supported by the United States Geological Survey (USGS), the agency within the Department of the Interior that studies the science underneath our nation’s lands and the hazards that threaten them. The USGS and CMU are exploring how sensor systems can be used to monitor major waterways to predict floods and other threats. However, the places that need sensing are often the worst places to install sensors. The earliest indications of potential problems are often found far from civilization—in remote areas that lack readily available power and wireless connectivity.

“I’m tempted to say that what we’ve got here is a failure to communicate. Not only is wireless coverage a problem, there are also power and programming problems,” begins Bob Iannucci, who is leading the research. Iannucci, the director of the CyLab Mobility Research Center at CMU Silicon Valley, explains that to create vast sensor systems, the sensors have to be inexpensive to install and maintain, and their energy source must last for years. While sensors appear to perform simple tasks, programming them to successfully run on ultra-low power presents more complications. Iannucci’s team is addressing low-power operation from the top down, including how to design the sensors, how to engineer the software, and how to internetwork them. The research is playing out in an outdoor setting that spans three thousand acres.

“We’re looking at this as a full-system problem, rather than just a sensor or radio problem,” says Iannucci. He and his team of Carnegie Mellon graduate students are adapting low-power, wide-area wireless network (LP-WAN) technologies to monitor rural areas. LP-WANs make it possible to gather sensor data over large areas at low cost.

**WHAT WE ARE BUILDING AND WHY**

At the heart of the Pepperwood Preserve installation is a solar-powered LP-WAN gateway that relays information between sensor devices at the streams being monitored in Carnegie Mellon laboratories in the Silicon Valley. The sensors, using ultrasonic ranging, measure the height of the streams and send data back through the gateway to CMU servers. The data will be analyzed and the results published on a webpage. Earth science researchers have the ability to remotely alter the schedule the sensors follow so that precious battery energy is only spent when the conditions warrant it.

“We are building a system that serves the USGS’ real needs, but it also provides a vehicle for us to do research on low-power wide-area networks as they scale up,” says Iannucci. In addition to a warning system, the USGS wants a system that preserves historical sensor readings to enable longitudinal studies of how waterway conditions change over time.

“Sensing and telemetry [the process of collecting and
transmitting data] are expensive. But LP-WANs and less expensive sensors have the potential to raise existing awareness of water hazards and to enable us to rethink how we manage our nation’s waterways. We are exploring if this approach is right for broader investment, and Pepperwood Preserve is a test bed,” says Jonathan Stock, director of the USGS National Innovation Center.

“Our Sentinel Site project is collecting detailed climate-hydrology-ecosystem data for the long term, to understand the impact of climate variability on our region’s watersheds and biodiversity. [Pepperwood] having burned over in the 2017 Northern California fires, our data sets are now an absolutely unique resource for understanding the role of fire in watershed processes in California’s Coast Ranges. By partnering with Pepperwood, USGS and CMU have the opportunity to contribute directly to short-term recovery and long-term resilience strategies for California as a whole,” says Lisa Micheli, president & CEO of the Pepperwood Foundation.

WHAT LIES AHEAD

The work Iannucci’s team is doing in the preserve is part of a larger CMU initiative called SMILE: the Synchronized Multi-sensor Integrated Learning Environment. “The concept is to have an array of dissimilar sensors that can be integrated, possibly on the fly, into a single homogenous system,” says Iannucci. For example, different kinds of sensors can be mounted on drones or road surfaces, and a unified, low-power, wide-area network can help bring all their data together. The environment can be anything: smart buildings, car-lined city streets, or grassy hills in California.

“We are building a toolkit that can be used across a variety of sensing environments,” states Iannucci. The kit’s components include a family of flexible sensors, a unifying LP-WAN, and programming and reasoning tools for achieving low-power operation and making sense of collected data through a combination of traditional analysis and machine learning techniques.

“We would be pleased if the work we’re doing with the USGS was generalizable enough to be applied in other environments,” says Iannucci. He explains that deep sensor science—more sensors in more places—can provide hyper-local insights such as how changes in soil moisture benefit plant life or foretell mudslides. The wider a sensor network is, the better and earlier we can detect forest fires, air quality issues, erosion, and other conservation challenges. Today, the costs of installing and operating dense sensor networks are high; however, Iannucci suggests that this will change.

“Solving core problems related to low-power environmental sensing has the potential to substantially lower deployment and operational costs. This can enable more sensors for the same investment and, with it, the ability to draw better-informed conclusions about the environment.”
On a frigid day in December 2015, more than 230,000 Ukrainian residents lost power for an afternoon. Lights went out, televisions shut off, and heaters seized up. Their power grid had been hacked.

The threat malicious hackers pose to the energy grid is a legitimate one, and that’s precisely why the U.S. Department of Energy has awarded two Carnegie Mellon researchers a $400,000 grant to strengthen grid security using blockchain technology.

“Hackers were able to attack the Ukrainian power plants by exploiting a central control system,” says Rahul Panat, an associate professor in the Department of Mechanical Engineering. “If that control system was placed on a distributed network—a blockchain—then in theory, pulling off an attack would have been much more difficult.”

Panat’s expertise lies in high temperature sensor networks, much like those that feed information to the Supervisor Control and Data Acquisition (SCADA) system power plants employ to make decisions such as how much power to generate and where to send it. Panat will be working alongside Vipul Goyal, an associate professor in the Computer Science Department with chops in blockchain technologies.

“SCADA is a huge center point for attack from an attacker,” Goyal says. “But if the data from the sensors is placed on a blockchain, then the attacker does not have to attack a single computer, but multiple computers—maybe tens or hundreds of computers depending on how large the blockchain is.”

The researchers will be creating a simulated SCADA system and integrating it onto an eight-node blockchain. Eight was chosen as the number of nodes just for the purposes of experiment, Panat says, but the blockchain can easily scale, and at an affordable cost.

“A simple laptop computer—just $200 or $300—can be a node on this blockchain,” says Panat. “You don’t need a fancy workstation or supercomputer to do this.”

Although blockchains’ most popular applications—serving as the infrastructure for cryptocurrencies like Bitcoin or Ethereum—involves a public ledger that anyone can see, Goyal and Panat’s technology will be mainly private, hiding critical information from everyone—even those inside the company—except for a few authorized employees.

“This hierarchical access control will protect against insider threats in addition to outsiders trying to attack the grid,” Goyal says.

The researchers are targeting to conclude this project by the end of summer 2021, and at that point, they’ll hand a complete prototype of their eight-node blockchain system to the National Energy Technology Laboratory (NETL), a national lab under the Department of Energy Office of Fossil Energy.

“If this project was sponsored by one single power generation company, then the solution might remain right there,” Panat says. “By working with a national lab like NETL, it can be a benefit to the entire nation.”
Researchers from Carnegie Mellon University’s College of Engineering and the Institute of Systems and Robotics of the University of Coimbra, Portugal have developed a simple, efficient method to make robust, highly flexible, tattoo-like circuits for use in wearable computing. The low-cost process adds trace amounts of an electrically conductive, liquid metal alloy to tattoo paper that adheres to human skin. These ultrathin tattoos can be applied easily with water, the same way one would apply a child’s decorative tattoo with a damp sponge.

Other tattoo-like electronics either require complex fabrication techniques inside a cleanroom or lack the material performance required for stretchable digital circuit functionality on skin.

Carmel Majidi, an associate professor of mechanical engineering and the director of the Soft Machines Lab at Carnegie Mellon, and Mahmoud Tavakoli, the director of the Soft and Printed Microelectronics Laboratory at the University of Coimbra, teamed up to develop methods for direct printing of stretchable electronic circuits. Their collaboration succeeded. “The technique is simple. The tattoos are ultrathin, very stretchable, and inexpensive to produce,” said Majidi.

“This is a breakthrough in the printed electronics area,” said Tavakoli. “We showed for the first time that inkjet-printed patterns of silver nano particles can be sintered at room temperature using the gallium indium alloy. Removing the need for high temperature sintering makes our technique compatible with thin-film and heat sensitive substrates.”

In addition to low-cost processing, these tattoos provide other advantages. Because they have mechanical properties similar to lightweight fabrics, they remain functional under bending, folding, twisting, and strains above 30% (which is the typical stretchability of human skin). They can conform and adhere to highly curved 3D surfaces, like a model of a human brain or a lemon.

Applications for ultrathin, compliant tattoos include epidermal biomonitoring, soft robotics, flexible displays, and 3D-transferable printed electronics.

The findings were published in Advanced Materials in a paper titled “EGaIn-Assisted Room-Temperature Sintering of Silver Nanoparticles for Stretchable, Inkjet-Printed, Thin-Film Electronics.”

This collaboration is part of the Carnegie Mellon-Portugal Program (http://www.cmuportugal.org).
THREE THINGS CAME TOGETHER TO ALLOW THE WIDESPREAD IMPLEMENTATION OF AI: INCREASED COMPUTATIONAL POWER, STORAGE CAPACITY, AND DATA.

Artificial intelligence research began in the 1950s with theoretical exploration leading up to the advent of deep neural networks, a type of AI system loosely based on the way our brains work where computations are made through a series of interconnected nodes with tens or even hundreds of layers. Three key advances in computing came about which enabled deep layer neural networks to work really well, and AI exploded.

“After deep layer neural networks were introduced, it was like flood gates—AI research and applications abounded,” says Kumar Bhagavatula, director of CMU-Africa and an electrical and computer engineering professor who has worked in AI for over 30 years. “Three technological breakthroughs converged together at once: computational power in the form of GPUs, increased storage capacity that enabled cloud computing, and the collection of tons of data through sensors and IoT devices. The availability of hardware is really what enabled AI to be implemented in such a broad way.”

AI IS NOT MAGIC.

Artificial intelligence does not magically discover what isn't already there. AI is based on concepts that engineers, mathematicians, and computer scientists already know: math, statistics, signal processing, and optimization, but put together in a way that can handle bigger data and a broader scope.

“AI is not magic. It cannot create something from nothing and is built on concepts we already know,” says Liz Holm, a professor of materials science and engineering. “The results are also not magic—the information is already in the data and AI is a way of getting it out. Sometimes it does that better than humans because we think differently, but it is not making anything up: its only finding things that are hard for us to see.”

BIG DOES NOT ALWAYS MEAN BETTER FOR DATA.

Access to more data is one reason why AI has been able to solve many problems that humans cannot. But just because a lot of data is available, it doesn’t always mean it is better. There are times when data doesn’t exist, when it is costly to obtain and label, or when there’s more noise than signal that renders much of the data useless. Researchers are finding ways to make small data meaningful by designing algorithms to work with small data and get more from less data.

“More data is not always better,” says ECE assistant professor Yuejie Chi. “It is if the data quality is good, but one issue with big data is that it can be very messy and you might have a lot of missing data. Big data problems also involve a lot of computation, so we want to minimize the computational complexity of the algorithm by doing more with less data.”
AS A FAST-PACED FIELD, THERE’S POTENTIAL TO HAVE AN IMMEDIATE IMPACT ON A LOT OF PEOPLE.

Mechanical Engineering Assistant Professor Amir Barati Farimani sees AI as a way to rapidly improve quality of life for many people because the period from research to product can be very quick. Right now, applications in robotics and healthcare are some of the fastest-growing areas of AI research. For researchers, one of the biggest challenges is keeping up with developments and advancements in methodology in the field.

“It’s exciting because the time from developing the technology to the product stage is really short for AI products,” says Barati Farimani. “This is really interesting, especially for engineers, to think about creating products that are meaningful and have an immediate impact on people’s lives.”

ON-DEVICE AI WILL BRING THE BIGGEST IMPACT.

One way that technology will work to improve quality of life is through on-device AI. AI systems currently rely on powerful machines or the cloud to run, so applications like Siri or Alexa only work by sending data to and from the cloud. But researchers like ECE Professor Radu Marculescu are busy making on-device AI a reality: rather than running on a giant super computer or sending data to the cloud, computations using AI can take place locally on your device at an increased speed while preserving your privacy.

“The biggest impact of AI research will come when mobile and wearable devices will run AI applications,” he says. “This will completely change the way we interact among ourselves and with the environment. On-device AI is also an essential evolution in a world where demand for privacy and security from consumers is growing exponentially.”

WE NEED TO UNDERSTAND HOW AND WHY AI SYSTEMS PREDICT AND DECIDE.

Many AI systems that make high-stakes decisions about credit, insurance, and other factors operate as black boxes—meaning there’s no way to tell how and why it makes its decisions, or what variables most heavily influence its decisions. For high-stakes applications where the cost of a wrong answer could mean to unjustly deny someone credit, there is a great need to understand what happens inside the black box to ensure fairness and trust.

“My perspective is that it is incredibly important for us to look inside black box AI systems and understand the rationale behind their predictions and decisions,” says Anupam Datta, an ECE professor whose research seeks to peer inside these black box systems. “It’s important in order to ensure that models continue to be performant in production and unjust bias is mitigated.”
ENGINEERING & PUBLIC POLICY

Sean Qian has been researching how ridesharing through companies like Uber and Lyft affects traffic. His group’s findings are that ridesharing is likely to cause an increase in traffic, unless riders are carpooling or moving at scheduled times.

ELECTRICAL & COMPUTER ENGINEERING

Adam Feinberg and his team published a paper in Science that details a technique allowing anyone to 3D bioprint tissue scaffolds out of collagen. The technique—known as Freeform Reversible Embedding of Suspended Hydrogels (FRESH)—has allowed researchers to 3D print functional components of the heart, such as trileaflet heart valves and complex vasculatures.

CIVIL & ENVIRONMENTAL ENGINEERING

Ignacio Grossmann was awarded the Founders Award for Outstanding Contributions to the Field of Chemical Engineering from the American Institute of Chemical Engineers. This is the highest award given by the Institute, presented each year to one member who has had a great impact on the field of chemical engineering.

BIOMEDICAL ENGINEERING

Sean Qian has been researching how ridesharing through companies like Uber and Lyft affects traffic. His group’s findings are that ridesharing is likely to cause an increase in traffic, unless riders are carpooling or moving at scheduled times.
Edward S. Rubin spoke at the World Sustainable Urban Food Centre in Spain. Rubin’s speech was about the links between climate change and urban food systems. Queen Letizia Ortiz of Spain and 250 invited guests and officials from countries across the globe were in attendance.

Yuejie Chi has received a Presidential Early Career Award for Scientists and Engineers (PECASE). This is the highest honor bestowed by the U.S. government to acknowledge the contributions of engineers and scientists at the outset of their research careers. Her research is motivated by the challenge of extracting information embedded in a large amount of data and gathering actionable information.

Michael E. McHenry was recognized by NATO at the 2019 Applied Vehicles Technology Meeting in Slovakia. He is part of a team studying rare earth element criticality—recent constraints on supplies have led to concerns about their long-term availability as well as the consequences that shortages would pose for technology.

Over 1,200 cybersecurity professionals and students attended the Women in Cybersecurity Conference 2019 that was hosted by CMU. President Farnam Jahanian gave the welcome keynote. INI Director Dena Haritos Tsamitis (left) served as conference program co-lead with CMU’s Software Engineering Institute’s Bobbie Stempfley; CyLab’s Lorrie Cranor gave a keynote. The collaboration reflects CMU’s commitment to diversity in STEM.

Last year, the U.S. generated over four trillion kilowatt hours of electricity, about half of which was lost as waste heat. Jonathan Malen and his research group received a $500,000 award from the National Science Foundation to develop a thermoelectric semiconductor using tungsten disulfide to convert waste heat into energy.
The Tech Spark prototyping facility is nestled in Hamerschlag Hall, where students move about, using laser cutting machines, 3D printers, soldering stations, power tools, welding equipment, metal mills, and other technical machinery. The rooms are filled with the sound of buzzing machines, the clanking of heavy materials, and the chatter of students working on different projects. Above the facility’s workstations hangs a glowing LED light system that reads each user’s university ID card to check for safety certifications. The lights change colors based on the system’s findings.

This safety system is necessary due to Tech Spark’s hundreds of unique users from across campus. The call to create this check system came from Diana Haidar, assistant teaching professor of Mechanical Engineering and educational director of Tech Spark. She approached the Department of Electrical and Computer Engineering IT group in the fall of 2017, and Robert Smith, senior Windows systems engineer in ECE, was selected to spearhead the project.

For the light tree system, a housing unit of LED lights glow specific colors according to the experience and ability of the user at a given machine. When at rest, waiting for a user, the lights are blue. When users insert their ID cards to access the machine, the lights will glow yellow or green—yellow if they are currently in a training course for the machine and green if they have passed...
the course. For users without appropriate safety credentials, the lights will flash red and student workers will help users find necessary training.

“When we first started with the project, I wasn’t sure what the best method would be for the visual indication,” Smith said. They wanted a 360-degree view of the hanging lights from anywhere in the room and decided on halo-like lights. The units were designed by Nikhil Shinde, a MechE master’s student, employed in Tech Spark’s TEAM (Training Engineers and Makers). Smith built the verification system using Windows PowerShell, which includes an LDAP (Lightweight Directory Access Protocol) to look up student or staff member information and denote their training level and accessibility to specific machines.

The College of Engineering offers training courses for a wide range of machines and technical skills and the courses are open to all at Carnegie Mellon. Students across the university use Tech Spark, from students in engineering and design to those in art, architecture, computer science, and business. “We want Tech Spark to be a place for everyone, with the physical, digital, and intellectual resources open and available,” said Haidar.
Carnegie Mellon University's College of Engineering named Larry Pileggi to head its Department of Electrical and Computer Engineering (ECE), effective March 1, 2019. The college conducted a national search considering a diverse pool of both internal and external candidates. Pileggi was selected for his leadership in the field and his vision for the next phase of the department's growth.

"His presentation to the ECE community outlined the creation of more maker initiatives throughout the curriculum and research thrusts," said Interim Dean Jon Cagan. "He identified the structuring of research around application domains that span from the electrical engineering to the computer engineering communities."

Pileggi is the Tanoto Professor of Electrical and Computer Engineering and has previously held positions at Westinghouse Research and Development and the University of Texas at Austin. He received his Ph.D. in Electrical and Computer Engineering from Carnegie Mellon University in 1989. As a faculty member, Pileggi has worked extensively with semiconductor and electronic design automation (EDA) companies, and has co-founded four start-up companies (Xigmix, Extreme DA, Fabbrix, and Pearl Street Technologies) with some of his former students.

An innovative researcher, Pileggi has published more than 350 conference and journal papers and holds 40 U.S. patents. He has active programs in various aspects of digital and analog integrated circuit design, and simulation and optimization of electric power systems. He has received several national accolades, including Westinghouse Corporation's highest engineering achievement award, a Presidential Young Investigator Award from the National Science Foundation, a 2010 IEEE Circuits and Systems Society Mac Van Valkenburg Award, and a 2015 Semiconductor Industry Association (SIA) University Researcher Award, to cite just a few. Pileggi is a fellow of IEEE and has supervised 47 Ph.D. students through their degree completion.

Pileggi joins a long list of prominent department heads, succeeding Jelena Kovačević, who served in this role for the previous four and a half years. She is now the dean of the Tandon School of Engineering at New York University.
A car breaks down. An accident halts traffic. A few streets away, a road closes for construction. In many cities, congested roadways are simply inescapable.

With his research, CEE Associate Professor Zhen (Sean) Qian is working toward a different world, one where real-time and historical data allow us to better manage our aging and overcrowded infrastructure. Through data modeling and frameworks, Qian is not only finding ways to reduce congestion, energy use and emissions within existing systems but also to design sustainable, resilient, and intelligent infrastructure for the future.

As director of Carnegie Mellon’s Mobility Data Analytics Center (MAC), Qian integrates massive amounts of data from various agencies and private sector to look holistically at our transportation systems. By analyzing data on weather, parking, public transit, roadways, incidents, events, and more, Qian can better understand travel behavior, identify efficient management strategies, and develop decision-making tools for legislators, transportation planners, engineers, researchers, and even travelers.

Qian has previously received a Greenshields Prize from the Transportation Research Board and an NSF CAREER Award for his work. Now, he’s being honored with the inaugural Henry Posner, Anne Molloy, and Robert and Christine Pietrandrea Career Development Chair in Civil Engineering, an endowed term professorship created to support a faculty member in the early phases of their career.

“I am extremely honored to receive this endowed professorship at the early stage of my career,” say Qian. “This early career development chair will not only provide resources to advance my research, but also allow me to further expand on the impact of my work, particularly understanding the societal consequence of emerging technologies to infrastructure and human beings. I am so grateful for the recognition and the support from Mr. and Mrs. Pietrandrea, Mr. Posner, and Ms. Molloy.”

This prestigious award was made possible by the generosity of Robert and Christine Pietrandrea, who chose to honor their long-time friends Henry Posner III and Anne Molloy in the naming of the chair. Robert Pietrandrea and Posner have together run the Railroad Development Corporation (RDC) since 1987, and Anne Molloy, Posner’s wife, is a Carnegie Mellon trustee. The Posner family has previously supported the construction of Carnegie Mellon’s Posner Center and provided significant contributions to the Presidential Scholarship program.
IN MEMORIAM

JOHN WISS

John William Wiss, a professor of mechanical engineering at Carnegie Mellon University for 30 years, passed away on January 13, 2019. He was a respected and beloved teacher, mentor, and colleague. “Professor Wiss truly cared about the students, and this did not end at the classroom door,” said Allen Robinson, head of the Department of Mechanical Engineering.

Wiss was an integral part of Carnegie Mellon Racing (CMR), the university’s student chapter of the Society of Automotive Engineers (SAE) that designs, builds, and races vehicles. He served as the faculty advisor for many years, often generously funding the team from his own pocket.

“John’s heart was really in the work. He enjoyed teaching the internal combustion engines course and working with the CMR team. Indeed, he was partly responsible for starting CMR,” said Satbir Singh, an associate teaching professor who now teaches the course and advises the team. “I learned a lot from John.”

Wiss brought to CMU a wealth of experience. He received his education from the U.S. Military Academy at West Point, Rensselaer Polytechnic Institute, and the University of Michigan. He was a retired lieutenant colonel in the United States Army. His career included work at the Jet Propulsion Laboratory, the White Sands Proving Ground, and the Army Tank-Automotive Laboratories where he served as chief. Additional roles included chief technical officer at Rockwell Engineering, Fulbright scholar, entrepreneur of a fuel cell start-up, husband, father, grandfather and great grandfather.

CHUCK NEUMAN


“Professor Neuman had a great love for Carnegie Mellon, and the electrical and computer engineering department in particular,” said Larry Pileggi, head of the Department of Electrical and Computer Engineering. “His passion for teaching was obvious, as was his concern for his students’ wellbeing. Many students recall his unique style of teaching which impacted generations of engineers.”

Vijayakumar Bhagavatula, professor and director of Carnegie Mellon University Africa, remembers Neuman as being a great mentor to him in his early faculty career.

“In my technical interactions with him, he was always asking challenging questions, forcing me to be more accurate and precise in my statements,” said Bhagavatula. “I may not have realized it at that time, but this helped me become a more effective teacher in the classroom and better at communicating our research. Those of us, who have been with the department for a long time, realize how much he loved the department and how much he contributed to the training of our students.”

Neuman received his bachelor’s degree in electrical engineering from the Carnegie Institute of Technology and earned his master’s and doctorate degrees in applied mathematics from Harvard University. He was at Bell Telephone Laboratories in Whippany, NJ from 1967-1969 and then returned to Carnegie Mellon University as a professor in the electrical and computer engineering department until 2015.
A variety of neural imaging techniques are used to identify and diagnose neurological disorders like epilepsy, sleep disorders, strokes, and more. Devices vary in cost, resolution, and accessibility, with magnetic resonance imaging (MRI) machines as the most effective for the highest price but also the most difficult to maintain. Electroencephalography (EEG) machines are at the other end of the range as the most affordable and portable but at a lower resolution—usually.

Typical EEG machines often do not have high enough resolution to get highly detailed brain scans because the number of sensing nodes that are attached to a patient’s scalp—10 to 40 electrodes—is too low. For this reason, EEG as a neural imaging technique is often replaced with more invasive, risky, and expensive methods. But Pulkit Grover, an assistant professor of electrical and computer engineering (ECE) at CMU, still has faith in EEG. His group’s research predicts that current theories about EEG severely underestimate their capacity for spatial resolution. They postulate that high-density EEG, with 64 to 256 electrodes, offers clearer images that better send and receive signals through human skulls. Even more effective are UHD EEG: ultra-high-density EEG with up to 1,000 electrodes.

Of course, with more nodes come new problems, such as figuring out how to attach all of them and how to get the most out of each node. To address these problems, Grover’s lab includes a group of instrumentation engineers, led by post-doctoral researcher Ashwati Krishnan and doctoral candidate Ritesh Kumar in collaboration with Shawn Kelly, senior systems scientist in the Engineering Research Accelerator. Rounding out the team, are students who are providing crucial insight into how to make EEG as accessible as possible for a variety of people.

EEG FOR VIRTUAL REALITY

Shi Johnson-Bey is a master’s student in biomedical engineering whose research focuses on EEG sensing as an input method for virtual reality (VR) modules. This means that a user can interact with a virtual world without making use of hand-held controllers—an ideal situation for individuals who have limited mobility without a loss of mental capabilities, such as patients with amyotrophic lateral sclerosis (ALS).

Johnson-Bey was a Journeyman Fellow for the U.S. Army Research Laboratory both in the summer of 2017 and again for his final year of study. In his summer experience, Johnson-Bey learned about various brain-computer interfaces and created a P300 speller application that allowed users to type text by using brain activity. He continued this research to develop a system where users can interact with objects in VR settings by using audio cues.

Within a virtual system, a user would see an environment or layout, such as a menu of options. In addition to wearing a VR headset, which includes immersion by sight and sound, the user would also be hooked up to EEG nodes that connect with the VR system. When hearing or seeing certain sounds or icons next to menu items, the EEG nodes would pick up electrical signals from the brain when the user is paying more attention, a reaction they have when they want to select an option. Reading that signal, the VR system can then select that item, essentially reading the user’s mind.

This technology could open up the world of video games to those who previously did not have access, can provide simulations for medical and emotional treatment, and can lead to better understanding of how neurological patients with low communication skills function. Johnson-Bey also gave the example of using this kind of technology as something of a universal remote.
In Mechanical Engineering’s Aaron Johnson’s course 24-775 Robot Design and Experimentation graduate students applied what they learned at Carnegie Mellon to build bio-inspired robots.

Inspired by the brittle star, touch sensors on the limbs of this legged robot offer an alternative to remote sensing, allowing for omnidirectional movement and obstacle avoidance.
within the chest and designed in geometries that optimize how much oxygen and carbon dioxide can be cycled in and out of the circulatory system.

Existing artificial lungs are largely stopgap measures, and a plethora of complications can arise from their use. The average duration of use is about a week, and a patient’s chance of surviving the therapy shrinks the longer they’ve been supported. Artificial lungs made from polymers can also cause blood to form clots on the surface, which is why they fail, and have to be frequently replaced. Drugs used to slow blood clots can also cause patients to bleed. Each time artificial lungs are replaced, the patient can be exposed to infection risk.

De novo lung biofabrication could be the key to solving these issues. By designing artificial lungs that can be permanently attached to the circulatory system, and that can be created in geometries that approximate lung geometries but optimize for gas exchange, researchers could remedy the blood clotting and bleeding risk associated with existing artificial lungs.

“We have a long way to go,” says Comber, “but we expect to see these de novo organs commercially available in our lifetime.”

Comber is co-advised by Cook and Adam Feinberg, professor of biomedical engineering and materials science and engineering. Co-authors on this paper include Cook, and BME faculty Xi Ren and Rachelle Palchesko Simko, and BME postdoctoral researcher Wai Hoe Ng.

Lungs From Scratch

Millions of people suffer from organ failure; 15 million people need lung transplants alone. But the organ transplant system currently has nowhere near the number of organs needed to help patients suffering from organ failure. Particularly when it comes to lungs, the current available treatments are not enough to help people breathe easily.

Erica Comber, a Ph.D. student in the Department of Biomedical Engineering (BME), is part of Carnegie Mellon’s Bioengineered Organs Initiative. And the great thing about the Initiative, according to Comber, is that its researchers are all working toward the goal of handling, and eliminating, the organ deficit. And sometimes this means not only obtaining organs for patients—but making them.

There are many ways to make a lung, however, and with so many possible approaches, where do you even start?

That’s exactly the question that Comber and her advisor Keith Cook, professor of biomedical engineering, addressed in a recent, first-of-its-kind paper, outlining several different approaches to creating human lungs from scratch.

“There’s a huge divergence of approaches in this field, and no one approach is necessarily more valid than another,” says Comber. “It’s about using different techniques to try to accomplish the same goal and then learning from each other.”

By identifying important parameters to consider and describing the ways that one could approach this problem, the paper, published in *Translational Research*, will act as a guide to future researchers looking to create human organs *de novo*, or “from scratch.”

The paper discusses a few different approaches to addressing the problem of *de novo* organ creation. Approaches span from using existing biological organs as a starting point—by removing cells from existing organs and recellularizing them with the patient’s own cells—to generating completely artificial organs.

Comber’s work is a hybrid of those two approaches. This paper outlines approaches to her work, which is to create *de novo* artificial lungs. Using natural materials such as collagen type 1, Comber makes artificial lungs that can be housed within the chest and designed in geometries that optimize how much oxygen and carbon dioxide can be cycled in and out of the circulatory system.

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When Agnes Marszalik (CEE BS ’13) decided to focus her job search on areas near mountains, she had no idea that she’d end up in an area reeling from the impacts of climate change. Working as an engineer for the Division of Environmental Health and Engineering at the Alaska Native Tribal Health Consortium, she sees first-hand that native communities are relocating—or planning to relocate—due to the changing environment.

“The melting of permafrost, which causes the ground to thaw and shift, is resulting in damage and failure of current infrastructure,” she says. The moving ground is a challenge that engineers must take into consideration when creating designs for the future. Marszalik’s current work is focused on providing design and construction administration services for sanitation projects in Alaska native villages. She chose the position based in Anchorage, Alaska because it combined her interest in water and sanitation.

“Most of my work deals with water and wastewater treatment along with distribution and collection,” she adds. She’s involved in projects from start to finish—from writing preliminary engineering reports to design and construction.

Marszalik is just about to wrap up the first two projects that she’s worked on for the consortium. Marszalik credits her education in civil and environmental engineering (CEE) with preparing her for a challenging career. Her involvement in Engineers without Borders (EWB) while at CMU also provided real-world experience in the design, construction, and monitoring of a water collection and distribution project in the Ecuadorian Andes.

She takes pride in the tangible benefits her work provides to native villages. Marszalik mentions that she is especially interested in water treatment pilot studies, projects that evaluate water quality, test scenarios, and determine the best solutions to bring systems efficiently into compliance.

“These [studies] have been the most rewarding because once we find a solution for the water source, it then becomes the basis of the water treatment plant design,” Marszalik says. She adds that bringing critical infrastructure to remote Alaskan areas is a big challenge. Many native villages are accessible only by small aircraft or boat. Some lack basic water and sewer connections to their homes—and have been waiting for decades for improvements.

“These challenges, along with the extreme weather, require creative design and significant planning. We need to provide systems that can be constructed and operated in these areas while maximizing the public health benefits,” Marszalik states.
CMU President Farnham Jahanian announced in October 2018 a $30 million lead grant from the Allegheny Foundation to build a brand-new Scaife Hall. The new building will replace the current home of the Department of Mechanical Engineering and will carry the same name.

New Scaife Hall will be sited in the same location of the current building, next to the new ANSYS Hall and Hamerschlag Hall. It will feature modern laboratories, flexible classrooms, and formal and informal collaborative spaces. Doubling the size of its predecessor, the new building will allow the Mechanical Engineering Department to accommodate its growing number of students, and expand its collection of state-of-the-art lab facilities for 21st-century engineering research.

Celebrating its 57th birthday this year, the once-futuristic looking building, encased in metal scaffolding and nestled beside its “potato chip” lecture hall, recalls a previous era. Perched above the leafy edge of Junction Hollow, ever-more modern buildings in the surrounding campuses have sprouted up around it since its 1962 construction.
In its heyday, Scaife Hall reflected an optimistic vision of a technologically-driven future. Its metal scaffolding was of a different world than the yellow brick of next-door Porter Hall. Scaife’s image of futurism was enhanced by housing the cutting-edge Computation Center on its 4th floor during the late 1960s, which played a key role in CMU’s development as a juggernaut in computer science during that time and attracted aspiring engineering students.

One of those students was Chris Hausler (E’71), who found an immediate home in Scaife Hall when he came to Engineering in 1966 to study electrical engineering. He recalls spending many late nights in the Computation Center as an operator at the helm of the “Univac 1108.” Eager students would compete for time on the Univac to practice programming and perform research. Though cutting-edge at the time, the machine filled an entire room on Scaife’s fourth floor. It had to be disassembled and air-lifted through the roof by crane. Hausler was on-hand to photograph.

“The Computation Center developed this strong community of users. It was a society of its own,” he recalled. “Scaife Hall was where the action was.”

Equipment like the Univac 1108 drew Hausler to Scaife Hall, allowing him and others to hone their skills as computer programmers. He credits his time in Scaife as “the key reason that led to my career as a software engineer.”

What attracts students to CMU and inspires them to pursue engineering is constantly changing. Room-sized computers are out, while robots and 3D printers are in. And tomorrow will bring something new entirely. But there to house those technologies, and the communities of learning and research that grow alongside them, will be Scaife Hall.
Gift To Advance Mechanical Engineering

An entrepreneurial idea to expand training for 21st-century careers, hatched on a working ranch in Montana and in Carnegie Mellon University’s advanced manufacturing laboratories, has sparked a $10 million gift to support mechanical engineering at the institution.

Trustee and alumnus David Coulter and his wife, Susan Coulter, have made the transformational commitment that will endow the headship for the Department of Mechanical Engineering, as well as support the construction of a new Scaife Hall, which will house the department. The endowment to support the department head will provide critical funds for emerging priorities in mechanical engineering, and is the first endowed headship announced in the nation by U.S. News & World Report, which also places the College of Engineering at number 4 for graduate studies and number 6 for undergraduate.

“David and Susan have been outstanding university citizens for decades,” CMU President Farnam Jahanian said. “Their latest act of generosity that will benefit the Carnegie Mellon community promises to advance one of our leading programs—one that is driving manufacturing innovations for our modern world.”

The inspiration for the gift began on the Coulters’ ranch outside of Bozeman, Montana, where David Coulter saw the need for workers with high-tech skills to operate and maintain modern machinery related to the local mining and agriculture economy. Following a conversation with Carnegie Mellon Provost Jim Garrett, then dean of the College of Engineering, he began working with the NextManufacturing Center, part of the college’s advanced manufacturing initiative, which includes additive manufacturing or 3D printing, as it is commonly known.

There, the center’s leadership, including Sandra DeVincent Wolf, Jack Beuth, and Anthony Rollett, helped Coulter evolve his initial vision of vocational training into an expansive idea that combines traditional skill development with new technology such as additive manufacturing. A facility where locals will be able to train for manufacturing careers at the leading edge of the new economy is now under construction in Montana.

The positive collaboration between the Tepper School of Business alumnus and mechanical engineering faculty became the foundation for the Coulters’ generous gift.

“At Carnegie Mellon, we often speak about how our strengths in deep disciplinary knowledge truly take flight when we collaborate across disciplines,” Coulter said. “I feel like we’re doing that real-time with this project, and I see our involvement as an alumni prototype for these cross-disciplinary projects. We’re proud to support both the Tepper School of Business as well as the College of Engineering, and are excited to see what the Mechanical Engineering Department will achieve.”

The Coulters’ commitment to a new Scaife Hall follows a lead grant from the Allegheny Foundation. When complete, the new building will more than double the size of the existing building, and will include expanded, technology-rich labs; modern, flexible classrooms; and spaces that facilitate collaborations. Following demolition of the current building, the new facility is constructed on an expanded footprint at the same location on Frew Street, near Flagstaff Hill on the CMU campus.

“Mechanical Engineering is a leader in emerging fields such as soft robotics and advanced batteries. We need world-class facilities to support the exceptional work of our faculty and students,” said Allen Robinson, department head and professor. “We are so grateful for David and Susan’s extraordinary generosity, which will impact the department
AN ENTREPRENEURIAL IDEA TO EXPAND TRAINING FOR 21ST-CENTURY CAREERS HAS SPARKED A $10 MILLION GIFT TO SUPPORT MECHANICAL ENGINEERING AT CARNEGIE MELLON.

for decades to come."

Robinson, who became the first Coulter Head of the Department of Mechanical Engineering, will continue to hold the Raymond J. Lane Distinguished Professorship in Mechanical Engineering.

The Coulters’ past CMU support includes a $5 million contribution to the recently completed first building on the David A. Tepper Quadrangle. The David and Susan Coulter Welcome Center, housed in the Tepper Quad building, is the new front door to campus, a one-stop destination for all visitors.

A 1971 alumnus of the Graduate School of Industrial Administration, now the Tepper School of Business, David Coulter is a special limited partner with Warburg Pincus LLC in New York City. Previously, he was vice chairman of JPMorgan Chase and Co. and chairman and CEO of Bank of America Corp. In 2018, he was honored with the Tepper School Alumni Lifetime Achievement Award.
Once I graduated, I had a plethora of job offers from top companies and national laboratories. Holliday accepted a position with Lawrence Livermore National Laboratory, working there for a short time before joining Stanford’s mechanical engineering design graduate program. He had been a student at CMU during the nuclear accident at Three Mile Island and had followed CMU Professor of Robotics Red Whittaker’s subsequent efforts to develop field robotics solutions. At Stanford, Holliday took every robotics class available.

With the collapse of the USSR in 1991, the Cooperative Threat Reduction Program was established to work with former Soviet scientists to help stabilize their newly independent states and ensure former weapons experts had gainful employment; this gave Holliday an idea. “I wanted to go to Ukraine to work with the Ukrainians on stabilizing Chernobyl,” he says, “so I started traveling there in ’94.”

With this in mind, he joined a technology policy fellowship with the American Association for the Advancement of Science at USAID in Washington, D.C. While completing this program, he successfully

“I grew up reading comic books, motivated by things like reruns of the original Star Trek and the diversity I saw there. I said ‘Hey, I’d like to go to space one day. How do you do that?’ This was the question that absorbed young Maynard Holliday, growing up in Scarsdale, New York. The answer, he says, was clear. “Become an engineer.” Holliday would never make it to space, but he would go on to have a career that would take him from the boardrooms of Silicon Valley to the remains of Ukraine’s infamous Chernobyl nuclear power plant.

Having been set on an engineering path at a young age, Holliday’s voracious appetite for math and science brought him to Carnegie Mellon University. One of just a handful of African American students in his class, he found support through the Carnegie Mellon Action Program (CMAP, now CMARC: the Carnegie Mellon Advising Resource Center), a program for African-American students.

“It was grueling,” he says, “But I made lifelong friendships, and I credit what I went through with raising my capacity for hard work and analytical thinking.

SHOOT FOR THE STARS

MAYNARD HOLLIDAY ON THE DAY OF HIS GRADUATION FROM CMU.
pitched a proposal to the U.S. State Department’s International Nuclear Reactor Safety Group that any international funding for the Chernobyl site should include funding for robotics.

An interagency group was convened to fund the project, including NASA, the Department of Energy, and the Department of Commerce. Once funding was secured, Holliday reached out to RedZone Robotics, a company founded by CMU’s Whittaker to apply robotics in natural and manmade disasters. Over the course of the next three years, the team created a robot capable of entering and gathering data from the hazardous ground zero beneath where the reactor once stood, delivering the finished product to Ukrainian scientists in 1999.

After the success of the project, Holliday pivoted, spending the next decade working his way around a series of Bay Area robotics startups and doing a stint at Apple. He had scarcely rejoined the national lab system at Sandia when, in 2014, he was tapped by the Obama administration to serve as special assistant to the Undersecretary of Defense for Acquisition. He was tasked to help lead a new initiative to facilitate government investment in Silicon Valley toward key areas like robotics, cybersecurity, satellites, and others. To attract his former colleagues in the Bay Area, the Defense Innovation Unit Experimental offered an array of advantages to their private partners.

Holliday would stay at the Pentagon until the end of the Administration before joining the RAND Corporation, where he works today. In his 30+ year career, one thing has always stood out to him.

“In all of these rarefied environments, a lot of the time I’ve been the only underrepresented person there,” he notes. “These organizations, whether national labs or Silicon Valley companies, are doing things that affect the entire population, and it’s important that there are diverse voices at the table to be able to promote those viewpoints.”

Though his feet would remain firmly on the ground (despite twice qualifying as an astronaut candidate), it wasn’t just the futuristic setting of Star Trek that had enchanted the young Holliday—it was the diverse array of faces he saw reflected there. Now, Holliday spends much of his free time volunteering to teach a weekly afterschool robotics program with an organization called Citizen Schools, earning him the group’s 2012 Volunteer of the Year award.

“I volunteer to teach in urban communities to show the kids a reflection of themselves, because I think that’s important,” he says. “They’re able to see someone that looks like them, who has a background like them, and who can show them these tremendous career opportunities.”
NEW ANSYS HALL
OPENING OCTOBER 31, 2019

FACTS ABOUT THE STRUCTURE:

• ANSYS Hall is 36,000 GSF; 4 floors, basement, and mezzanine.

• Stormwater management practices are used, which include water infiltration and detention.

• Green roof reduces runoff, improves water quality, and conserves energy while providing a natural habitat for small pollinators.

• Five types of exterior glazes are used on the building. Each type was selected based on its thermal performance and visible light transmittance.

• High bay area for large-scale student projects.

Please join us at the opening of our new building. More details on ANSYS Hall will appear in our next magazine.
As a student, Barry enjoyed the subject of corrosion science. He graduated top of his class.

Accomplished in his field, he has been chosen as a Fellow in the National Association of Corrosion Engineers.

Barry and his wife Aldene have created a lasting legacy at Carnegie Mellon through a gift in their estate plan that will provide scholarship support to undergraduate students in the Department of Materials Science and Engineering in perpetuity. The couple have also created a second scholarship in the School of Drama because of their love of the arts.

Barry serves as the Carnegie Mellon University Admission Council chairperson, where he often reflects on the rewards and demands of a Carnegie Mellon education.

Barry and Aldene enjoy competitive cycling. They organize the Cat’s Hill Classic race in Los Gatos, CA each year.

Learn how easy it is to achieve your philanthropic vision through a planned gift by visiting giftplanning.cmu.edu.

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