A 3-D approach to stop cancer in its tracks

Although cell analysis traditionally occurs in a plastic petri dish, Medical College of Georgia, Georgia Regents University, and University of Pittsburgh’s Dr. Daniel MacKenzie created a 3-D model that allows researchers to analyze the complex interactions of cancer cells in an environment more closely mimics the human body.

The model can be made up of cells from a single tumor that has spread to a distant organ, or cells from different patients. This could help researchers to better understand how the body fights cancer and develop new treatments.

An American company, MitoCure, is working on a drug that could help prevent the growth of tumors. The drug works by blocking the death of cells, which can lead to the spread of cancer. This is one of the main goals of cancer research.

For more information on cancer research, you can visit the National Cancer Institute website.
How we gather, process, and analyze big data and ultimately use it in decision making is revolutionizing engineering in the digital age. What can be learned from large datasets, with artificial intelligence (AI), has captured the imagination of researchers in the College of Engineering. Today, many researchers in the College are exploring AI and rightly so, because it is revealing information and new insights that previously were indiscernible, while simultaneously enhancing the speed at which we can solve problems.

Ironically, many people don’t realize that the College has been developing and applying AI long before the words artificial intelligence entered our daily lexicon. Perhaps this is because people have different definitions of the term, as AI touches different fields with myriad ramifications to give computers capabilities we consider intelligent or “smart.” Within the AI realm, researchers in the College of Engineering are exploring language processing, computer vision, and machine learning, with applications ranging from brain research to monitoring infrastructure.

Advanced computer vision capability aligns with the College’s history of pioneering work in the field of pattern recognition. Our efforts have contributed much to image recognition and classification, which affects everything from facial recognition technologies used at security checkpoints to cameras installed in autonomous vehicles to analyzing microstructures of materials. Beyond giving computers the capability to “see,” our researchers at Carnegie Mellon Silicon Valley have developed a system that distinguishes various people talking in a car to intelligently navigate and interact with passengers. The system combines computer vision and natural language processing to detect if a person is pointing to a restaurant they want to visit and then the system offers recommendations.

Machine learning is an area of AI that our faculty and students readily apply in their projects. College researchers are training computers to sift through massive data sets so that the machines will teach themselves how to complete engineering tasks. We have been doing this for a long time, and we’re good at it, and industry is taking note of our work. Bossa Nova, a leading provider of real-time, product data for the retail industry, is partnering with Professor Marios Savvides and his team to develop and integrate AI into their service robots.

The real world benefits of our AI efforts are becoming more apparent with each application. Our colleagues in Electrical and Computer Engineering are also figuring out how to shift machine-learning applications from the cloud and to mobile devices instead, which is remarkable when you think about the current computer power and storage needed for machine learning. People will be able to run complex tasks on their phones, without connecting to the network and accessing the cloud. This work has great implications for privacy, too, as personal information can remain on local devices.

In this magazine, we present a look at how we employ AI, but as always, there is much more underway in the College. I am proud to tell you that we have a number of early-career faculty members who have earned important National Science Foundation awards for their exciting work, ranging from 3-D printed ceramics to creating an architecture for pricing the usage of IoT devices. The students are flexing their creativity, as well. They want to drill for ice on Mars and here on earth, they are teaming with the Pittsburgh Penguins to make ice hockey safer. We are excited to tell you about the research, and of our ingenious faculty and students as they create innovations this academic year.

Sincerely,
James H. Garrett
Jack Forman (MSE/BME’19) worked with a diverse team to create a fashion collection called Homeostasis, which demonstrates different transformations that fabric can achieve.

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As artificial intelligence continues to revolutionize the face of research, researchers in the College of Engineering are creating and applying artificially intelligent technologies to solve engineering challenges. These methods augment researchers’ capabilities to find answers faster, sift through large datasets, and eliminate tedious tasks—allowing researchers to focus on what they do best, like interpret data and draw conclusions. Carnegie Mellon engineers are also powering the AI systems of the future by creating next generation hardware, storage, memory, and processing technology.

Carnegie Mellon engineering researchers have been working on new algorithms, applying existing algorithms, and developing state of the art systems for many years. From a machine learning method that optimizes chemical engineering processes, to facial recognition systems, to training the engineers of the future with AI courses and hands-on projects, our researchers are accelerating change and creating next-generation AI technologies and engineering solutions.
Machine learning applications are seamlessly interwoven into everyday tasks—Alexa, Siri, and Cortana compile our grocery lists and answer questions. But sending information to and from the cloud is not an ideal situation, for privacy reasons, convenience, or energy efficiency. Diana Marculescu, a professor in the Department of Electrical and Computer Engineering, is discovering efficient and accurate ways to run machine learning applications on mobile devices instead of relying solely on the cloud.

Most machine learning applications require computing power, data storage, and run-time costs that don’t allow for easy computing on a mobile device. Marculescu studies the energy efficiency of neural networks, or a type of machine learning where the configuration consists of many densely interconnected nodes. A neural network learns to perform a function, such as classifying images, by identifying correlations within a set of training data.

“Many people are looking at ways to represent everything that happens in neural networks, in terms of computation, with fewer precision bits,” said Marculescu. “If you quantize the values, rather than use continuous values, you don’t lose a lot of precision or accuracy in the results, but save runtime, storage, and improve energy efficiency. Storage efficiency is a big deal because all of these applications require massive amounts of data.”

For example, a designer may want to implement an image classification system on a smart phone, but the system needs to satisfy a certain power or storage constraint, so you don’t need to constantly charge the phone. With the work from Marculescu’s group, the designer can determine what configuration should be used.

Most recently, Marculescu and the students in her group have developed a framework called Hyper Power that introduces energy efficiency and runtime as constraints in the design process for neural networks. The framework considers power efficiency to be just as important as accuracy.

To find the best design for machine learning systems, designers usually have to experiment before they get to a configuration that will yield the best results. But as they experiment, it’s unclear where they are in the process—how accurate are the results that the configuration will yield?
We are devising accurate and efficient ways to run machine learning applications on mobile devices.

Are they moving in the right direction? To combat the uncertainty of designing these configurations, Marculescu’s team developed a way to put constraints on the configurations that are likely to be too slow or too power consuming, restricting search space and getting to a solution faster.

“With our framework, you don’t have to wait until you enumerate many configurations to find a solution,” said Marculescu. “Say I want to build a neural network for image classification for an autonomous vehicle application. The system has to run in real-time because you want to have certain things happen at a certain time and not later, for safety reasons. If you have those constraints, you want to eliminate any configuration that’s not going to fit them.”

The framework has great implications for moving machine learning applications from the cloud to a mobile device. For example, suppose a botanist in the wild wants information about a particular plant. Without being connected to the network and accessing the cloud, they could determine if it’s something edible or poisonous.

Running these applications could not only be faster, but also more private. If you run medical health applications on a local device, you can preserve the privacy of the individual. Likewise, when smart appliances make autonomous decisions about your home (whether to turn the temperature up or down, or what items are missing from your fridge, for example), that information should stay private.

“As much as we can make these a local decision rather than having to rely on the cloud, it’s a good thing,” said Marculescu.
CMU, Bossa Nova to Apply AI to Retail Analytics

Carnegie Mellon is partnering with Bossa Nova—the leading provider of real-time, on-shelf product data for the global retail industry—to develop and integrate artificial intelligence into service robots in retail stores nationwide. Bossa Nova’s robots are currently used in 50 Walmart stores across the United States, making it the largest deployment of this kind of technology in any retailer.

“This exciting collaboration between Bossa Nova and Carnegie Mellon reflects the growing synergy between universities engaged in cutting-edge research and companies that specialize in emerging technologies,” said Farnam Jahanian, president of Carnegie Mellon. “By bringing together CMU’s expertise in advanced artificial intelligence with Bossa Nova’s revolutionary software and industry partnerships, we can improve the retail experience for millions of consumers.”

Bossa Nova recently acquired the AI company, HawXeye, a CMU spinoff founded by Professor Marios Savvides and Andy Lin. Savvides is the director of the CyLab Biometrics Center and a professor in ECE.

“With the leadership of Prof. Savvides, the HawXeye team has an impressive track record of successfully transferring AI research out of a lab environment and into reliable and scalable products,” said Bruce McWilliams, CEO of Bossa Nova. “We have only scratched the surface of what’s possible in retail, and together, we will accelerate the development of advanced, AI-powered, data-focused solutions. We’re thrilled to welcome the HawXeye team and Prof. Savvides to Bossa Nova and to further expand our relationship with CMU.”

To date, Savvides’ biometrics lab has largely focused on using AI to detect and identify faces for authentication or surveillance applications. Through this new partnership with Bossa Nova, Savvides’ lab will adapt their AI analytics to detect and identify retail products on store shelves.

“We’re very proud of Marios for his groundbreaking work in biometrics,” said James H. Garrett, Jr., dean of Carnegie Mellon’s College of Engineering. “This is an exciting illustration of the College of Engineering engaging in unique approaches and applications of AI.”

Savvides’ lab will work to implement AI analytics into Bossa Nova’s technology, which work in-tandem with store managers and associates for precise product recognition at large scale, out-of-stock detection, and misplaced products by autonomously scanning retail store shelves.
We’re in the age of big data. Data collected through sensors and new technologies at multiple scales can be leveraged to make decisions and infer relationships. But it takes the right techniques and tools to do so.

Machine learning is one way that scientists and researchers are making sense of large amounts of data in a fast, efficient, and accurate way. Researchers in Carnegie Mellon’s Department of Chemical Engineering (ChemE) are using a novel machine learning approach, called ALAMO, to build simple, but accurate models for many applications.

“We don't just use algorithms that others develop,” says Nikolaos Sahinidis, a professor of chemical engineering and developer of ALAMO. “In our group, we also develop the algorithms ourselves and then we apply them to many application domains, both within and outside of process systems engineering.”

Process systems engineering involves making decisions about chemical processes—from designing molecules to designing entire supply chains. In all of these domains there are decision-making problems where algorithms are useful for optimizing these processes.

While deep neural networks provide accurate models, these models are very complex. Leveraging mathematical optimization techniques, ALAMO was developed as a new methodology to simply and accurately represent complex processes and account for physical constraints.

“What we started looking at seven years ago was the modeling and optimization of very complex processes for which we don’t have analytical models. So then the question was, can we use data to build mathematical models that we can then use to analyze and optimize these processes?” says Sahinidis.

To create these simple models, the ALAMO methodology uses a small set of experimental or simulation data and builds models that are as simple as possible. In the development process, the team has also found how to enforce physical constraints of processes in the modeling process.

Currently, a number of students in Sahinidis’ group are applying the ALAMO methodology, or similar approaches, to multiple chemical engineering problems.

Fifth year Ph.D. student Zachary Wilson is applying the ALAMO method to his work in reactions engineering. Wilson uses the ALAMO approach to create models that can predict what reactions or reaction mechanisms are occurring inside a chemical reactor, based on process data. In many problems, such as in computer vision and other problems that computer scientists tackle, the main goal of a model is to generalize and predict well. Understanding and interpreting the inner workings of the model often becomes a secondary priority. But in engineering, the parameters that researchers need to estimate are imperative, often having physical meaning.

“We've taken the integer programming methodology in ALAMO, which discretely considers sub-models, and have applied it to these engineering domains,” says Wilson.

Another application is in thermodynamics. Third year Ph.D. student Marissa Engle is extending the ALAMO approach to incorporate all of the datasets measuring different properties of the same fluid, creating one big picture to characterize its thermodynamic properties. Using data on pressure, volume, temperature, heat capacities, and speed of sound, Engle is developing machine learning techniques to find one equation based on these datasets that can easily be used for optimization.

“The problem with these equations is that they get very complex,” says Engle. “Using an ALAMO-like approach, we can suggest basis functions and limit how many terms are being used. We want to improve on these empirical equations so that they are simple, but accurate in the regions where new technologies are starting to push into areas where the thermodynamics get complicated, so we can accurately represent them and control them.”

Artificial intelligence and machine learning are providing new avenues for scientists and engineers to do their work better. But not all types of machine learning work for every problem. ALAMO is one example of how engineers are leveraging these techniques in order to accurately solve the problems that face engineers of every discipline.

“In some cases you can model from first principles,” says Sahinidis. “If the problem is too complex or too modern for first principles, then that's where we see the potential usefulness of machine learning.”
How can we turn chips into high-speed computers? ECE Professor Jimmy Zhu is making artificial intelligence pervasive with remanence computing. This new computer platform fuses logic, memory, and data on a single chip, enabling data-centric computing at a higher speed with fast and low power data processing.

The Prevalence of Artificial Intelligence in Engineering

Powering AI systems
- ECE Professor Diana Marculescu works on making AI systems more efficient so that they can run on local devices, instead of relying solely on the cloud.
- ECE Assistant Professor Gauri Joshi designs cloud and machine learning infrastructure to reduce delays in AI systems.
- ECE Professor Franz Franchetti works on improving the hardware that supports AI systems. He works across the stack to develop AI systems that are faster, accurate, and efficient.

Al for biological applications
- BME Associate Professor Steve Chase and ECE Associate Professor Byron Yu are using machine learning to understand motor learning. They apply machine learning algorithms to brain computer interfaces to better understand and explain neural activity.
- ECE Professor Radu Marculescu uses machine learning to infer microbial relationships in humans. He developed a machine learning algorithm—called MPLasso—that mines medical and scientific literature from the past few decades in search of experimental data from research focused on various types of microbial interactions and associations. MPLasso pulls this disparate information into a centralized dataset that catalogs microbial interactions within the human GI tract.

AI for materials classification and discovery
- MSE Professor Liz Holm uses machine vision to autonomously sort and classify materials microstructures, including 3-D printing powders. Using machine learning, Holm and her team can easily recognize whether or not a metal powder has the microstructural qualities—like strength, fatigue life, and toughness—needed for production.
- ChemE Assistant Professor Zack Ulissi uses machine learning to accelerate materials screening and catalyst discovery. Machine learning methods also allow him to predict the properties of small molecules and how they will interact with surfaces.

AI for infrastructure and buildings
- CEE Associate Professor Mario Berge is using a combination of sensors and artificial intelligence technologies to continuously monitor bridges, roadways, buildings, and other infrastructure systems in what is called indirect structural health monitoring. He also uses machine learning to study how much energy individual appliances use, and how appliances can meet the demands of the power grid.
- CEE Professor Burcu Akinci takes a big data analytics approach to facility and infrastructure operations and management. She uses object detection and 3-D imaging to extract building information needed for data-driven decision making in managing facilities.

AI in Mechanical Engineering
- MechE Professor Burak Kara uses machine learning to find lightweight options for 3-D printing, called topology optimization. He also developed a tool that uses AI for intuitive design. The tool recognizes what makes a car “sporty” or a shoe “comfortable.”
- MechE Associate Professor Albert Presto and his team used a machine learning approach to calibrate their low-cost air quality sensors. The calibration technique was found to improve accuracy and derive more sensitive readings.

AI and Privacy
- ECE Associate Professor Lujo Bauer developed glasses that fool facial-recognition systems. He also creates machine-learning-based personal privacy assistants to help users preserve their privacy.
- ECE Professor Marios Savvides develops facial and biometric recognition systems. He works on algorithms that are accurate and more reliable when variations occur.
- ECE Professor Anupam Datta studies accountability and fairness in AI systems. He develops ways to create trust in systems, by detecting and eradicating bias.
Developing new models and methods

EPP Assistant Professor Alex Davis worked with BME Associate Professor Adam Feinberg to develop a method to optimize 3-D printing with soft materials. The Expert-Guided Optimization (EGO) method combines expert judgment with an optimization algorithm that efficiently searches combinations of parameters relevant for 3-D printing, enabling high-fidelity soft material products to be printed.

BME/Chemistry Professor Newell Washburn developed an algorithm that predicts and optimizes complex physical systems, using small data sets. Most machine learning algorithms require very large data sets to train the system. But in some instances researchers only have a few data points to train an algorithm.

ChemE Professor Nick Sahinidis developed the ALAMO approach to machine learning that generates simple and accurate models for process systems engineering. While the method was developed to optimize chemical processes, it also has applications in other domains, such as thermodynamics.

ChemE Professor John Kitchin uses machine learning to generate models for molecular simulation.

ECE Assistant Professor Carlee Joe-Wong develops new algorithms for users in shared resource settings, such as taxi companies that compete to pick up passengers and use machine learning to learn where to go. She takes into account the user competition, and attempts to quantify the algorithm’s effectiveness when compared to non-competitive scenarios or naive ways of handling competition.

AI in Action

Over the last several years, Mechanical Engineering Professor Levent Burak Kara has watched the number of students in his artificial intelligence and machine learning course grow steadily. In this graduate course, students learn fundamentals—probabilistic learning, pattern recognition, neural networks, clustering, regression, and search—to develop skills to solve engineering tasks.

Building on these concepts, Kara launched a new course this spring, Artificial Intelligence and Machine Learning—Project, in which students take the AI techniques they previously learned and apply them to real-world engineering problems.

“They’re tackling interesting problems within their own research field, and we’re using machine learning mostly to solve those problems,” says Kara.

Because the new course focuses on applying AI, it was structured as a project-based course, with the students divided into small groups. Every week, the groups met with Kara to discuss their progress, challenges they faced, and possible solutions.

AI is reshaping the research landscape and changing what engineers and scientists can do. Courses like this one allow students to go into the work force with an advantage.

“A lot of IT companies are interested in machine learning talents because if you understand the principles of machine learning, you can apply them to a wide range of interesting problems,” said Kara. “You can take the foundation, your basic skills, and apply them to a different application with very little overhead.”

“In the course, students formulate the problem, develop and test multiple approaches, and run rigorous validation studies to justify their claims. This allows students to get a better appreciation for the strengths and weaknesses of different algorithms, while enabling them to come up with interesting variations to the conventional algorithms,” said Kara.

The student projects covered a wide range of topics. One project explored what constitutes a “good” and a “bad” photo, and how to use AI to compose a “good,” or aesthetically pleasing, photograph. Another group worked on a system that can deblur a selected part of an image.

“Our project could be subdivided into two parts. One was object detection, and the second was image deblurring,” said Ojas Joshi, who graduated this spring with his M.S. in Mechanical Engineering. “We combined those two things in an ensemble. The image deblurring algorithms deblurred the whole image—they don’t care about the detection part. So, we focused on improving object detection with image deblurring.”

Mechanical Engineering Ph.D. student Rebecca Tanzer along with her group predicted pollutant concentration at locations around Pittsburgh without monitors. The group set up a network of 50 sensors dispersed throughout the city to measure particles, specifically PM 2.5, an air pollutant that is a health concern at high concentration levels. The group gathered a large dataset consisting of data from their sensors, land use data, and meteorological data and fed it into a random forest model and neural network, two techniques they learned in Kara’s prerequisite course. The algorithms then had outputs of predicted concentration levels.

“You want to know what concentration you’re being exposed to in any given spot in Pittsburgh,” said Tanzer. “If you have a map on a website or an app, it could tell you how high the pollutant concentration is for where you are, and that might impact your decisions about where you go in the city.”

“It was good to learn about machine learning while applying it to a real problem,” said Tanzer. “It’s not just learning for the sake of learning.”
Simulating Railway Health

Civil engineers are using ANSYS software to monitor infrastructure systems.
Infrastructure is in need of a makeover—we see it as bridges, roadways, water systems, and railways crack and crumble. At Carnegie Mellon University, the work of researchers across many disciplines intersects to create technologies that will improve and extend the life of transportation infrastructure.

Researchers in the Department of Civil and Environmental Engineering (CEE) are leaders in indirect structural health monitoring, a low-cost and low-maintenance monitoring approach where moving vehicles use sensors to indirectly sense railways, roads, and bridges while traveling their normal routes.

“By instrumenting operational vehicles with sensors, we can conduct inspections and maintenance, without having to instrument the structures themselves. This reduces costs and won’t interfere with regular traffic. Further, more data can be collected from vehicles that routinely run on roads and railroad tracks,” says Hae Young Noh, a professor in CEE.

**Modeling Railways**

Track geometry is the measurement of a track system in three dimensions. Currently, the researchers use a track geometry car that runs once or twice a year to collect data. Ideally, the car should run constantly, but that would be too expensive.

Jingxiao Liu, a CEE Ph.D. student advised by professors Noh and Mario Berges, uses ANSYS simulation software to model how a track geometry train car moves and collects data.

The simulation models track parameters for a light rail system to predict when the railway’s health is degrading and in need of repair, or when the geometry indicates a dangerous situation that could cause a derailment. The predictive model provides a complementary way to continuously monitor infrastructure systems.

Liu’s project simulates a bogie (or wheel and axle system) accelerating over a railway. Using previously recorded data, the model predicts railway health by allowing researchers to test physical aspects of the bogie-track system. While they cannot change the parameters on the actual physical track, they can change parameters on the model. Testing the effects of different parameters can indicate when there may be a problem on the track, and maintenance can be done before an incident occurs.

(continued)
Research

To simulate how the bogie-track system operates, researchers conduct finite element analysis. This helps them understand how the system behaves physically under different loads and situations. Once the finite element analysis is complete, the final step is to analyze the system as it’s in motion.

According to Noh, the ANSYS software provides insight on how vehicles behave on the track, it helps the team develop algorithms from their collected data and simulations, and then it helps them validate their results.

“The value of this software is that we can make our simulation approximately realistic to the real world,” said Liu.

Collaborators on this research include Noh, Berges, CEE University Professor Emeritus Jacobo Bielak, former Department Head of Electrical and Computer Engineering Jelena Kovačević, and Dean of the College of Engineering Jim Garrett.

This project is supported by the National University Transportation Center Mobility21 at Carnegie Mellon. Mobility21 is a member of the university’s Metro21: Smart Cities Institute, which seeks to research, develop, and deploy solutions to improve the quality of urban life.

“By instrumenting operational vehicles with sensors, we can conduct inspections and maintenance, without having to instrument the structures themselves. This reduces costs and won’t interfere with regular traffic. Further, more data can be collected from vehicles that routinely run on roads and railroad tracks,” says Hae Young Noh.
This autonomously self-healing material is a breakthrough for soft-matter electronics.

Many natural organisms have the ability to repair themselves. Now, manufactured machines will be able to mimic this property. In findings published in *Nature Materials*, researchers at Carnegie Mellon University have created a self-healing material that spontaneously repairs itself under extreme mechanical damage.

This soft-matter composite material is composed of liquid metal droplets suspended in a soft elastomer. When damaged, the droplets rupture to form new connections with neighboring droplets and reroute electrical signals without interruption. Circuits produced with conductive traces of this material remain fully and continuously operational when severed, punctured, or if material is removed.

“Other research in soft electronics has resulted in materials that are elastic and deformable, but still vulnerable to mechanical damage that causes immediate electrical failure,” said Carmel Majidi, an associate professor of mechanical engineering. “The unprecedented level of functionality of our self-healing material can enable soft-matter electronics and machines to exhibit the extraordinary resilience of soft biological tissue and organisms.”

Applications for its use include bio-inspired robotics, human-machine interaction, and wearable computing. Because the material also exhibits high electrical conductivity that does not change when stretched, it is ideal for use in power and data transmission.

Think of a first responder robot that can rescue humans during an emergency without sustaining damage, a health-monitoring device on an athlete during rigorous training, or an inflatable structure that can withstand environmental extremes on Mars.

Majidi, who directs the Integrated Soft Machines Laboratory, is a pioneer in developing new classes of materials in the fields of soft matter engineering and soft robotics.

“If we want to build machines that are more compatible with the human body and the natural environment, we have to start with new types of materials,” he said.

The findings were reported in “An Autonomously Electrically Self-Healing, Liquid Metal-Elastomer Composite for Robust Soft-Matter Robotics and Electronics,” *Nature Materials*.

Majidi holds a courtesy appointment in the Robotics Institute. Other authors include Eric Markvicka and Xiaonan Huang of Carnegie Mellon University, and Michael D. Bartlett of Iowa State University.
New process turns sand and plant materials into a cheap and effective water filtration tool.

F-sand uses proteins from the Moringa oleifera plant, a tree native to India that grows in tropical and subtropical climates. The tree is cultivated for food and natural oils, and the seeds are already used for a type of rudimentary water purification. However, this traditional means of purification leaves behind high amounts of dissolved organic carbon (DOC) from the seeds, allowing bacteria to regrow after just 24 hours. This leaves only a short window in which the water is drinkable.

Velegol, who is now a professor of chemical engineering at Pennsylvania State University, had the idea to combine this method of water purification with sand filtration methods common in developing areas. By extracting the seed proteins and adsorbing (adhering) them to the surface of silica particles, the principal component of sand, she created f-sand. F-sand both kills microorganisms and reduces turbidity, adhering to particulate and organic matter. These undesirable contaminants and DOC can then be washed out, leaving the water clean for longer, and the f-sand ready for reuse.

While the basic process was proven and effective, there were still many questions surrounding f-sand’s creation and use—questions Tilton and Przybycien resolved to answer.

Would isolating certain proteins from the M. oleifera seeds increase f-sand’s effectiveness? Are the fatty acids and oils found in the seeds important to the adsorption process? What effect would water conditions have? What concentration of proteins is necessary to create an effective product?

The answers to these questions could have big implications on the future of f-sand.
Fractionation

The seed of M. oleifera contains at least eight different proteins. Separating these proteins (a process known as fractionation) would introduce another step to the process. Prior to their research, the authors theorized that isolating certain proteins might provide a more efficient finished product.

However, through the course of testing, Tilton and Przybycien found that this was not the case. Fractionating the proteins had little discernible effect on the proteins’ ability to adsorb to the silica particles, meaning this step was unnecessary to the f-sand creation process.

The finding that fractionation is unnecessary is advantageous, as leaving this step out of the process helps to cut costs, lower processing requirements, and simplify the overall process.

Concentration

Another parameter of the f-sand manufacturing process that Tilton and Przybycien tested was the concentration of seed proteins needed to create an effective product. The necessary concentration has a major impact on the amount of seeds required, which in turn has a direct effect on overall efficiency and cost effectiveness.

The key to achieving the proper concentration is ensuring that there are enough positively charged proteins to overcome the negative charge of the silica particles to which they are attached, creating a net positive charge. This positive charge is crucial to attract the negatively charged organic matter, particulates, and microbes contaminating the water.

This relates to another potential improvement to drinking water treatment investigated by Tilton, Przybycien, and Nordmark in a separate publication. In this project, they used seed proteins to coagulate contaminants in the water prior to f-sand filtration. This also relies on controlling the charge of the contaminants, which coagulate when they are neutralized. Applying too much protein can over-charge the contaminants and inhibit coagulation.

“There’s kind of a sweet spot in the middle,” says Tilton, “and it lies in the details of how the different proteins in these seed protein mixtures compete with each other for adsorption to the surface, which tended to broaden that sweet spot.”

This broad range of concentrations means that not only can water treatment processes be created at relatively low concentrations, thereby conserving materials, but that there is little risk of accidentally causing water contamination by overshooting the concentration. In areas where exact measurements may be difficult to make, this is crucial.

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Researchers develop new materials and processes to fabricate neural probes that mimic the mechanical properties of the nervous system.

The nervous system is loaded with encoded information: thoughts, emotions, motor control. This system in our bodies is an enigma, and the more we can do to understand it, the more we can do to improve human life. Brain-machine interfaces provide one way to connect with this puzzling organ system. But because electronic devices are stiff, planar, and rigid, they cause injury to the brain's soft tissue.

Until now, it's been extremely challenging to develop a material and fabrication method that is flexible enough to meld with the brain, but adhesive enough to stay in one place. However, associate professor of MSE and BME Chris Bettinger and his group have created a hydrogel material and fabrication process for electrodes that stick to the brain, matching its soft, squishy makeup.

"Imagine you have a bowl of Jell-O, and you insert a rigid plastic fork into the bowl and move it around," says Bettinger. "It's going to damage the Jell-O, producing defects and irreversible structural changes. That situation is analogous to inserting a rigid electronic probe into soft tissue such as someone's brain. It's a combination of what we call micro-motion and mechanics, which work together to not only damage the brain,
but also compromise the function of the implanted sensor."

The rigid electrode detects when neurons are firing and records the voltages associated with those firing neurons. But over time, the body interprets this material as an injury and a foreign body that needs to be attacked, degraded, isolated, and removed. Inflammatory cells then surround the probe, disrupting the signal strength of the neurons in that area.

In the past 20 years, silicon-based electronics have progressed from rigid and planar in form to curved, flexible, and stretchable. The rigidity of these electronics has evolved from being stiff like wood, to thin and flexible like paper, to stretchy and pliable like rubber bands. Now, Bettinger’s team is taking it one step further, making them not only flexible and stretchable, but also extremely soft and adhesive.

“If we could fabricate electronic devices that have mechanical properties closer to Jell-O rather than wood or plastic, then we can surreptitiously interface neural probes with the brain in a more benign manner,” says Bettinger.

The challenge is that the processes used to make sophisticated electronics require high temperatures (400 C or higher), a vacuum, and exotic solvents, buffers, acids, and bases to etch materials and patterns. None of these are compatible with soft hydrogel materials.

To combat these fundamental issues, Bettinger and his team created a new way to fabricate the electronics—decoupling the fabrication processes of the electronic part and the soft substrate it is embedded in. First, they construct the electronic part on a substrate that is compatible with high temperatures, extreme solvents, and a vacuum, and create the hydrogel substrate separately. Then, they remove the electronic piece from its original substrate and adhere it to the hydrogel substrate. The final device contains a thin layer of electronics on a soft, flexible, and sticky substrate that has mechanical properties similar to those of the nervous system.

Another challenge was creating a material that was still adhesive in fluid. If the material cannot adhere when wet, it would be like trying to keep a Band-Aid on while in the pool. For the electrode to work it needs to stick in one place for a long period of time. The researchers studied the properties of animals like the blue mussel, which sticks to rocks underwater. They applied those same chemical principles when creating the hydrogel substrate.

“Instead of having to take a brain or a spinal cord and then stick something into it and then injure it,” says Bettinger, “we can laminate it on top and avoid injury to the tissue.”

The fact that the nodes do not injure the tissue and do not move around means that they are able to record a stronger and more accurate signal from the firing neurons. The probes could now be used not only to record signals, but also for stimulation therapies.

For example, the electrode array in the probe could block the signal that induces inflammation in people with rheumatoid arthritis. Instead of using painkillers like opiates, an electronic-based therapy that stimulates appropriate regions of the spinal cord could be more targeted and effective, while avoiding the risk of addiction when compared to pharmaceutical-based interventions. The electrodes can also be used for long-term recording applications, such as testing how a new drug could affect the heart. A sticky, soft electrode that can bend and flex can ensconce the heart, record its contractions, and indicate which drug might be most effective.

“We’re trying to improve the temporal bandwidth of these probes, by preserving the longevity of the material. Then we can acquire more information and maintain a suitable signal-to-noise ratio,” said Bettinger. “Researchers in multiple disciplines are trying to improve the way that electronic devices can interface with the nervous system. We feel that we are contributing to this broader effort by expanding the materials toolbox to improve device performance.”

Bettinger and his group are collaborating with researchers in ECE at Carnegie Mellon and with researchers at the University of Pittsburgh. Their findings have been published in Advanced Functional Materials.
A High-tech Spin on Spider Silk

Game-changing technology can transform polymers from soft and thermally insulating materials to an ultra-strong and thermally conductive material.

Spiderman has it figured out.

It’s no coincidence then that when Sheng Shen talks about his work with polymer nanofibers he compares it to a spider spinning its web.

“Just as a spider synthesizes silk from protein polymer to form a fiber with strength similar to high tensile steel, polymers can be spun and drawn to form high-strength materials with exceptionally high thermal conductivity,” said Shen, associate professor of mechanical engineering at Carnegie Mellon University.

Shen and his team have developed a polymer nanofiber that is strong, lightweight, thermally conductive, electrically insulating, and bio-compatible. They accomplished all of this in a single polymer fiber strand measuring less than 100 nanometers.

According to Shen, the potential impact of this development is tremendous. The characteristics of his polymer nanofiber give it application in aerospace and automotive systems, civil and structural engineering, medical devices, and robotics.

In their simplest form, polymers are lots of identical molecules joined together over and over. The molecules could be joined in “simple” chains or more complicated structures. Either way, the resulting polymer has the same characteristics as the molecules used to create it. This means a polymer could be sticky, solid, pliable, or any number of other physical characteristics contained in its molecules.

Traditionally, said Shen, polymers are “the general material platform (used) to develop multifunctional materials,” including plastics, nylon, and rubbers. Polymers are easily processed at relatively low price points, but do have their drawbacks.

Prototypical bulk polymers are often amorphous, meaning their molecule chains are randomly coiled and lacking a defined shape and form. This lack of definition can lead to reduced strength, reduced thermal conductivity, and increased defects like voids and molecule entanglements.

The challenge was to develop a polymer that is both ultra-strong and thermally conductive.

For Shen, the place to do this was at the nano-level. At this level—one-billionth of one meter—Shen can engineer individual molecules to join together in exactly the way he wants them to join together.

“At the nanoscale, the polymer chains become highly oriented and defects that lower strength and thermal conductivity can be eliminated,” Shen said.

The resulting polymer nanofiber has a Young’s Modulus (the measure of the stiffness of a solid material) and a strength that Shen said are 300-times greater than bulk polymers.

As for thermal conductivity, Shen reports that his polymer nanofiber measures a conductivity rate of 100 W/mK. On average, the conductivity rate of steel is 54 W/mK and the rate of iron is 73 W/mK.

“These nanofibers provide a low-cost route to achieving highly effective heat removal in electronic systems,” said Shen. “They can also be bio-compatible heat spreaders for improving patient care.”

To date, Shen and his team have tested single nanofibers. On the strength of the results from those tests, they have turned their attention to creating an innovative manufacturing approach that will allow for the mass production of the polymer nanofibers.

Shen is confident that he and his team have invented a product that will have practical and large-scale impacts sooner rather than later.

“We really believe this is a game-changing technology by transforming polymers from soft and thermally insulating materials to ultra-strong and thermally conductive material,” Shen said.

Ph.D. candidate Ramesh Shrestha and Maarten de Boer, a professor of mechanical engineering, made significant contributions to this research. The article, “Crystalline polymer nanofibers with ultra-high strength and thermal conductivity,” was published in Nature Communications in April 2018.
The Vanishing Nuclear Industry

Could nuclear power make a significant contribution to decarbonizing the U.S. energy system over the next three or four decades? That is the question asked by four current and former researchers from Carnegie Mellon University’s Department of Engineering and Public Policy (EPP). Their answer: probably not.

In a paper, “U.S. nuclear power: The vanishing low-carbon wedge,” published in the Proceedings of the National Academy of Science (PNAS), the team examined the current U.S. nuclear fleet, which is made up of large light water nuclear reactors (LWRs). While for three decades, approximately 20% of U.S. power generation has come from these LWRs, these plants are ageing, and the cost of maintaining and updating them along with competition from low cost natural gas, makes them less and less competitive in today’s power markets.

In place of these LWRs, the team asked whether advanced reactor designs might play a significant role in U.S. energy markets in the next few decades. They concluded that they probably would not. Then, the team examined the viability of developing and deploying a fleet of factory manufactured smaller light water reactors, known as small modular reactors (SMRs). The team examined several ways in which a large enough market might be developed to support such an SMR industry, including using them to back up wind and solar and desalinate water, produce heat for industrial processes, or serve military bases. Again, given the current market and policy environments, they concluded that the prospects for this occurrence do not look good.

In the article’s conclusion, the team writes, “It should be a source of profound concern for all who care about climate change that, for entirely predictable and resolvable reasons, the United States appears set to virtually lose nuclear power, and thus a wedge of reliable and low-carbon energy, over the next few decades.”

Lead author on the paper was EPP’s M. Granger Morgan, Hamerschlag University Professor of Engineering at Carnegie Mellon. He was joined by Ahmed Abdulla, adjunct assistant professor in EPP and fellow at the University of San Diego California School of Global Policy and Strategy; recent EPP Ph.D. graduate Michael J. Ford (U.S. Navy Retired), now a postdoctoral researcher at Harvard; and current EPP Ph.D. student Michael Rath.
The National Science Foundation Faculty Early Career Development Program (CAREER) Award is given to rising faculty who are expanding their field by conducting groundbreaking research and educating the next generation of innovators. The College is proud to introduce its latest CAREER Award recipients.

Is 3-D Printing the Future for Ceramics?

The Department of Mechanical Engineering’s B. Reeja Jayan is no stranger to accolades; she’s received awards from the Army Research Office and the Air Force Office of Scientific Research and was named one of Pittsburgh Magazine’s 2017 40 under 40 honorees. Now she has once again been recognized for innovations in materials processing as a recipient of a NSF CAREER Award and $500,000 in research funding.

The focus of this research will examine how electromagnetic (EM) waves may be used to alter the structure within ceramic materials, potentially enabling the 3-D printing of ceramics.

The development of ceramic 3-D printing has lagged behind that of other materials, such as polymers or metals. Traditional ceramic manufacturing uses large amounts of energy, often requiring materials to be heated at extremely high temperatures. Jayan, however, hopes to instead use EM waves (such as the microwaves we use to heat our food) to induce changes within ceramics at the structural level. If successful, she could potentially achieve the same quality of results as current manufacturing methods—at a fraction of the energy cost.

The practical applications created by this potential manufacturing process are as significant as they are varied. 3-D printed ceramic parts could find use in sustainable infrastructure, transportation, clean energy, water management, aerospace engineering, and healthcare. By combining research in the fields of electrical and computer engineering, electromagnetics, materials science, mechanical engineering, and chemical engineering, the process Jayan is developing could provide a low-energy means to meet these industries’ demands for lightweight, high-strength materials.

The focus of the CAREER Award is not only to continue producing breakthrough research, but also to integrate this research into an educational setting. In the past, Jayan earned media attention for being among the first to fully integrate the popular open-world game, Minecraft, into a university-level engineering course. She plans to continue using “builder’s games” like Minecraft to teach students how building (aka processing) can change the way materials assemble (their structure) and alter the properties of the material.

“Games create a higher level of student engagement and a more stimulating learning environment, reaching a broader spectrum of learners in the classroom.” Says Jayan, “this helps address the challenge of cultivating a diverse and highly skilled manufacturing workforce in the United States.”
Almost everyone knows--and dreads--the feeling of getting stuck in traffic. Annually Americans spend billions of hours idling in egregious congestion, yet this doesn't necessarily have to be the case. The Department of Civil and Environmental Engineering's (CEE) Sean Qian is working with big data and transportation system modeling to develop a mathematical framework to improve the flow of traffic, and to improve the way we design, plan, and operate transportation systems. For his work, Qian has earned an NSF CAREER Award and $500,000 in funding for the next five years.

Qian uses massive amounts of data that's available from various sources to better understand and predict the function of multi-modal transportation systems (combinations of multiple transportation systems, such as highways, urban streets, public transit, parking, bikes, connected automated vehicles, etc.).

The data Qian uses is already available; however, it is siloed, meaning it's split between multiple transportation agencies. This makes it practically impossible to analyze or draw inferences about the operation of the overarching multi-modal system. Qian's project will bring together disparate data sets, fusing the information to create a clearer picture of how each system functions and affects the next. This will better reflect how individuals move through and between systems toward their destinations.

The information gleaned from Qian's work will help transportation agencies manage their respective systems. He'll look at changes in vehicular and passenger flow from one day to the next, or the day-to-day variance. His project will examine unique factors that distinguish each day to predict how individuals will move through the system.

He will also examine how likely the vehicle/passenger flow exceeds a threshold at any location in the transportation network, rather than an average. This can be learned from massive data collected over many years. This would allow more informative and reliable decision-making on infrastructure design and operation.

"If we know that there will be higher demand, we can allocate more resources and workers to manage this," says Qian. "If there's an incident, we can do the same, or possibly redesign the road to reduce the possibility or effect of future incidents."

For Qian, an incident isn't just a traffic accident or a natural disaster; an incident can be any major event that disrupts traffic, be it a sporting event, road closure, or an unplanned work zone. With the way data is siloed, we are unable to gain a clear picture of how these events affect the larger multi-modal system. If we can help travelers understand when and where people are traveling, they can better plan or be guided to avoid congestion. This reduces the overall strain on the system, ensuring better, more consistent transit times.

"The idea is that we can develop a decision-making tool for travelers and provide agencies with easy, more effective ways to manage traffic and reduce congestion and emissions. It's a win-win for both sides," Qian says.

Many of those who will use his framework will be engineers who are currently in school. With the lessons learned through this project, Qian will develop infrastructure management courses that place greater emphasis on data analysis.
NSF CAREER Awards

The Internet of Things (IoT), mobile networks, and edge devices are integral to daily life. Yet, with their everydayness, how do we take an eye off their tasks and rather, assess their economics?

ECE assistant professor Carlee Joe-Wong is working to establish the economic foundations for the next generation of computing. She noticed that despite the rising trend in the diversity of computing devices, nobody had seriously researched or discussed the economics. The National Science Foundation has given Joe-Wong a CAREER Award to explore this field so ripe for discovery.

Joe-Wong is trying to create an architecture for pricing usage of IoT devices that other innovators and companies can respond to and utilize. To her, “Figuring out how to price mobile networks is still an open question.” She outlines some possible options: one is to use flat-fee plans that allow customers “unlimited” access; another is to use data-capped plans that require monthly payment for a specific amount of use, such as only five GB for a monthly cellular data plan.

“My proposed work posits that, in the future, access to mobile networks will be sold in bundles, the devices accessing combined plans on other networks,” Joe-Wong says. A customer would pay for a plan sharing, for instance, mobile with Wi-Fi networks. Joe-Wong points out that this network access strategy has precedent. “AT&T sells bundled access to cellular and Wi-Fi networks, and Google Fi aggregates Sprint, T-Mobile, and US Cellular networks with Wi-Fi,” she says.

But network users need different things from their plans, depending on the devices they employ. IoT devices, from smart fridges to security cameras, require different arrays of data to use with their hardware and software. Joe-Wong’s proposal makes room for these realities. She suggests two forms of pricing: “simple, flat-rate plans aggregating access to multiple networks, and more dynamic plans where users bid for access on different networks according to their needs.”

As IoT develops, innovation and consumer interest could be determined by commercial pricing. Joe-Wong advocates for a sound strategy, wanting to “develop new types of pricing algorithms” for IoT. More importantly, she wants to investigate these models’ viability, and “whether they disproportionately benefit certain types of users.” She suggests that new pricing may spur development or take advantage of existing technology. One scenario she proposes is that a user finds it far easier to run machine learning software across multiple devices. Something like an aggregated data plan could make this possible.

For the short term, though, Joe-Wong wonders how her work could apply to industry. “Service providers might apply my findings to determine how to price access to mobile and computing networks for IoT applications,” she says. Regardless, she may just lay the groundwork for future pricing strategies and how IoT devices might integrate more into our lives.
Energy-Harvesting Devices

Energy-harvesting devices are tiny, embedded computing and sensing systems that operate by extracting small amounts of energy from their environment by tapping into sources such as radio waves, solar energy, and vibration. With system support to make batteryless devices operate reliably, these novel devices will advance future applications for the Internet of Things, disaster zone and conflict zone sensing and communication, wearable and implantable medical devices, and aerospace initiatives, including chip-scale nano-satellites.

Brandon Lucia, assistant professor of electrical and computer engineering, received a CAREER Award and a $654,500 grant over the next five years to further his research on energy-harvesting devices.

Building reliable batteryless hardware and software systems is a challenge because, unlike in a typical system, energy is only intermittently available. When a batteryless device’s energy supply is interrupted, the system suddenly resets, erasing some of the computer’s memory, and requiring the system to collect more energy before it can continue operating. The intermittent power interruptions lead to new kinds of software errors that are extremely difficult for a system designer to fix.

Lucia intends to develop the tools and techniques needed by nonexperts so they can build and leverage reliable and efficient batteryless computer systems. “Our goal is to make it as easy to build reliable energy harvesting applications as it is today to build an application for your iphone,” he says.

Making these systems reliable enables their use in domains that demand dependable operation such as medical devices and emerging consumer space exploration. As energy-harvesting devices evolve, they will benefit existing economic sectors such as IoT and Smart Cities, and industry’s adoption of the ideas developed in Lucia’s research will contribute to the creation of new economic sectors.

Realizing the importance of measuring the stress heavy machinery undergoes, the United States Air Force has awarded Assistant Professor of Mechanical Engineering Rebecca Taylor with funding to develop so-called “nanosprings,” which could stick to soft materials or eventually be sprayed onto metals or other conventional materials to estimate the mechanical strain a piece of machinery endures. The nanosprings would allow mechanics and engineers to monitor the integrity and function of mechanical equipment, such as struts or aircraft components.

Over the next few years, Taylor’s team expects to verify their experiments and submit their findings to the Air Force Office of Scientific Research. Funding for this project comes from the Air Force’s Office of Scientific Research Young Investigator Program.
ECE Ph.D. students Yang Gao and Wenbo Zhao have learned how to identify occupants in a room by their breathing. They investigated the personal and unique sounds produced during intra-speech inhalation, which the researchers used to identify occupants in a room with 91.3% accuracy.

ECE

Anne Skaja Robinson will be the next ChemE department head effective November 2018. Robinson has served as chair of the Department of Chemical and Biomolecular Engineering at Tulane University, where she increased the number of undergraduate and doctoral level students and raised the department’s U.S. News & World Report ranking 25 places.

ChemE

Tzahi Cohen-Karni, of BME and MSE, was named a 2018 Young Innovator by the Biomedical Engineering Society’s journal Cellular and Molecular Bioengineering. He is creating electrical microelectrode sensors out of graphene, setting the ground for investigating diseases such as Alzheimer’s, Parkinson’s, and heart arrhythmias.

BME

Nearly two dozen researchers associated with CyLab are individually investigating the world of blockchain. The group decided to create a central web presence to feature their work which will promote education about blockchain and demonstrate to the outside world (including funding agencies) that CMU is a thought-leader on the topic.

CyLab

Greg Lowry, of CEE, served on a National Academy of Sciences committee that investigated challenges to the future of agriculture and identified potential solutions. “Our committee proposes areas for strategic research investments to achieve science breakthroughs needed to make our food and agricultural systems more resilient and sustainable by 2030,” says Lowry.

CEE

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CyLab
MechE

MechE Department Head Allen L. Robinson and a team of scientists collaborating with the Environmental Defense Fund found that methane emissions from the U.S. oil and natural gas supply chain exceed EPA’s estimates by nearly 60%. They discovered that midstream emissions often contain super emitters, which contribute around half the total amount of all leaked methane.

EPP

EPP faculty members are contributing op-ed pieces to *The Hill*. Department Head Doug Sicker wrote about net neutrality; Tamar Krishnamurti and Alex Davis penned a piece on U.S. maternal morbidity rates; and Daniel Armanios wrote about the U.S. and China influencing Africa’s infrastructure and economy. Armanios also had a piece on intellectual diversity featured in *The Hechinger Report*.

INI

This fall, the Information Networking Institute (INI) welcomed an incoming class of 42% women—a vast increase from 2002 when women made up only six percent of the student population. Two new female faculty members have joined the INI: Aleecia M. McDonald, assistant professor of the practice, and Hanan Hibshi, research and teaching scientist and 2011 INI alumna.

MSE

Five MSE undergraduate students led by Liz Holm participated in the NextGen Fellowship summer research program, which was sponsored by materials informatics company Citrine and funded by the Schmidt Foundation. CMU was one of five universities to travel to the Bay Area for this program that gives undergrads hands-on experience with AI to work on materials science problems.
Welcome Carnegie Bosch Institute!

Carnegie Bosch Institute Relocates to the College of Engineering
Carnegie Mellon University (CMU) celebrates the relocation of the Carnegie Bosch Institute (CBI) to the College of Engineering, enabling the university to work with a major industry partner and forge new grounds in their long relationship with the Bosch Group.

CBI was established as an entity within CMU in 1990 through a major endowment gift provided by the Bosch Group, a leading global supplier of technology and services headquartered in Stuttgart, Germany. The Institute, which has been housed in the Tepper School of Business for 28 years, has moved to the College of Engineering in order to strengthen their focus on technological research, specifically in the areas of the Internet of Things (IoT), cybersecurity, artificial intelligence, big data, and related areas of innovation. Tepper will continue to work with CBI through the continued sponsorship of chaired research professorships of business school faculty.

“The purpose of the Institute aligns with CMU’s top research competencies: we focus on topics of innovation at the intersection of technology and business, essentially related to our increasingly connected world and Internet of Things,” says James H. Garrett Jr., dean of the College of Engineering.

Research projects will be selected for funding by a steering committee that includes representatives from both the Bosch Group and from multiple colleges at CMU. The committee will finalize funding decisions for these cross-college projects in December.

The partnership will allow both the Bosch Group and CMU to further the cutting-edge research efforts in which both are highly invested and train executives in areas of ever-growing importance for global industry. It will also be an additional tool for the cross-campus, interdisciplinary research for which CMU is known.

“I am excited to celebrate the relaunch of CBI within the College of Engineering,” says Garrett. “This partnership will undoubtedly result in identifying and supporting research opportunities that will have a positive, permanent and profound impact on the world.”

CMU, Howard University Offer Dual Ph.D. Degrees

Carnegie Mellon College of Engineering is pleased to announce a new partnership with the College of Engineering and Architecture of Howard University. This partnership will cover wide-ranging initiatives between the two institutions, including a dual-degree Ph.D. program that allows students to earn a Ph.D. degree from both schools.

To qualify for the dual-degree program, students must be admitted to engineering Ph.D. programs at both institutions. Students will spend at least three semesters at each school.

Students will have an advisor from each program who will collaborate with them on research. Students may transfer courses between the programs, but will submit and defend a single dissertation. In addition to the benefit of two academic advisors, students will have access to a greater number of courses, a larger set of research facilities, and a wider research community located in two major metropolitan areas, Pittsburgh, PA and Washington DC.

“The clear opportunities presented by this new CEA-CMU Partnership constitute yet another outstanding example of what we can and will continue to accomplish as a college,” said Achille Messac, dean of Howard University’s College of Engineering and Architecture.

In addition to the dual-degree program, the partnership includes a bridge program to provide eligible undergraduates with the opportunity to engage in research at the other institution over the summer. The program also includes coaching for students transitioning into the dual-degree Ph.D. program, as well as professional development programs.
James H. Garrett, Jr., dean of the College of Engineering at Carnegie Mellon was named a Distinguished Member of the American Society of Civil Engineers (ASCE) for 2018. This honor is reserved for the most eminent society members, as only 229 of the ASCE’s more than 150,000 members have earned this honor.

Garrett was recognized by the ASCE as a pioneer in advanced computing techniques. Throughout his research career, he has focused on how sensors and data analytics can make our cities more adaptive and efficient. This approach aims to give our built infrastructure the ability to detect problems and report them directly to the humans charged with maintaining those structures, allowing for more proactive and cost-effective infrastructure management.

The Society also acknowledged Garrett’s contributions to education and professional service. At Carnegie Mellon, he has demonstrated an unprecedented commitment to integrating research and teaching across engineering, science, arts, business, and other disciplines, to produce a generation of creative and technically strong engineers. In a professional leadership capacity, he is actively involved with the American Society for Engineering Education, ABET Academic Advisory Council, and the American Association for the Advancement of Science (Fellow).
Faculty Urge EPA to Fix Data Transparency Rule

Faculty members in EPP and CEE filed a comment urging the Environmental Protection Agency to correct deficiencies in its proposal on data transparency in the studies used to inform its regulations. They explained that the mandate might undercut regulations based on past studies that used private medical data.

The EPA argues that data transparency—use of public data in studies—allows it to rationally explain its actions. It claims that the use of public data will allow for greater independent verification and accords with policies ensuring public participation in lawmaking. This claim undergirds how the policy evaluates “pivotal regulatory science,” a phrase describing studies, models, and analyses that underpin regulatory decisions and cost-benefit calculations.

While the faculty endorse use of public data, they take issue with the policy’s wording. They argue that this policy could be applied retroactively to studies that have long informed EPA regulations, such as those of the Clean Air Act, as they rely on private medical data. This new policy would render those well-vetted, peer-reviewed studies unusable. The faculty argue that factoring-in the privacy status of data sets would allow the EPA to ignore available and impactful studies.

“Transparency is important,” the faculty attest in the comment, “but the underlying mission of the Agency is to protect public health and the environment using the best available scientific evidence.”

The faculty recommend that the EPA apply their mandate only to new data and studies using standard methods for anonymizing data. The faculty reference how the Food and Drug Administration sets research standards that limit how secondary studies affect regulatory decisions, and they advise the EPA to consider a similar approach to setting standards.

Scott Pruitt, former administrator of the EPA, declared that the policy would end “the era of secret science at EPA.” However, an article in the May 4 issue of the journal Science notes that the policy aligns with Republican objectives to loosen clean air regulations. Moreover, the studies based on private data that prompted the policy's creation have been independently verified. Regardless, researchers have found workarounds to EPA's policy. For example, Francesca Dominici's team at Harvard University's T. H. Chan School of Public Health has used public data to create detailed findings on air pollution.

The CMU faculty maintain that protection of patient privacy and “a poorly conceived transparency requirement could preclude the use of any epidemiological data to support agency decision making.” The result would undermine the EPA's mandate to set pollution standards that reflect and usefully implement the latest scientific knowledge.

In Memoriam

Fran McMichael

Dr. Francis Clay McMichael, emeritus professor of engineering at Carnegie Mellon and former civil and environmental engineering department head, passed away on July 28, 2018 at 80 years old. McMichael left a profound legacy at CMU, which he joined in 1967. He had been a faculty member in Civil and Environmental Engineering (CEE) and also in Engineering and Public Policy (EPP). He was the CEE department head from 1975-1979, and was appointed the first Walter J. Blenko, Sr. Professor of Environmental Engineering in 1981.

He was an influential teacher, mentor, colleague, and friend to many, and remained an active part of the college after transitioning to Emeritus Professor in 2002. CEE Department Head David Dzombak, a student of McMichael in the 1970s, said, “Fran McMichael built the environmental engineering program at Carnegie Mellon, starting with teaching and research of his own in the 1960s and 70s, and then he hired others to expand the program. The program has been consistently ranked as among the top environmental engineering programs in the nation for decades.”

In addition to his contributions to CEE and EPP, McMichael was instrumental in founding the Green Design Institute at Carnegie Mellon, along with CEE Professor Chris Hendrickson and Professor Lester Lave of EPP and the Tepper School. McMichael was one of the nation's leading researchers and educators in interdisciplinary engineering-based environmental problem solving.

“Dr. McMichael’s influence on the college and the field of environmental engineering was indispensable,” said Dean of the College of Engineering Jim Garrett. “He asked probing questions and he pursued the truth no matter the consequences to him.”

McMichael is survived by his wife Patricia, his daughters Jessica and Laureen, and four grandchildren.
Students

Drilling for Martian Ice

CMU competes at NASA’s Mars Ice Challenge
Just beneath the crust of Mars’ surface lies a valuable resource—subterranean ice deposits. Since water is the main ingredient in rocket fuel, being able to harvest the ice for in-situ resource utilization would make space exploration to the red planet much easier. Why carry heavy fuel through space when you can just make an extraterrestrial pit stop?

NASA and the National Institute of Aerospace first challenged groups of students with harvesting Martian water with their Mars Ice Challenge in 2017. This year Carnegie Mellon engineering students were selected as one of the ten finalist teams who would compete in Hampton, Virginia.

The Tartan Ice Drilling System (TIDS) team was comprised of 15 students spanning various majors in the College of Engineering. The team was advised by Aaron Johnson, a MechE professor who specializes in robomechanics, and MechE Ph.D. candidate Catherine Pavlov, a previous NASA researcher.

The system was designed to work as a series of processes that required little human involvement. First, a drill rigged to an XYZ positioning system cored into the dirt. Then, it removed a chunk of ice from the dirt and brought it to an induction heating chamber. Once the ice was placed inside, the coils surrounding the chamber ran electrical current to heat the chamber. The ice would melt, evaporate, and then be cooled to re-condense as usable water in the collection bucket.

Paula Zubiri (MechE’19) oversaw the creation of the XYZ positioning system which controls how the drill enters the dirt. A large challenge was dealing with high rotational velocity and torque in the middle of their system which was only a few square feet. “A lot of my MechE background deals with analysis of, not just structures, but how different objects interact,” she said. She worked closely with the leader of the drill group, Tim Cote (MSE’18). Cote chose materials that would suit a drill traveling to Mars, saying, “I can’t just throw a huge steel bar up on Mars because it’s too heavy.”

The drill group in turn needed to work with the water group led by Caroline Morin (ChemE/BME’18). Most of the other universities at the competition used auger drills to break the ice into small chunks before heating it and vacuuming up the water. The TIDS team chose to go for a cleaner method of water extraction, “thermal distillation where we will vaporize the water and then recondense it so that we are able to fully separate it from all minerals,” explained Morin. Heating and cooling methods would allow for less dirt build-up in the machine and would not require filter replacements, which would be a task for an otherwise busy astronaut.

Devin Gund (ECE’18) and Christina Ou (ECE’19) together led the electrical controls system group. “It really matters ... what kind of computer we use and what kind of sensors we hook up because everything needs to be very small and power efficient but also extremely fast,” Gund explained. Having a wide variety of engineering majors represented on the team helped them to plan for a variety of problems that could arise during the competition, whether they were mechanical, chemical, electrical, environmental, or related to material properties.

Three of the group leads—Cote, Gund, and Morin—were able to travel to Virginia for the competition. They were joined by Johnson, their advisor, and Ishmael Mercier (ECE’20), who helped on the hardware side of the electrical controls system. Mercier also works in the Tech Spark, the maker space in Scott Hall where the team set up their base of operations.

“The maker space was very gracious in giving us this space to work,” Mercier explained. “The machinists in the maker space, they’re awesome,” he added, referring to the expertise which staff and student workers shared with the team in terms of fixing bugs and finding parts to order.

The TIDS team successfully extracted a chunk of ice during the competition, navigating through the thick dirt that stalled other teams’ progress when it got wet and became clay-like. Although TIDS was not able to melt, evaporate, and condense the ice chunk into water in their allotted time, the team hopes to improve upon their methods and compete again next year with a similar but improved system.

Mercier has yet to graduate, so he looks forward to working on TIDS again next year. “Our plan for this [next] year is to actually design all of our parts from scratch in the maker space,” he says. The team also hopes to do more complete systems tests in the hopes of being selected again as a finalist in this prestigious and educational competition.
Say Yes To the Morphing Dress of the Future

Opening and closing the curtains every morning and evening. Wearing a cardigan to your chilly office even when it’s a hot summer day. Packing extra outfits while camping when the weather is unpredictable. So many inconveniences could potentially be fixed with fabric that modulates itself.

The concept of futuristic clothing and fabric that can change to adapt to its environment is nothing new. However, feasible solutions have yet to become mainstream commercially due to materials being costly, inflexible, or unwashable. Intrigued by this issue, Jack Forman (MSE/BME’19) worked together with a diverse team to create a fashion collection called Homeostasis which demonstrates different transformations that fabric can achieve.

In his junior year, Forman learned that Lining Yao would be coming to CMU as a professor of human-computer interaction. Forman had heard about her work on bioLogic—a project in which living cells serve as actuators for moisture-responsive athletic fabrics—and reached out to her right away.

A few months later, he found himself spending time in the Morphing Matter Lab, which Yao directs in the School of Computer Science. Here Forman met collaborators from different backgrounds, formed his interdisciplinary team, developed the technology, and incubated the fashion collection. The researchers he worked with include Hieu Pham, a visiting doctoral student from Stanford, Alan Guo (MSE’19), and Meng-Han (Mohan) Yeh, a costume design MFA student in the School of Drama.

One of the first people he worked with was Pham, who was looking into twisted-then-coiled polymer muscles to create shape-changing knitwear. Textile engineers and fashion designers trying to create shape-changing materials usually look into nickel-titanium NiTi, an alloy known for its shape-memory ability which is also prohibitively expensive. Pham was exploring the use of fishing wire as a suitable alternative that would cost less, be stronger, and have no hysteresis (i.e. it can completely reform to its original shape).

This inspiration turned into a plan after Guo suggested that he and Forman submit a
proposal to Lunar Gala, an annual student-run fashion show at CMU which is one of the largest fashion events in Pittsburgh. They iterated and finalized clothing designs with Yeh, who served as the main designer and draper for Homeostasis.

“As a materials scientist and biomedical engineer,” Forman said, “my coursework has given me a toolkit to contextualize biological processes in materials systems.” The way he and Guo transformed the looks was by sewing silver-coated nylon thread and small electrical circuits into the garments. Twisting, coiling, and bending the silver threads produced the desired movement in the fabric once the conductive silver was heated electrically by a handheld switch that the models could easily activate.

Each look in the Homeostasis collection showed off a different type of transformation. Linear thread in the bodice of a long black and silver dress could expand or contract an origami-inspired cutout to expose or conceal the midriff. Coiled thread would wind and unwind to spin tassel accessories on the large sleeves of a crisp white top. Bending strips of thread lifted a translucent over-skirt to create more volume at a shorter length and show off the white shorts underneath. And thread sewn directly into triangles of fabric on a little black dress allowed for a neckline that changed shape.

Forman says the team has continued to explore the possibilities of this technology beyond their debut at Lunar Gala. “By experimenting with composite structures, we are able to generate reversible actuators,” which means multiple transformations which can revert themselves are possible, an advancement on Homeostasis’ one-time transformation looks.

Something like solar-activated curtains could already be developed with the types of technology available, but one of the next steps for Forman is figuring out how to make shape-changing fabrics washable so they can be used for clothing. Creating waterproof systems without sacrificing actuation strength is the challenge, but solving it opens a lot of doors for shape-changing fashion, both for utilitarian and aesthetic purposes.
Mari-Therese Burton

Honorable Mention

Mari-Therese Burton, a senior in materials science and engineering received an honorable mention for the Goldwater scholarship.

“It’s a huge honor to even be nominated by CMU because there are so many wonderful students,” said Burton. “As someone who wants to procure a career in research, it is encouraging and inspiring to have the affirmation that I have a place in that area.”

“This is an extremely prestigious and competitive process,” said MSE Head Gregory Rohrer in noting how proud MSE and the College are of Burton. Burton works closely with MSE Professors David Laughlin and Michael McHenry to pursue her research passion in metallurgy. “They have helped me a lot with what I want to do when I graduate and they also encourage me to not be afraid to take risks.”

Burton hopes to get a Ph.D. and then gain industry experience. Burton has also considered becoming a professor of materials science. This past summer she interned at Carpenter Technology Corporation, a specialty metals company that does alloy research development.
Facebook and CMU-Africa Host Cybersecurity Hackathon

Facebook and Carnegie Mellon University Africa hosted a 24-hour cybersecurity hackathon from April 4-5, 2018, in Rwanda at the Kigali Marriott Hotel. The goal of the hackathon was to engage and inspire students to become more involved in the cybersecurity field by giving them a cybersecurity challenge to solve. Hackathons are a cherished Facebook tradition wherein engineers, product designers, and their colleagues collaborate to develop an innovative project to address a specific problem within an allocated timeframe.

“Hackathons spark student interest—in this case, in security and privacy—and encourage creativity,” said Lujo Bauer, a cybersecurity expert from CMU who participated in the event. “Both of these are crucial as we try to develop a workforce that will be able to answer the security and privacy challenges of tomorrow. CMU-Africa and Facebook holding this event here in Kigali reflects the recognition that security and privacy threats are a global problem that can only be solved by drawing on talents and viewpoints of people across the globe. Holding the event here is also a wonderful recognition of the high quality of our CMU-Africa students. I hope this event will be an inspiration and motivation to them as they graduate and start applying their skills in the workforce.”

A team of eight from Facebook traveled to Kigali to participate in the Cybersecurity Hackathon and the Facebook Carnegie Mellon University Africa Cybersecurity Summit, which included talks given by Facebook Engineers Vlad Ionescu and Peter Huitsing, Lujo Bauer, associate professor of ECE and Computer Science at CMU, and a keynote talk given by Facebook Chief Security Officer Alex Stamos.

According to Betsy Bevilacqua, Facebook’s Head of Security Programs and Operations, “the cybersecurity industry needs to be reflective of the diversity of people we aim to protect. Facebook has invested heavily in security education programs so all different kinds of people get to experience security fundamentals, hands-on.”

According to Crystal Rugege, director of strategy and operations at CMU-Africa “The rapid adoption of technology in Africa presents unprecedented opportunities for innovation, but also introduces massive threats in the cybersecurity space. CMU-Africa’s programs are uniquely positioned to address these security issues with the contextual intelligence and cultural nuances required for such a diverse continent.”

CMU-Africa first partnered with Facebook in 2017 for a Bot-Party and Hackathon in which students worked for 24 hours to build Facebook Bots. “Cybersecurity is extremely important in the development of transformative technology solutions in Africa,” said Andrea Ponce, director of development at CMU-Africa. “Through our partnership with Facebook, we are able to engage our students in an exciting challenge to create cybersecurity solutions for the continent and to expose them to Facebook’s top security engineers and leaders.”

This year, 65 student participants representing Rwanda, Kenya, Uganda, Nigeria, Ghana, Ethiopia, Zambia, Tanzania, Lesotho, and Togo formed teams to tackle a cybersecurity challenge that was disclosed on the day of the event. Participants got to interact with leading Facebook engineers and staff during their project development.

The winning team was ‘SUSSD’ comprised of second-year students Rahab Wairimu Wangari, Yvonne Wambui Gitau, and Emmanuel Biketi Chebukati, who developed a platform that detects fraud in mobile money using machine learning. They received a grand prize of an all expense-paid trip to the F8 developer conference in San Jose, California on May 1-2, 2018. Facebook’s annual developer conference showcases Facebook’s latest technology and gives participants a glimpse into what’s next for Facebook.
The Pittsburgh Penguins have teamed up with two international giants of science and technology—Carnegie Mellon University’s College of Engineering and Covestro—on a bold initiative to make hockey safer.

“Rethink The Rink,” a first-of-its-kind project, challenged students to develop material solutions that enhance the safety of the sport without compromising game performance. Their assignment focused on redesigning the rink dasher boards and glass.

“Players are bigger, faster, and stronger than ever before, and so our challenge is to find new ways to keep them safer and reduce injuries,” said David Morehouse, president and CEO of the Penguins. “This collaboration with Covestro and Carnegie Mellon is a specific attempt to use recent advances in material science to address the physical boundary that surrounds a hockey rink. Can we come up with a material solution that reduces the impact of players hitting the boards and makes the game safer for players of all ages?”

The first major step in the process was a “Make-a-thon” that was held on March 12-16 at the College of Engineering. The event brought five CMU student teams together to design and develop prototypes for testing. Prior to brainstorming concepts, 25 students attended briefings on the history of hockey rinks, the technology used in dasher boards today, and the joint injuries most common in the sport. They also learned about the properties of several different materials they could use. Throughout the process they had access to experts and materials technologies from Covestro, a high-tech polymers producer and “Official Innovation Partner of the Pittsburgh Penguins.”

While working to decrease injuries among hockey players, the teams faced an additional challenge: their new designs for rink boards must not affect how hockey pucks bounce off of them. Engineering students are primed to problem-solve for this type of paradox.

Details about the students’ prototypes are not available because their work is proprietary, however, successful prototypes could be submitted to experts at the NHL and USA Hockey for their feedback.

“I cannot imagine better partners than Covestro and Carnegie Mellon Engineering, acknowledged global engines of innovation in materials and engineering,” Morehouse said. “Combined with insight from the Penguins and the NHL on the hockey and rink management side, we think it is an exceptional team to explore ways to make an inherently physical sport safer for all players. This can be a meaningful research project that, if we achieve our goal, could help make a long-term impact on the game.”

If successful with the initiative on the dasher boards and glass, the “Rethink the Rink” group may explore the role of materials in other areas of hockey, including player equipment and rink construction.
Update: CMU, Covestro, and the Pittsburgh Penguins were pleased with the results from the project. Covestro offered paid internships to MechE’s junior Ian Suzuki and recent integrated master’s/bachelor’s graduate Alexander Duncan (’17, ’18) to work with a team of Covestro engineers, facilities personnel from the Penguins, and the dasherboard manufacturing company to develop the next stage of prototypes over the summer. The new dasher board prototypes will be manufactured and installed in the Penguins’ practice facility later this year.
There was option one, the pipedream that meant fighting for sponsorships, potential financial insecurity, and overall uncertainty.

Then there was option two. This one promised more stability. After all, he’d interviewed at a similar company before. He knew the possibility—and the security—was there.

Whether option one or two, CMU alumnus Matt Simone (MSE/BME’06) knew one thing: golf was absolutely going to be involved.

“I was always thinking about golf when I was at work,” Simone laughs. “I needed to somehow get it into my daily life.”

Last fall, Simone was promoted from Senior Research Engineer to Manager of Innovation at golf equipment manufacturer PING. Option two it was.
Simone grew up near Pittsburgh. He played sports as a kid—baseball and hockey mostly—but didn’t get serious about golf until his first year at North Allegheny High School. Around the same time, he took a physiology class and realized he enjoyed medicine. Both his parents were physical education teachers, “so sports performance and biomechanics were always of interest to me,” he says.

As he moved through high school, his golf game steadily improved. Running parallel to his maturing golf game was his interest in how the human body works. This interest evolved into a curiosity about biomedical engineering. So much so that when his senior year rolled around, his post-graduation path was all but crystalized.

“I was looking for a school where I could play golf and do good engineering,” Simone says. “I didn’t necessarily plan on staying in Pittsburgh. It just so happened that a world-class engineering program was in my backyard.”

He met with Carnegie Mellon’s then-head golf coach, Richard Erdelyi, and the fit was perfect. Academically, he discovered an interest in materials science, specifically the connection between biomaterials and tissue engineering, and his penchant for biotechnology.

After four years, he graduated with degrees in materials science and engineering and biomedical engineering. He also possessed a golf game that had grown by leaps and bounds. He enrolled in Johns Hopkins’ biomaterials graduate program. He kept golfing as well, winning a few Baltimore-area tournaments.

“Unfortunately, 2008, when I came out of grad school, was basically the worst time to come out,” Simone says. “Nobody in the startup biomed game was hiring.”

He interviewed for a few biomed positions, but nothing panned out. He eventually was hired as a product engineer at ATI, a Pittsburgh-based specialty metals supplier. “Obviously it’s not medical at all,” Simone quips. That didn’t mean he wasn’t well-prepared and highly capable. It simply meant using more of his materials science degree than he’d planned.

He started his career, continued golfing, and got to a point where he was happy with what he had—a great boss, a great company—but was starting to “lose focus a little bit.”

“I knew someone who I’d golfed with growing up who’d turned professional,” Simone says. “I asked myself ‘Well, do I look like that?’”

Hello options one and two.

Newly married, he talked with his wife about his ideas and options. Still unsure which direction to go, he applied at PING. It made sense because the work he was doing at ATI—searching for innovations to make steel and titanium perform better—was wholly applicable to the golf industry. He flew to PING’s Phoenix headquarters to interview, an experience that “changed the game for me.”

“The entire engineering department was a bunch of men and women who were like me and thought about golf 100 percent of the time,” says Simone. “They were obsessed. It was like ‘This is where I belong.’”

The fact that his wife grew up in northern Arizona made their decision that much more apparent. He was offered and accepted the job as a senior research engineer. He was responsible for exploring new metal innovations and manufacturing processes to create higher performing golf clubs. His recent promotion moved him to the head of his department where he leads the search for unrecognized materials and manufacturing processes to bolster PING’s hard-good lines—drivers and woods down to wedges and putters.

While he never planned to build a career centered around his materials science degree, what he learned at Carnegie Mellon naturally found a place alongside something he loves—golf. CMU taught him about priorities, about boundaries, and about working hard but still giving time to what you love. As much as he shudders to hear himself say it, it’s this very lesson he shares as a mentor to current students in the CMU Student-Athlete Alumni Mentoring Program.

“It sounds super cliché, like in a movie or something, but it’s true,” Simone says. “You never know who you might come across or what might influence you in a way that you never really thought was possible.”
An Engineer On Wall Street

Miles Hinderliter (MSE’02) has had a winding career path: he engineered stealth fighters, worked in food and agricultural investments, and now advises CEOs.

Upon graduation, Hinderliter interviewed with Lockheed Martin. The company invited him to visit their production plant. “Flat out, it’s enormous, technologically complex, and exciting,” Hinderliter said. “Seeing that made me decide to go with Lockheed Martin, and I started on their F-22 program.” Quite the first job.

Lockheed Martin invests deeply in talent development. “You could expand, change, and modify your role, and as long as you’re productive, the company would endorse your work,” explained Hinderliter.

His managers helped him move around the company, meet with senior managers, and work on high-level projects. “Lockheed Martin is engineering-heavy,” Hinderliter said, “but it’s where I learned a lot on how to present my ideas.” He honed his soft skills, pitching and managing projects and articulating how they fit into the company’s objectives.

Lockheed Martin put Hinderliter into a leadership development program. The program required him to pursue a master’s program, for which he chose an MBA at Emory University from 2006–07.

Fortuitously, his MBA introduced Hinderliter to finance. Several factors attracted him to the industry: he excelled at the hard math behind finance, and Wall Street enjoyed incredible success during Hinderliter’s studies.

He took a risk: he left Lockheed Martin to intern with Lehman Brothers in 2007. He returned to Lehman Brothers in 2008—on the day the company filed for bankruptcy. But despite the hullabaloo of Hinderliter’s first day, Barclays absorbed the company.

Hinderliter started at Barclays in the technology group because of his interest in computer chip design. In professional life, he emphasizes engaging with one’s interests. Moreover, he finds it vital “to like the people you work with, since I would work 16-, 18-, or even 20-hour days.”

Hinderliter later moved into the food and agriculture group, attracted by the chance to work with complex technology and forward Barclays’ initiative to fund sustainable, clean technology.

Hinderliter notes that the perceived gap between engineering and financing is quite narrow. “You know, at Lockheed I did spreadsheets and presentations, and at Barclays I did spreadsheets and presentations,” he jokes.

His time at Lockheed Martin gave him valuable perspective to view the challenges of finance. When pricing a bond once, others made the process needlessly difficult. “Look,” Hinderliter quipped, “I worked with a group that made airplanes invisible. We can figure out how to price a bond.”

Recently, Hinderliter accepted a new position at the advisory firm Evercore. Because of the 2008 financial crash, successful bankers, including Hinderliter, found more desirable jobs outside of traditional banks. Advisory firms are free from the bureaucracy that other banks comply with. While Hinderliter’s employer has changed, his job remains the same—strategizing for chief executive and financial officers.

Since Harvard, Yale, and Princeton grads dominate finance, Hinderliter said that his Carnegie Mellon credentials raise eyebrows. “Engineering is a profession that sticks out on Wall Street,” he said. “I get a lot of credibility from CMU and Lockheed Martin, and my technical skills never get questioned.”

At Barclays, Hinderliter learned the phrase, “success breeds success: one opportunity opens access to another.” For Hinderliter, that holds true.
ACROSS
1 Cancer-causing radioactive gas
3 Strong, thick rope
5 Reduces friction
7 Line gauge
10 Wooden-headed hammer
11 Iron + air + water =
13 Atomic particle
15 Hole maker
16 Å
18 Thirsty car (2 words)
21 Moves fluid
22 Blue element
24 Temperature reader
27 Juvenile caterpillar
30 Everyone’s favorite ads
31 Coating that stops water
32 Top dirt
33 Headless nail
34 Night loving
37 Random access memory
40 Plants making dinner
42 Sneaky software
47 Woven material
48 Speeds up reactions
49 The P in HTTP
51 Quicksilver
52 Measures weight
56 Not software, instead
58 Science fair ingredient
59 Whoa, big wave
60 Shed feathers
61 Hypertext Markup Language
62 Dastardly code

DOWN
1 Moves data between networks
2 Airship
4 Provides electric current or a criminal offense
5 Rules
6 Increase speed
8 Home planet
9 Make bigger
12 Non-elastic or candy
14 Fig roll or force
17 Slick hill (2 words)
19 Crop cutter
20 Total emptiness
23 Twisting force
25 Temp for liquid ice (2 words)
26 Digging tool
28 Pollution type (2 words)
29 Cruise internet
35 Grants access (to device)
36 Hardened gravel and cement mix
38 Hand tool
39 What remains behind
41 Not online
42 New company
43 A billion bytes
44 Superman’s elemental home
45 Salt
46 Semiconductor
47 A push or pull
50 Makes a bumper shine
52 Experiment room
53 In science, proceed with order
54 Nasty for pipes or paint
55 Weighs 14 pounds
56 Make temperatures rise
57 Won’t bend

Answers shown on back cover
BILL McGAW (MechE ’39) sees motivation in hard work. During a 35-year engineering career at Pratt & Whitney, he was instrumental in converting gas turbines from aircrafts and battleships for use in operating pumps and electric power generation.

At Carnegie Mellon University, Bill has created a lasting legacy by establishing two gift annuities that will support a graduate fellowship in mechanical engineering, spurring innovation for generations to come. Bill named the fellowship in honor of his father (CIT 1917) and mother. The fellowship is a fitting celebration of Bill’s parents, who worked hard in order to support his education.

Learn how easy it is to achieve your philanthropic vision through a planned gift by visiting giftplanning.cmu.edu. Contact the Office of Gift Planning today at 412.268.5346 or askjoebull@andrew.cmu.edu.

Carnegie Mellon University
College of Engineering
The Tech Spark opened this summer. It is the cornerstone of the College of Engineering’s maker ecosystem, an integrated set of resources where faculty and students create and develop new ideas, concepts and products for courses and research. The space houses a simulation cluster, 3D printers, rapid prototyping equipment, electronic fabrication facilities, and traditional manual and CNC machining to allow students and faculty to design and fabricate at the nano, micro and macro scales.