THE UNIVERSITY OF UTAH

JOHN AND MARCIA PRICE COLLEGE OF ENGINEERING

RESEARCH REPORT

2023

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FROM THE DEAN

Last March, the Institute for Electrical and Electronics Engineers presented the University of Utah with the prestigious IEEE Milestone, recognizing the U's foundational contributions to computer graphics some 50 years ago. To honor the occasion, computer science graduates from the '60s and '70s who went on to become the "who's who" of computing, returned to campus for a once-in-a-century reunion and symposium (see story page 14).

The same spirit of discovery that led to such a unique era continues to propel faculty today to ever greater heights of achievement. From the seven young faculty who received 2022 NSF Early Career Development Awards, to the spin-off of 100 faculty–research based companies since 2006, the John and Marcia Price College of Engineering consistently ranks in the top 40 of U.S. universities in annual research expenditures with more than $100M/year.

In this year's Research Report, you'll meet just a few of the faculty who are keeping the Price College of Engineering at the forefront of discoveries in fields ranging from nuclear to biomedical engineering.

Utah's most respected engineering and computer science program inspired two of the nation's leading philanthropists to secure the future of the college with transformational gifts. Building on the U's national reputation in computing, the Kahlert Foundation made a historic $15M commitment last November to name the School of Computing. Then, in January 2023, American diplomat and business leader John Price and his wife Marcia presented the University of Utah with a $50M gift to name the College of Engineering. Included in the gift was $17.5M designated for a new 250,000 square-foot computing and engineering building. Groundbreaking is scheduled for next May.

These developments undoubtedly influenced the 2023 Utah State Legislature's decision to provide $118M to support the building's construction. To date, this is the largest capital appropriation in the university's history, and it underpins the importance of engineering and computer science to the state's economy. In 2020, the contribution to Utah's gross domestic product was $25B.

While it's important to look back and celebrate the achievements of the past, it's even more exciting to contemplate the possibilities of the future. Looking forward, the John and Marcia Price College of Engineering has reached another inflection point and will continue to advance among research engineering and computing programs in the nation.

Richard B. Brown

H.E. Thomas Presidential Endowed Dean,
John and Marcia Price College of Engineering

CONTENTS

CATALYSTS OF CHANGE

In chemical engineering and materials science, it's common to find reactions that happen so slowly or rarely that they can hardly be said to occur at all. That is, until the introduction of a catalyst.

From the Greek "to loosen," catalysts provide new routes for reactions to take, freeing atoms and molecules from a previously stable state, and enabling them to interact and combine in ways that they would not otherwise have the energy to do.

When it comes to the actual practice of engineering or scientific research, catalysts take the form of people. Through their ideas, aspirations, connections, or resources, they enable sudden leaps of progress, disrupting the status quo.

The John and Marcia Price College of Engineering is fortunate to count many such catalysts among its friends and family. In the past year, three in particular have inspired enough change to etch their names in the College's history and infrastructure.

In honor of Alan W. Layton, the Julie M. and David S. Layton Foundation has provided a $1M commitment to the Department of Civil & Environmental Engineering's teaching laboratories. The Layton Building, opened in August 2023, will be home to new laboratories dedicated to Cyber Infrastructure, Hydraulics, and Construction Materials, as well as a Maker Space designed as an onramp into the discipline for new students.

A $15M donation from the Kahlert Foundation to the School of Computing has provided it with its new name, as well as an endowment that will expand student support, bring in top faculty and accelerate industry collaborations.

Finally, the John and Marcia Price Family Foundation's $50M gift is the most transformative in the school's history, an inflection point now recognized in the College's name itself. Beyond endowments for scholarships, labs and equipment, and new educational initiatives, the gift will support the construction of the John and Marcia Price Computing and Engineering Building, the construction of which will begin next year.

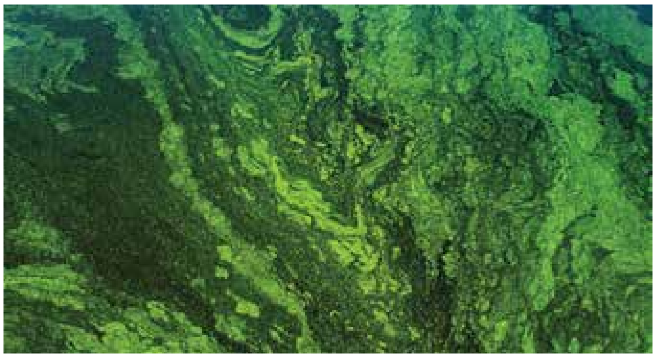
The impact of these three catalytic gifts is already being felt, and will be felt for generations to come.

THE LEADING EDGE

Researchers in the University of Utah's College of Engineering are continually discovering new ways to improve our world. Here are examples of their pioneering research that are making headlines. To read more about these and other projects, go to www.price.utah.edu.

ALGAL OVERLOAD

The simple water-based plants known as algae are some of the fastest-growing organisms on the planet. This is a boon for their potential use as biofuel, but can be a serious problem in lakes and waterways — especially when the algae in question are toxic. Thanks to a $3 million NSF grant, civil and environmental engineering professor Ramesh Goel is studying the genetic factors that make some species of algae produce toxins, while closely-related ones do not. Goel and his colleagues are also considering the effects of climate change and agricultural pollutants in investigating the roots of these toxic blooms. Preventing their proliferation not only protects livestock, pets, and people from being sickened, but the overall health of aquatic ecosystems.



AIR QUALITY MONITORING

Whether they come from wildfires, wind-blow dust, or industrial population, particulate matter in the atmosphere is pulled down by gravity, settling in layers of smog and haze. Nestled in a valley, Salt Lake City is particularly susceptible to this phenomenon, but the effects are not evenly distributed. Now, the U's AirU sensor network, built by chemical engineering associate professor Kerry Kelly, chemical engineering professor (lecturer) Tony Butterfield, Kalhert School of Computing professor Ross Whitaker and electrical and computer engineering associate professor Pierre-Emmanuel Gaillardon, is feeding its data into the Salt Lake County Department of Health's "Airview." This aerial map gives a real-time look at variations in air quality across the city. It can be viewed at *https://slco.org/health/air-quality/map/*

ELECTRIC AVENUE

One hurdle to the widespread adoption of electric cars is a modern ailment known as "range anxiety" — the fear that your vehicle's battery will deplete before you get to the next charging station, which are still relatively few-and-far-between. But what if your car could be recharged by the road itself? Price engineers have joined the NSF Research Center ASPIRE, based at Utah State University, to answer that question. Standing for "Advancing Sustainability through Powered Infrastructure for Roadway Electrification," ASPIRE aims to scale up wireless charging technologies, enabling future vehicles to pull electricity from them, even while driving. Masood Parvania, associate professor of electrical and computer engineering, will act as the U's site director for ASPIRE.

WEARABLE SAFETY

Thanks to miniaturized sensors, smartwatches and other everyday consumer electronics have gained an impressive array of health-monitoring abilities. However, how these devices interact with their more powerful, medical-grade cousins has not been extensively studied. Electrical and computer engineering assistant professor Benjamin Sanchez Terrones and U associate professor of medicine Benjamin Steinberg published a new paper suggesting that these consumer products need more scrutiny before they are used by people with certain cardiac medical implants. Their simulation and benchtop experiments showed that wearables that use bioimpedance sensors, which send an imperceptible small current through the user's body, could potentially interfere with pacemakers, as well as similar devices for managing the heart's electrical impulses.

MEASURING PV PERFORMANCE

The need for alternative energy sources has led to an explosion in research on photovoltaic materials, which convert light into electricity. As a result, the efficiency of new solar panels steadily rises year after year. It also makes for some tricky calculations — since solar panels must operate for years to recoup the expense of manufacturing and installing them, predicting the efficiency of future photovoltaic technologies is a key consideration. Mike Scarpulla, associate professor in the departments of Materials Science & Engineering and Electrical & Computer Engineering, along with University of Luxembourg's Phillip Dale, has published a new study that rethinks how such efficiency evaluations should be made. Their work will help funding agencies, researchers, and policy-makers make better investments over time.

waste not

Spent nuclear fuel risks polluting the environment or being turned into weapons. Michael Simpson has a solution for both.

“Shut it down and clean up the waste.”

According to Michael Simpson, professor in the Department of Materials Science & Engineering, that was the prevailing attitude toward nuclear power in the late 90s, when he began his research career at Argonne National Laboratory-West.

In the post-Cold-War years, concerns over safety, security, and the environmental impact of radioactive waste had soured public opinion. Working in national labs for the Department of Energy (DOE), he saw many nuclear projects fizzle and die on the vine in that era; the timelines needed for them to bear fruit were incompatible with the rhythms of federal funding and shifting political winds.

Fortunately for Simpson, whose work is focused on making nuclear energy safer and more environmentally sustainable, those winds are shifting again.

“When I first came to the U a decade or so ago, I still wasn’t sure what sort of federal funding I would be able to get for my research,” says Simpson. “But since then, there is a renewed positivity — there’s almost too much to work on now.”

That positivity was born of necessity. While fears of nuclear accidents and terrorism still weigh on the public consciousness, they are being overmatched by the growing realities of climate change.

Some of the shift was sparked by private investment, including from environmentally motivated billionaires like Bill Gates, which invigorated the nuclear industry by funding research, development, and design of new types of reactors. The waste problem, however, continues to hinder more widespread adoption.

“There is around 80,000 metric tons of spent fuel just sitting in temporary storage at nuclear power plant sites, with no real plan on what to do with it,” says Simpson. “But I think our approach to recycling this fuel will reveal a sensible path forward within the next few years.”

Simpson, a chemical engineer by training who also has appointments in the Nuclear Engineering Program and the College of Science’s Department of Metallurgical Engineering, sees his interdisciplinary background as critical to that challenge. That’s because both the promise and perils of recycling nuclear fuel lie in the materials involved.

Most current nuclear power plants use fuel rods, which consist of ceramic pellets of radioactive metal oxides — uranium, plutonium, and others. Heat

from the fission chain reaction within the fuel pellets produces the steam that spins the reactor's turbines, and control rods keep the rate of that reaction at a manageable level.

The physical makeup of spent fuel rods is also an intrinsic safeguard against them being weaponized; none of their fissile elements are pure enough to be used in a nuclear bomb, and the fission products are highly radioactive. It's the impact on these safeguards, however, that makes the prospect of recycling fuel rods daunting.

A spent fuel rod still has plenty of fissile material left inside, just not enough to overcome the limiting effects of its fission products. Ideally, the remaining fissile metal — such as uranium and plutonium — would be extracted and used to make new fuel rods, but purification processes come with a proliferation risk. Any technique that produces pure plutonium increases the likelihood of it falling into the wrong hands.

Simpson's latest research project, funded by the DOE's Advanced Research Project Agency, ARPA-E, aims to change that equation.

"When we discovered lead additives in gasoline were causing numerous health effects in people, we didn't stop using gasoline, we just changed its chemistry," Simpson says. "We're now aspiring to do the same with nuclear recycling; different chemical processes can reduce, or possibly eliminate, the risk of proliferation."

PUREX, one recycling method currently employed, involves dissolving spent nuclear fuel rods in acids, followed by selective extraction of uranium and plutonium into an organic liquid, then into separate, purified product streams. The possibility of diverting that pure plutonium, however, is the source of the proliferation risk.

Instead of acid, Simpson and his colleagues' proposed recycling method uses molten salt to dissolve the spent fuel. Chlorinating and dissolving spent fuel pellets in this way keeps a class of radioactive elements, including plutonium, bonded together. This method cannot produce weapons-grade plutonium, as it can't be separated from the uranium, neptunium, americium, and other actinides in the pellets. However, electrochemistry can be used to extract the combined actinides as a metal that can be used as a source of fuel for advanced reactors.

The remaining waste would still need to be safely stored, but with most of the long-lived radioactive elements going back into the fuel cycle, that storage could be managed in a timeframe of centuries rather than millennia.

Simpson is confident that this approach will be validated and scaled up in the next few years, and he credits the pace of this progress to his research group. It's one of the largest in the Materials Science Department, if not the College; another testament to how much the need for new energy sources has shifted public opinion.

"I'm finding freshmen who have so much excitement about the field, they stay with me throughout their undergraduate years, sometimes becoming grad students," Simpson says. "I've been impressed beyond my wildest expectations of the students I work with. They've all brought so much to my research program and a great deal of them have come from Utah. I'm so grateful to have the opportunity to work with them."

ACCELE

RATING IMPACT

Biomedical Engineering Chair David Grainger on how his department is adjusting to a dynamic technology environment

Orderly, engineered artificial systems, whether they're constructed out of bits, atoms, electronic circuitry, or mechanical gears, seem to stand in stark contrast with the squishy, chaotic world of cells, proteins, and nucleic acids that comprise natural biological systems.

For David Grainger, chair of the Department of Biomedical Engineering (BME), however, the barrier separating those two worlds is becoming increasingly diffuse. This technological overlap is endemic to the biomedical engineering field; roughly half of BME students perform their research in conjunction with School of Medicine and Health Sciences partners, and multiple BME faculty are cross-appointed into these departments. And significantly, more parts of the campus are forging inroads to biomedical engineering than ever before.

"Opportunities within healthcare to produce knowledge, education, and new technologies are expanding constantly, and involving increasingly diverse expertise and departments," Grainger says. "That's inspired a lot of students and faculty to get involved with our department, and we're carrying that momentum forward with broader research and new educational offerings."

As with many revolutions, scientific or otherwise, a crisis precipitated this change. The COVID pandemic thrust biomedical engineers onto the frontlines of a global battle with life-or-death stakes. Lacking much clinical validation for decades, the technology behind mRNA-based vaccines was revitalized in a crash program, with researchers turning a proof-of-concept into 13 billion effective doses in less than three years. This urgency also promoted interdisciplinary collaborations responsible for other innovations; materials scientists and mechanical engineers tapped BME expertise to load mRNA into safe delivery systems, develop personal protective equipment and patient mechanical ventilators, and innovate instant PCR testing methods.

Of course, the next revolution doesn't wait for the last one to finish; BME routinely responds to new challenges with partnered interdisciplinary design teams that address complex healthcare technology ambitions. As soon as "machine learning" and "big data" became commonplace terms within the discipline, biomedical engineers were forced to wrangle with new opportunities and applications. Targeted to sift through impossibly large sets of chemical permutations in search of drug candidates; automatically identify critical features in biomarker disease profiles and human-scale diagnostic imaging; or flag clinical features in patient electronic health records, new algorithmic technologies show great promise — and potential peril.

The decisions that AI-based tools make are only as good as the data upon which they are trained, and still must be implemented and verified by human clinicians on human patients. As such, the department is collaborating with other campus schools, institutes, and departments, as well as University-wide initiatives like DELPHI — Data Exploration and Learning for Precision Health Intelligence — to provide a path forward.

"We're in active discussions with our colleagues in the Kahlert School of Computing, Medicine's Department of Bioinformatics, Hunstman Cancer Institute, UCAIR, and others, to help guide how we train our students to engage with data science and AI as they evolve in healthcare technology," Grainger says. "These technologies, relatively new to BME endeavors, will alter future aspects of the BME discipline. As Chair, I'd prefer to act on our mission now than react later."

In many cases, that future is already here; new subfields where the biological, the biomedical and the technical merge to inform and complement one another are going viral. Recent advances in synthetic biology allow genetic sequences and their functional operations to be cut-and-pasted like lines of code between different organisms. Neuroengineering researchers are developing a new, innovative brain-machine interfaces, in which synaptic signals are directly read and translated into digital messages, which can then be deciphered and converted into action. This microelectronic communication conduit into tissue can mitigate the effects of stroke or spinal cord injuries, even allow patients to control computer interfaces and robotic operations with a thought.

On a smaller scale, wearables that record heart rates, sleep cycles, and other biometrics, will digitally monitor increasingly diverse physiological and pathological indicators enabling better telehealth and remote medical interfacing.

"The limited biometric reporting of your Apple Watch is just the tip of the iceberg," says Grainger. "The improved capabilities and fidelity of these sensors, their validation with regulatory bodies, and the rise of telemedicine in general, are rapidly improving medical technologies that provide physicians access to types, formats and amounts of health data we've never had before. This real-time remote monitoring capability will produce a dramatic shift in how patients are handled in the healthcare system."

Huge amounts of patient-derived medical data are also helping biological and computational technologies merge in an even more comprehensive way, through the concept of a "digital twin."

"If we had enough reliable, quality data to inform how the complex, interactive and often chaotic physiological processes in our bodies work to produce both health and disease, we could simulate them with elaborate computational models," Grainger says. "Then we wouldn't need to rely on mouse or zebrafish models to mimic human conditions, or blindly tweak a black-box experimental model to merely approximate what's going on inside a specific patient."

As these revolutionary technologies take further shape and disrupt the landscape of current healthcare protocols, Grainger sees anticipating and harnessing such changes as being inherent to his department's mission in research, training, and teaching.

"Our department has always focused on the value derived from medicine and engineering working together to address unmet clinical and healthcare needs," Grainger says. "BME relies on partnerships, teaming, and inter-personal engagement to perform our mission. It's necessary because of the breadth and complexity of human healthcare, rapid advances in both engineering capabilities and clinical standards of care, and evolving clinician needs in better addressing patients."

"Ultimately," he says, "we're a melting pot of faculty, students and disciplines, breaking down traditional academic silos in pursuit of that interdisciplinary and translational biomedical mission."

UTAH THE PLACE FOR COMPUT
GRAPHICS

IEEE Milestone Event Recognizes Pioneering Alumn

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At the mouth of Emigration Canyon, a monument stands where pioneer leader Brigham Young, upon first seeing the Salt Lake Valley, famously declared: "This is the place. Ride on." Those words have become something of a motto for Utahns, and the pioneering spirit a defining characteristic.

Two miles northwest of that spot, a different monument was recently erected. This one commemorates a group of pioneers that came a century after the handcarts and covered wagons. They would affirm Young's 1847 statement, but in a domain that neither he, nor anybody else at the time, could have fathomed. It turns out that Utah was not just "the place" for beleaguered pioneers to settle, but the place for computer graphics to be born.

The new monument is an IEEE Milestone, titled "Development of Computer Graphics and Visualization Techniques, 1965–1978." Located in front of the Merrill Engineering Building, the granite pedestal and bronze plaque marks the explosion of a new frontier. At the start of that period, computer graphics consisted of simple lines on a screen, but in the span of 15 years, they evolved into complex 3D objects; the beginnings of fully simulated virtual worlds. Since then, nearly every field has been transformed by increasingly advanced computer graphics and animation. It was all possible thanks to a special conjunction of people and place: a brilliant cohort of researcher-pioneers gathered at the University of Utah.

THE PIONEERS OF COMPUTER GRAPHICS

The 1960s and '70s saw a scrappy group of computer science students gravitate to the U. Their time in its computer science department would act as a launching off point, propelling them around the world and to the top of industry and academia. Yet in March 2023, for the first time ever, they assembled back on campus where it all began, for the unveiling of Utah's IEEE Milestone Award.

The renowned alums in attendance included Pixar Animation co-founder Ed Catmull, Adobe co-founder John Warnock, Netscape and Silicon Graphics founder James Clark, Atari co-founder Nolan Bushnell, and famed researchers Jim Blinn, Henri Gouraud, Martin Newell, and Henry Fuchs.

Under the encouragement and leadership of the late Computer Science Department Chair David Evans and professor Ivan Sutherland, this group and their peers produced innovation after innovation, creating the foundational techniques of modern computer-generated imagery.

THE IEEE MILESTONE AWARD

IEEE, or Institute for Electrical and Electronics Engineers, is the world's largest organization of technical professionals with 400,000 members in 160 countries. Its Milestone Program, overseen by the IEEE History Committee, honors significant and historical technical achievements that have benefited humanity. IEEE Milestones can be found in Silicon Valley, at CERN's Large Hadron Collider, and at the birthplaces of the telephone, the internet, radar, video games, and scientific calculators.

The dedication of Utah's Milestone Award, hosted by the John and Marcia Price College of Engineering, was kicked off by a celebration of the 50th anniversary of the Kahlert School of Computing. The next two days were filled with panels, symposiums, and talks reflecting on what made Utah "the place" for computer graphics, and how that legacy continues.

MAKING HISTORY

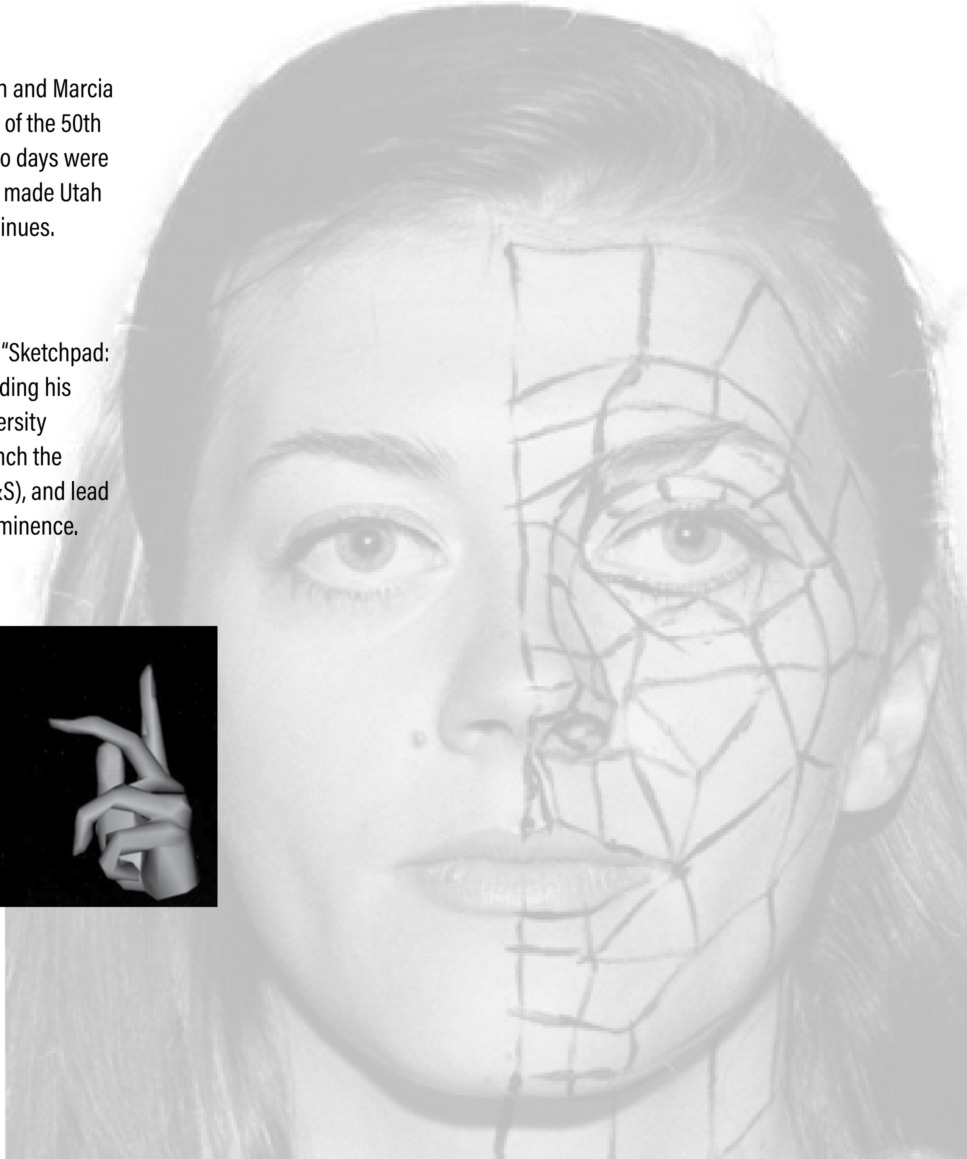
It all started with Ivan Sutherland's 1963 MIT doctoral thesis, "Sketchpad: A Man-Machine Graphical Communication System." After reading his thesis, David Evans asked Sutherland to join him at the University of Utah's Computer Science Department. The duo would launch the transformational graphics company, Evans & Sutherland (E&S), and lead the Utah Computer Science Department to international prominence.

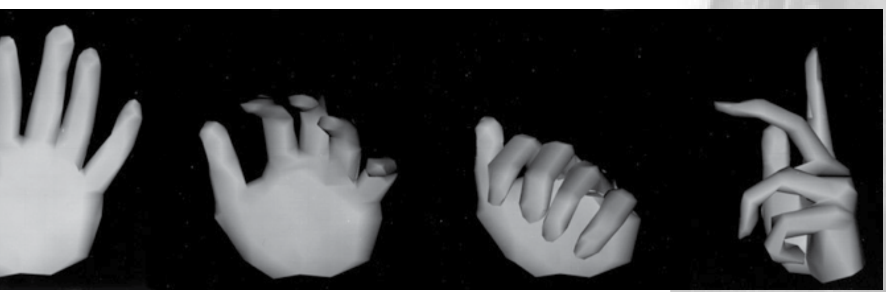
Mary Hall, director of the Kahlert School of Computing, said of the "Camelot Era" of her department: "Early on, the atmosphere for creative innovation attracted extraordinarily talented faculty. And success followed from there."

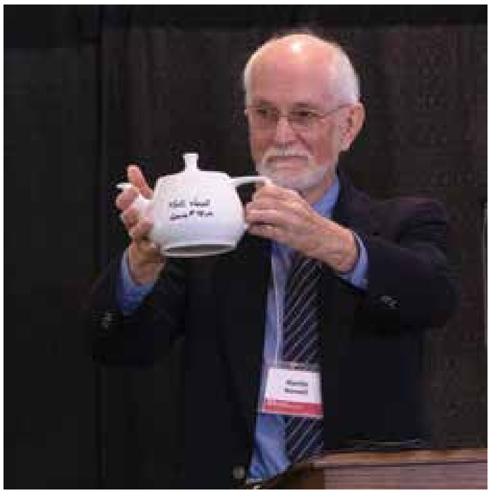
Trace back any of the standard techniques or algorithms used today in the complex process of making computer generated imagery, and you can find their roots in the dissertations of Evans' and Sutherland's grad students.

In his 1969 Ph.D. thesis, Utah native John Warnock cracked the "hidden surface problem" by creating an ingenious graphics algorithm that only rendered the sides and surfaces of a digital object that would be visible to the human eye. In the 70s, Henri Gouraud (Ph.D., '71) and Bui Tuong Phong (Ph.D., '73) sought to make these faceted and angular digital objects appear more realistic by smoothing and coloring their surfaces. The results were techniques known as Gouraud and Phong shading, rendering methods still used today. Jim Blinn (Ph.D., '78) performed pioneering research with specular lighting models, bump mapping, and environment mapping — building on Phong's shading method to better replicate the effect of light on textured and reflective objects.

Amidst this exciting and fast-paced atmosphere, and with the possibilities opened by these new techniques, Utah students and staff began digitizing real world objects. In 1972, Ed Catmull (Ph.D. '74) made a cast of his own hand, plotted the points into a computer, and fully animated the







resulting digital model. In that same year, a team of Sutherland's students collaborated on the painstaking process of hand-mapping and digitally plotting a Volkswagen Beetle. Gouraud's wife, Sylvie, graciously let him perform the same mapping and digitizing process on half of her face. All these computer graphics firsts have become iconic "digital artifacts," known and replicated the world over.

Most famously of all, English-born researcher Martin Newell (Ph.D., '75) collaborated with Blinn to digitally replicate a teapot that Newell's wife, Sandra, had purchased from ZCMI. The "Utah Teapot" is probably the most widely shared 3D model in the history of the medium.

Others, such as Alan Kay (Ph.D., '69), contributed immensely to both the school and the E&S company through the development of object-oriented programming languages. And as if having a realistic 3D object on a flat screen wasn't enough, Sutherland and doctoral students Jim Clark (Ph.D., '74) and Henry Fuchs (Ph.D., '75) developed the first series of head- mounted VR display devices capable of interacting with virtual environments.

THE CELEBRATION

March's event saw this history come alive, as the reunited luminaries shared stories and reminisced. Sutherland presented a lecture on his latest research interest, Single Flux Quantum Digital Electronics. Catmull spoke on how his time at Utah led directly to his success at Pixar, Lucasfilm, and Disney, Gouraud and Blinn detailed the inspirations and consequences of their pivotal research, and Clark and Fuchs both excitedly recounted their "aha!" moments regarding digital simulations — for Clark it was on a hike through Yosemite.

Warnock coyly understated his development of the hidden surface algorithm as "kind of a big deal," and his decision to start Adobe as a "pretty good idea." At the end of a keynote address titled "The Teapot Again? Why?" Newell presented Kahlert Director Mary Hall with a replica of the legendary teapot, signed by him and Jim Blinn.

Gouraud, Fuchs, Warnock, Blinn, and Newell all joined together on stage for the "Utah Illuminati Panel", where they made clear their continuing sense of comradery, and reiterated their fondness for their time at Utah. Together, they had achieved the impossible, effectively founding the field.

After the Milestone plaque had been presented by the IEEE Utah section, and the applause and laughter faded, those leaving the building on Friday couldn't quite make out the same view of the Valley Brigham Young saw 150 years ago, thanks to a late spring blizzard. Yet after hearing tales of and being inspired by our modern-day trailblazers, they were undoubtedly filled with the same conviction that Utah was indeed "the place."

NUCLEAR family

All the way at the bottom of the Periodic Table, tucked away in an inset, you'll find a double row of unusual elements: the actinides and lanthanides. Some of these metals are abundant in the Earth's crust, while others can only exist for split-seconds after being synthesized in advanced labs, but the chemical properties that define them are indispensable for a host of modern technologies.

Tara Mastren, assistant professor in the Nuclear Engineering Program housed in the Department of Civil & Environmental Engineering, specializes in this chemistry and its applications at the intersection of nuclear science and medicine. Various diagnostics and radiotherapies need specific isotopes of these elements, but as they are all inherently unstable, researchers like Mastren devise ways to capture them in their most useful states.

Mastren's lab doesn't just produce rare isotopes, however. It produces expertise.

Two of Mastren's students, Aidan Bender and Connor Holiski, were selected to participate in the U.S. Department of Energy's Office of Science Graduate Student Research (SCGSR) program.

Each year, this DOE program places graduate students into National Laboratories, giving them access to state-of-the-art equipment to continue their research and share knowledge with experts in their fields.

Bender and Holiski are among 87 students in this year's class, and the only two from Utah.

"This is an extremely prestigious program," says Mastren, "and I couldn't be prouder of Aidan and Connor."

The field of nuclear medicine involves using specific radioactive isotopes to destroy cancer cells or as part of advanced imaging technologies. These isotopes are carefully chosen based on the types of radiation they emit; different energetic particles can last longer or travel farther than others, making the selection for a given application a matter of both efficacy and safety.

Selecting the right isotope is one challenge; acquiring enough of it is another. The actinides, which include uranium and plutonium, are radioactive but many of them are rarely found in nature. The lanthanides, despite their moniker of "rare-earth metals," are much more common, but aren't naturally radioactive. As such, they must first be "transmuted" into the radioactive atoms called radionuclides via nuclear reactions. Mastren's research involves investigating such nuclear reactions using the University of Utah's TRIGA reactor.

Once transmuted into a radionuclide, the atoms begin to decay, emitting alpha particles or electrons at a predictable rate. Each step of decay makes a new radionuclide — so timing is critical when it comes to capturing the material in its desired state.

Bender and Holiski work on different aspects of this process.

Holiski's research is in creating resins that can capture terbium-161, a radioisotope of the lanthanide terbium that is used in both cancer treatments and diagnostic imaging.

Different lanthanides are very difficult to separate from one another; Holiski's new resins are designed to be more effective at isolating them. And as radio-lanthanides are also a byproduct of the fuel cycle used in power-generating nuclear reactors, Holiski will spend six months continuing his resin research at Lawrence Livermore National Labs, exploring whether his technique can be used to mitigate radioactive waste.

"Tara has been a great mentor, not just because of the knowledge she passes on, but because she is always looking out for these sorts of opportunities and pushing us to apply to them," says Holiski.

Bender's work is on the synthesis of multimodal chelates, ring-shaped molecules that can bind both radionuclides and the biomolecules that are used for delivering them to only cancerous cells. Such precision is necessary to identify the microscopic tumors treated by targeted alpha-therapy, which is highly effective but comes with the risk of destroying healthy cells if the cancer cells aren't targeted efficiently.

Mastren's lab has been collaborating with the Idaho National Laboratory (INL) in the creation of a new class of chelates; Bender will continue his work there this fall.

"The National Lab environment is exciting because there are so many people in so many disciplines," Bender says. "It brings together materials science, fusion research, and basic biology."

As the Mastren Lab's family tree continues to extend its branches into these other topics and laboratories, the benefits flow in both directions.

"Nuclear medicine is inherently interdisciplinary," says Mastren, "so building up these networks is fundamental to our work."

NEW FACULTY

The University of Utah's John and Marcia Price College of Engineering attracts some of the world's most innovative researchers and educators. As of July 2023, the College has added 17 new tenure-track faculty this year, bringing expertise in a diverse array of disciplines. Whether they are applying neuroengineering to injury rehabilitation, cryptography to privacy protection, or fluid dynamics to pollution mitigation, these new faculty members are already forging connections to other parts of campus and research communities across the globe.

ASHLEY DALRYMPLE

ASSISTANT PROFESSOR, BIOMEDICAL ENGINEERING

ALPHONSUS NG

ASSISTANT PROFESSOR, BIOMEDICAL ENGINEERING

AMY LENZ

ASSISTANT PROFESSOR, BIOMEDICAL ENGINEERING

KAI FU

ASSISTANT PROFESSOR, ELECTRICAL & COMPUTER ENGINEERING

ANNA FARIHA

ASSISTANT PROFESSOR, KAHLERT SCHOOL OF COMPUTING

LUIS GARCIA

ASSISTANT PROFESSOR, KAHLERT SCHOOL OF COMPUTING

BEN GREENMAN

ASSISTANT PROFESSOR, KAHLERT SCHOOL OF COMPUTING

VIJAY NAGARAJAN

PROFESSOR, KAHLERT SCHOOL OF COMPUTING

VINEET PANDEY

ASSISTANT PROFESSOR, KAHLERT SCHOOL OF COMPUTING

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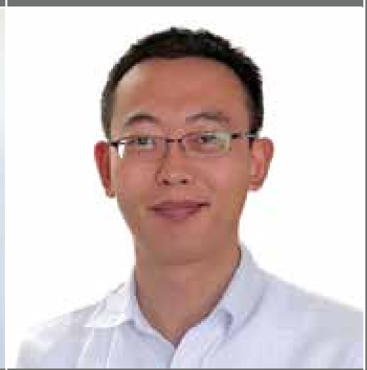
ERIKA PLINER

ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

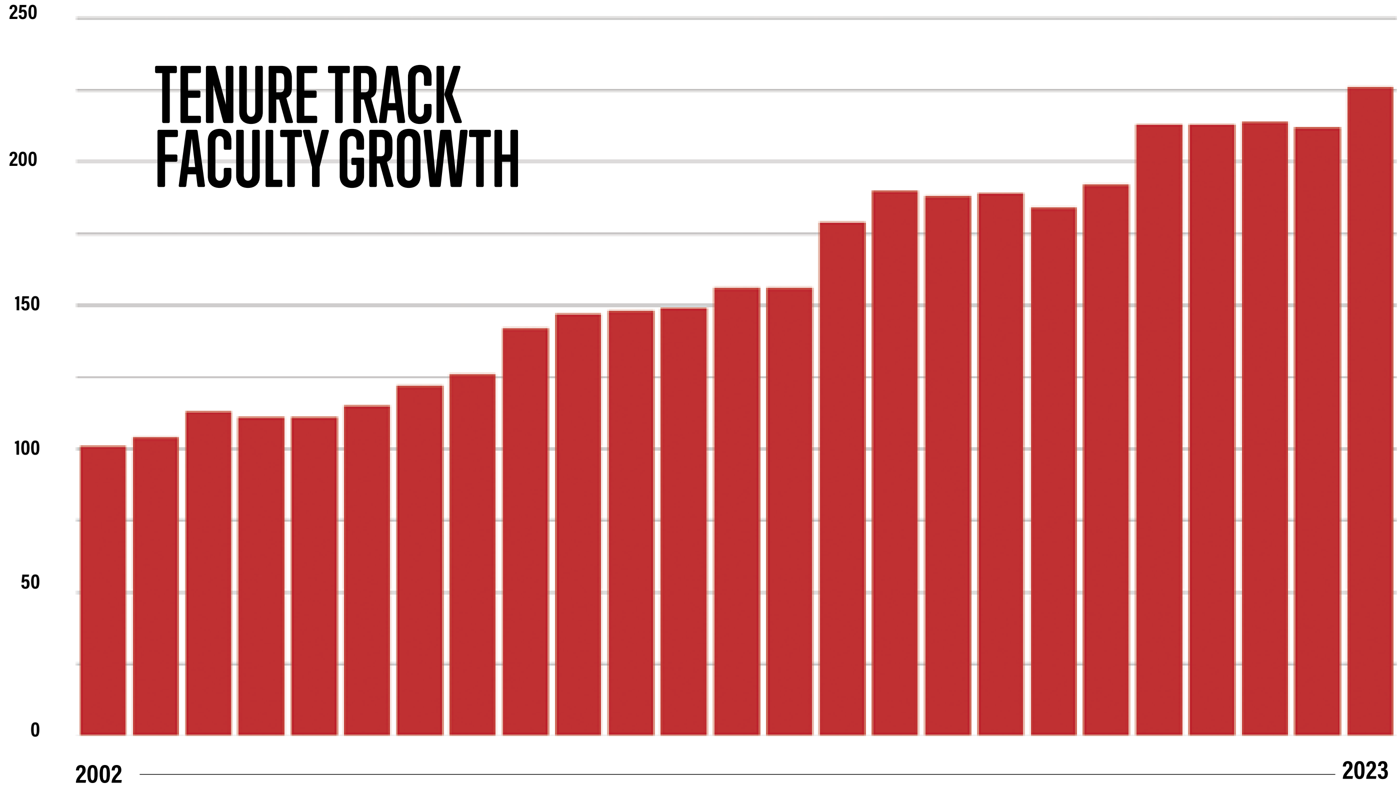


YONGZHI QU

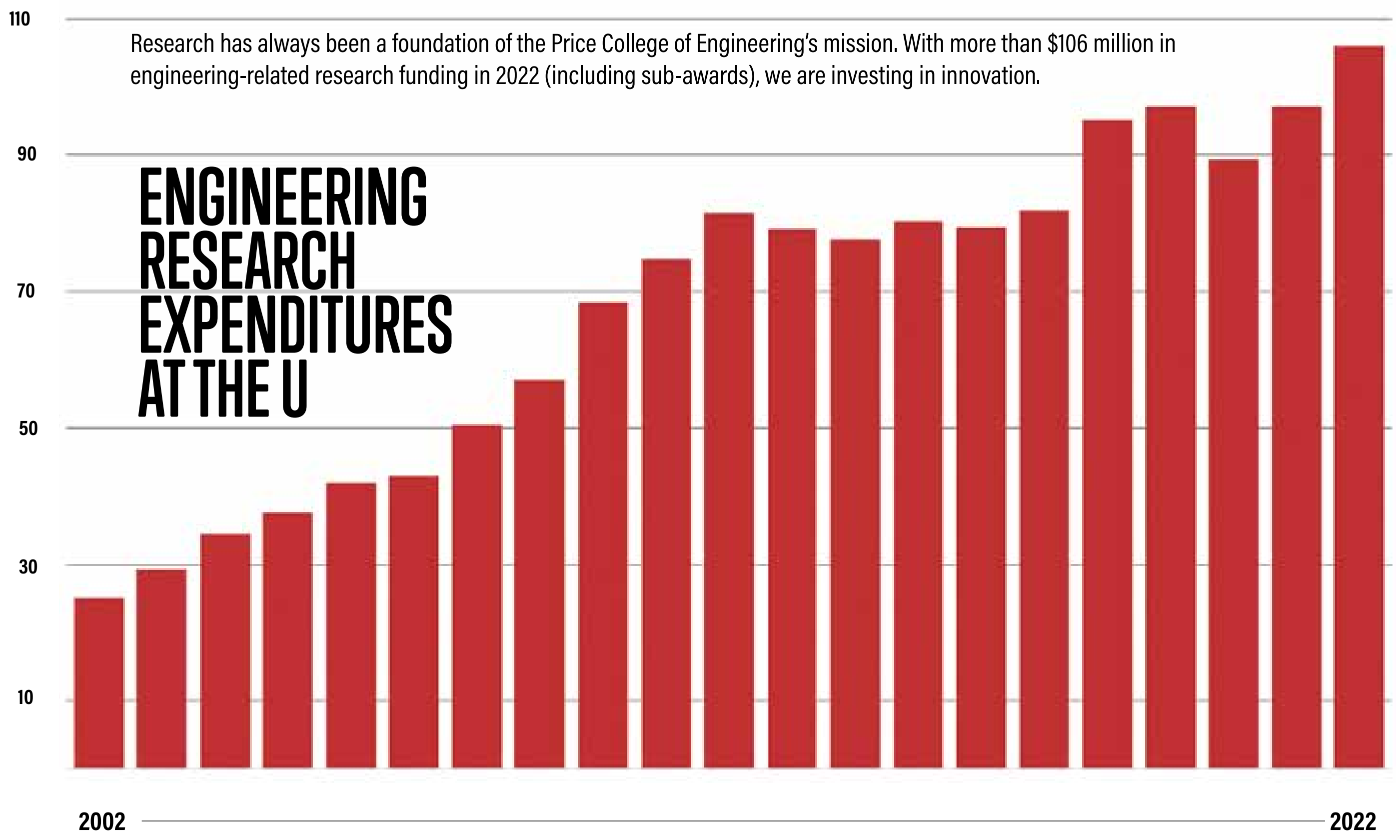
ASSISTANT PROFESSOR, MECHANICAL ENGINEERING

BY THE NUMBERS

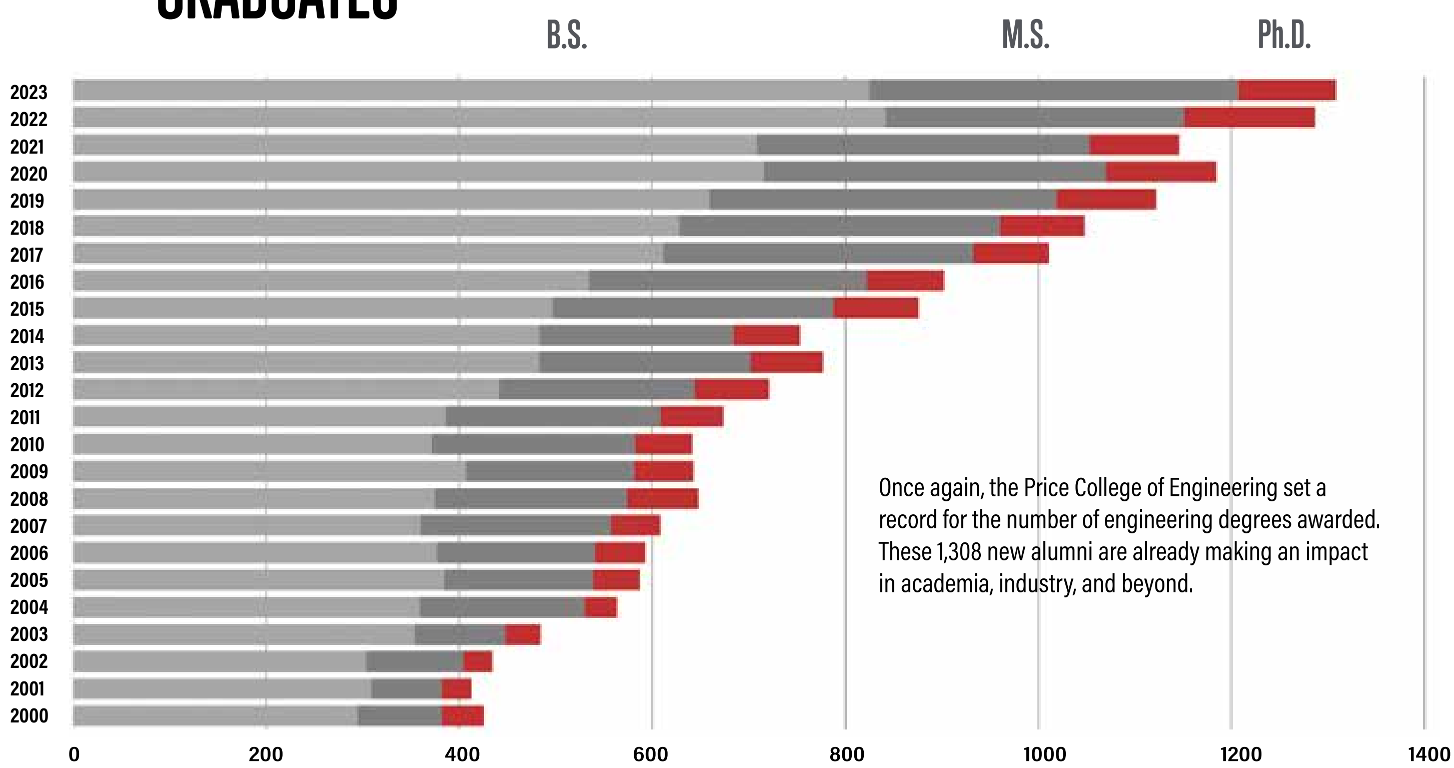
In 2023, the Price College of Engineering set a new high-water mark with 226 tenure-track faculty members, reflecting our commitment to a growing student body.



Research has always been a foundation of the Price College of Engineering's mission. With more than $106 million in engineering-related research funding in 2022 (including sub-awards), we are investing in innovation.



GRADUATES



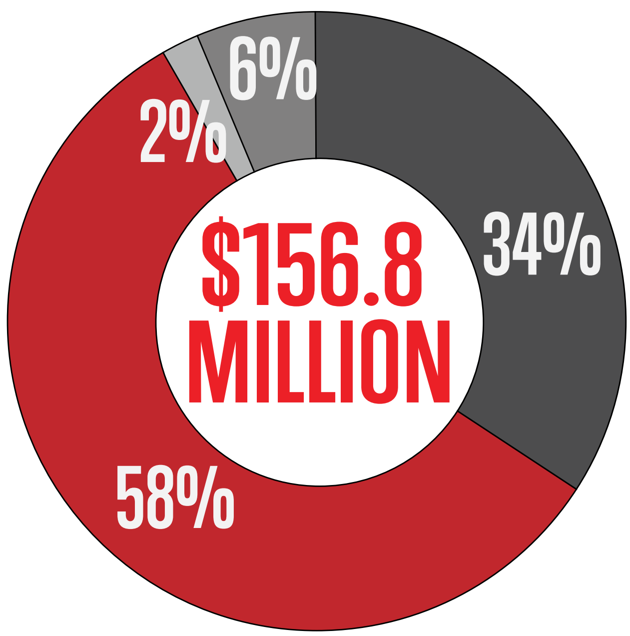
Once again, the Price College of Engineering set a record for the number of engineering degrees awarded. These 1,308 new alumni are already making an impact in academia, industry, and beyond.

RANKINGS

The John and Marcia Price College of Engineering remains one of the most sought-after educational institutions for computer science and engineering. Here is how the college ranks in important areas according to the latest statistics from Profiles of Engineering & Engineering Technology by the American Society for Engineering Education.

- Research expenditures — #40
- Engineering doctoral degrees awarded — #31
- Tenured/tenure-track faculty members — #35
- Undergraduate Enrollment #35
- Graduate Enrollment #46

ENGINEERING BUDGET 2021-2022



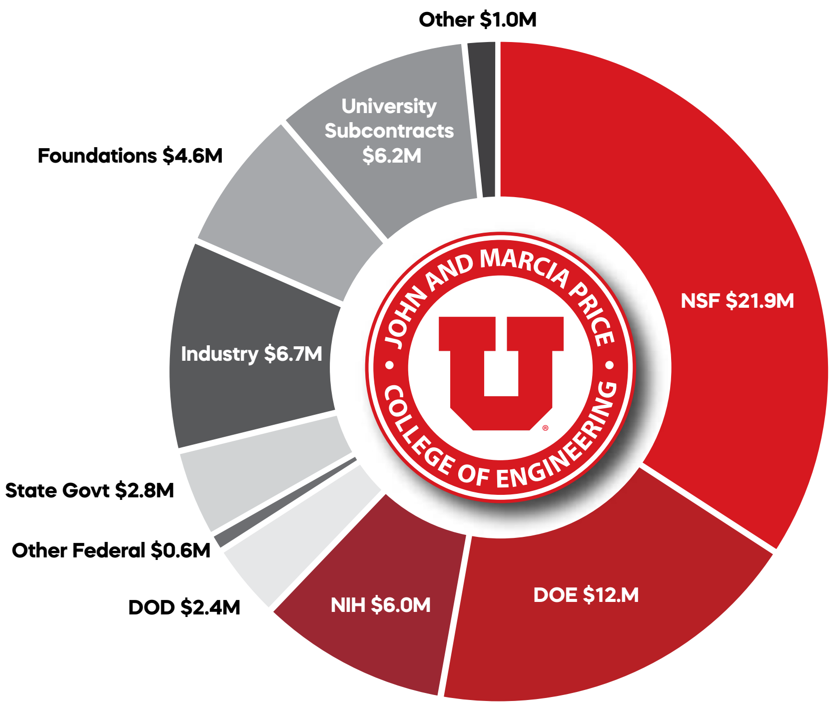
SPONSORED RESEARCH
STATE APPROPRIATIONS
OTHER FUNDS
DONATIONS

ENGINEERING ENTREPRENEURSHIP

A key to the College of Engineering's success is its ability to commercialize its research. Faculty as well as students are continually marketing their technologies to benefit people worldwide. Since 2006, the college has filed 1,172 invention disclosures, 372 U.S. patents, executed 117 licenses and launched 99 companies from its research.

FUNDING SOURCES

for research awards of John and Marcia Price College of Engineering faculty FY2022



FORGE project (Dept of Energy, $55.5M) is not included.

2022 NSF CAREER AWARDS

Tsung-Wei Huang: *Electrical & Computer Engineering*

Mingyue Ji: *Electrical & Computer Engineering*

Mingxi Liu: *Electrical & Computer Engineering*

Mostafa Ardakani: *Electrical & Computer Engineering*

Jason Wiese: *Kahlert School of Computing*

Huiwen Ji: *Materials Science & Engineering*

Bei Wang Phillips: *Kahlert School of Computing*

2022 ONR YOUNG INVESTIGATOR AWARD

Yong Lin Kong: *Mechanical Engineering*

NOTABLE RESEARCH AWARDS

FORGE - Enhanced Geothermal System Concept Testing and Development (DOE)
A Platform-Agnostic Testbed for Democratizing Data Delivery (NSF)
Expanding the Frontiers of Cloud Computing through World-Class Community Infrastructure (NSF)
POWDER – Platform for Open Wireless Data-Driven Experimental Research (US Ignite)
Utah Transportation and Public Safety – Crash Data Initiative (Utah Dept Public Safety)
Transforming Uinta Basin Earth Metals for Advanced Products (DOE)
Liquid-Solid Metal for Embodied Intelligence in Semi-Soft, Human-Collaborative Robots (NSF)
Rapid Quantitative Analysis and Adaptive Workflows for Fluorescence Microscopy Data in Pilot Research (NIH)
Ultra-Low Power Sensor Network (DOD/DARPA)
Advanced Acclimation and Protection Tool for Environmental Readiness (DOD/DARPA)
Lightweight Powered Knee-Angle Prosthesis for Community Ambulation (NIH)
Deployment of Dynamic Neural Network Optimization to Minimize Heat Rate during Ramping for Coal Power Plants (DOE)
Physics-Informed Artificial Intelligence for Parallel Design of Metal Matrix Composites (NSF)
Tissue Damage Progression in Repeated Mild Traumatic Brain Injury (NSF)

ENAC

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DMC Global

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and Compliance Officer
Tula Health

ALUMNI PROFILE

LYNN HOPPER

Soaring to the Top

Boeing isn't just one of the top engineering companies in the world; it's two dozen of them.

The company has been making airplanes for more than a hundred years, but has since diversified into rockets, satellites, and defense equipment, as well as subsidiaries that service and finance those products.

So when Lynne Hopper was promoted to vice-president and general manager for engineering strategy and operations of Boeing's commercial airplanes division in 2019, her job went beyond ensuring the safe and efficient operation of its flying machines. To do that, she first had to knit together the more than sixty thousand engineers who design, build, and maintain them.

This promotion also came at the most tumultuous time in Hopper's 36-year tenure at Boeing. The company's new 737 MAX aircraft line had been grounded by the FAA after two accidents; in her previous position of Boeing Commercial Airplanes' Chief Engineer, she had led the effort to recertify them as airworthy.

Hopper couldn't have accomplished these things without the technical skills she learned as an undergraduate mechanical engineering major at the University of Utah, but just as important were the principles of integrity and leadership it instilled in her.

"I didn't just feel like I was getting a great education, but accomplishing something amazing, by getting an engineering degree at the U," Hopper says.

Hopper's interest in science and engineering started at an early age. Her father, Dennis Neal Thompson, was a civil engineer, and though he passed away when she was only ten years old, his presence would start her on a soaring trajectory, from Kaysville, Utah to the boardrooms of the Fortune 100.

While the direction of that trajectory was still crystalizing, Hopper entered her high school's science fair in high school, eventually qualifying for the International Science and Engineering Fair in her junior year. She would go on to earn Utah's statewide Sterling Scholarship in the Science category.

With those accolades on her resume — and inspired by the long list of Utah alumni in her immediate and extended family — Hopper applied for scholarships in every department at the U's engineering school.

"Robert Boehm, who was then the chair of Mechanical Engineering, called me at home and asked which of them I was most interested in," Hopper says. "When I said 'mechanical,' there was a scholarship in my mailbox two days later."

Boehm kept engaged with Hopper for her entire time on campus, offering advice and direction, and helping solidify her interest in thermal and fluid dynamics.

Hopper's time in the mechanical engineering department also exposed her to a core ethos of the field.

"My experience as an undergraduate was very much about organizing and making things better for the team around me," Hopper says. "That's the same principle I've applied to my management career. How can we create an experience that's good for everyone, so everyone can thrive?"

As one of the few women in her class, she helped re-establish the University of Utah chapter of the Society of Women Engineers (SWE). She also took a leadership role in the department's seminar series, recruiting a slate of lectures that spoke to her perspective.

And while Boehm encouraged Hopper to stay at the U for a Ph.D., she received a job offer from Douglas Aircraft before she had even graduated. There, she would ply her

Photo courtesy of Marian Lockhart.

expertise in thermal dynamics, working on environmental control systems responsible for cabin pressure and temperature.

After three years at Douglas, Hopper secured a position at Boeing, where she began her long climb up the corporate ladder, gaining responsibility for more aircraft systems at each rung. This wasn't always easy in an engineering discipline with persistently low gender parity.

"I'm still regularly the only woman in the room — while being the highest-ranking person in the room," says Hopper. "But I'm at the table, and I shattered a lot of glass to get there."

Hopper's experiences, both at the U and at Boeing, have made a lasting impact on the way she sees her work. From "digital twin" technology that can simulate enormously complicated interactions between components before they're tested in the real world, to implementing meta-analyses of how Boeing's internal work flows, Hopper has paid forward the lessons she learned in organization and team building.

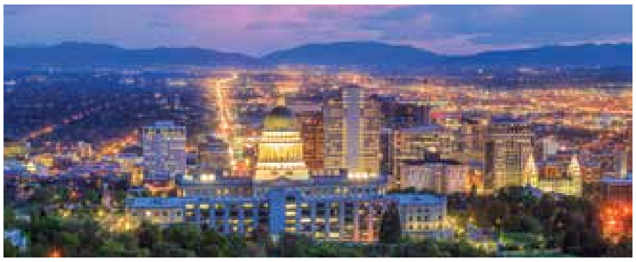
She has also worked to lower the barrier to entry for the female engineers following in her footsteps, serving as the executive sponsor of Boeing's SWE chapter for five years.

"In my first year, we hired 12 female engineers; in my fifth, we hired 180 of them," Hopper says. "Seeing so many young women in the room with me brought me to tears."

Despite her lofty position, Hopper has never forgotten the human factors that lie at the foundation of success.

"Engineers make products that make the world better, but someone has to create systems for the engineers too," Hopper says. "Individually, engineers are amazing, intelligent people, but you need a workplace that's full of diversity so you can get more and better ideas, and in turn, more and better products."

LIFE IN UTAH



Each year, U.S. News & World Report *ranks all 50 states, assessing how well each serves its citizens by compiling data from 71 metrics in 8 categories. In 2023, Utah took the top overall spot.*

With #1 rankings in the economy and fiscal stability categories, and top-ten placements in education, healthcare, and infrastructure, the data paint a picture that Utahns are already familiar with: a place brimming with opportunity and the resources its residents need to make the most of it.

Visit usnews.com/news/best-states for more information on these rankings and the methodology behind them.

#1 IN OVERALL RANKING

Best States 2023

U.S. News & World Report

#1 Economy
#1 Job Growth
#1 Growth of Young Population
#1 Low Debt at Higher Ed Graduation
#1 Government Credit Rating
#2 GDP Growth
#2 Health Care Quality
#2 Low Poverty Rate
#3 Employment Rate
#3 Business Creation Rate
#3 Gini Index

OTHER RANKINGS

#1 Economic Outlook — Rich States Poor States
#1 Best State to Start a Business — WalletHub
#1 State for the Middle Class — Smart Asset
#2 Financially Literate State — WalletHub
#2 Best Ski Resort North America (Alta) — PeakRankings
#2 Best Healthcare ROI — WalletHhub
#2 Best State for Teachers — WalletHhub
#4 Happiest State — WalletHub
#4 Best State for Millennials — WalletHub

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