TEXAS A&M UNIVERSITY

Artie McFerrin Department of Chemical Engineering

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CHEMICAL ENGINEERING

2023

Letter from the
Department Head

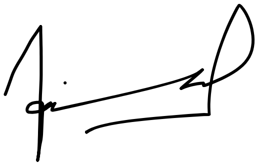
Howdy from the Artie McFerrin Department of Chemical Engineering!

First, let me introduce myself. My name is Dr. Faisal I Khan. On Aug. 15, I took responsibility as the Interim Department Head of Chemical Engineering. I came to Texas A&M University over three years ago as the Mike O'Connor II Chair Professor, director of the Mary Kay O'Connor Process Safety Center (MKOPSC) and the director of the Ocean Energy Safety Institute (OESI). It is my pleasure to serve you all in each of these capacities.

We are lucky to have outstanding colleagues and the best students who excel in academics as well as professional activities. Some of the recent achievements of students, alumni and faculty are attributed to their ongoing collaborative teaching, training and research with industry leaders – such as our work with Exxon and Chevron, just to name a few. The OESI, a federally funded research program run by the Mary Kay O'Connor Process Safety Center (a TEES research center affiliated with the chemical engineering department) has made great strides as they get ready to distribute funding to the awardees from the oil and gas request for proposals. OESI is currently working on the Marine Energy and Wind Energy RFP portfolio for potential funding.

Additional efforts made by the department include Professor Efstratios Pistikopoulos, a University Distinguished Professor, the Dow Chemical Chair, a professor of chemical engineering, and the director of the Texas A&M Energy Institute, being named the recipient of the 2023 American Institute of Chemical Engineers (AIChE) Computing & Systems Technology Division Distinguished Service Award. Professor Nimir O. Elbashir, the director of the TEES Gas and Fuels Research Center, a professor of petroleum engineering and chemical engineering at Texas A&M University at Qatar, and the chair of the ORYX Gas-to-Liquid Excellence Program, has been elected as a Fellow of the AIChE. Dr. Mark Barteau, along with Dr. Efstratios Pistikopoulos, were named key partners of a five-year, $70 million grant from the U.S. Department of Energy as part of the Manufacturing USA initiative. Their work will focus on advancing the electrification of hard-to-decarbonize heating and manufacturing processes in the chemical and petroleum sectors. None of these achievements would be possible without the diligent support of our students and staff.

Students remain the backbone of our department with approximately 1,000 students enrolled. We continue to graduate some of the most sought-after industry recruits. These successes would not be possible without your support and continued engagement. Therefore, I invite you to read this issue of our magazine as it showcases some of the exciting ways that Aggie chemical engineers are making a difference today that will impact society tomorrow and beyond.



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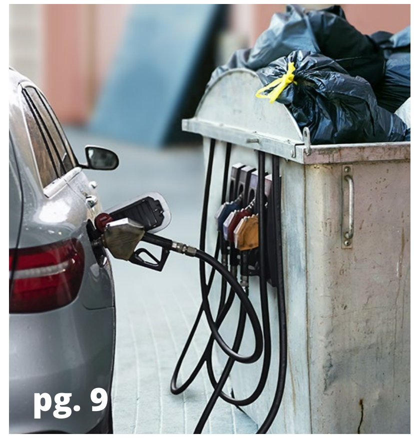

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FACTS **SHEET**

RANKINGS

(*U.S. NEWS & WORLD REPORT*, PUBLIC)

#12 Undergraduate *(2023)*

#14 Graduate *(2023)*

DEGREES AWARDED

306 Total

242 Bachelor's

33 Master's

31 Ph.D.

ENROLLMENT

1,034 Total

770 Undergraduate

133 Master's

131 Doctoral

FACULTY

45 Total Faculty

6 Endowed Faculty Fellows

8 Chair Holders

5 Endowed Professorships

RESEARCH AREAS

Biomedicine and biomolecules

- Catalysis
- Complex fluids, microfluidics and soft matter
- Energy
- Environmental and sustainability
- Materials and microelectronics
- Biofuels and biotechnology
- Computational chemical engineering
- Nanotechnology
- Process systems engineering
- Reaction engineering
- Process control and process safety

14th

IN THE NATION

AMONG PUBLIC INSTITUTIONS

TEXAS A&M UNIVERSITY
Artie McFerrin Department of
Chemical Engineering

TEAM FINDS MAJOR STORAGE CAPACITY IN WATER-BASED BATTERIES

Researchers at Texas A&M University have discovered a 1,000% difference in the storage capacity of metal-free, water-based battery electrodes.

These batteries are different from lithium-ion batteries that contain cobalt. The group's goal of researching metal-free batteries stems from having better control over the domestic supply chain since cobalt and lithium are outsourced. This safer chemistry would also prevent battery fires.

Chemical engineering professor Dr. Jodie Lutkenhaus and chemistry assistant professor Dr. Daniel Tabor has published their findings about lithium-free batteries in Nature Materials.

"There would be no battery fires anymore because it's water-based," Lutkenhaus said. "In the future, if materials shortages are projected, the price of lithium-ion batteries will go way up. If we have this alternative battery, we can turn to this chemistry, where the supply is much more stable because we can manufacture them here in the United States and materials to make them are here."

Aqueous batteries consist of a cathode, electrolyte and an anode, Lutkenhaus said. The cathodes and anodes are polymers that can store energy, and the electrolyte is water mixed with organic salts. The electrolyte is key to ion conduction and energy storage through its interactions with the electrode.

"If an electrode swells too much during cycling, then it can't conduct electrons very well, and you lose all the performance," she said. "I believe there is a 1,000% difference in energy storage capacity, depending on the electrolyte choice because of swelling effects."

According to their article, redox-active, non-conjugated radical polymers (electrodes) are promising candidates for metal-free aqueous batteries because of the polymers' high discharge voltage and fast redox kinetics. The reaction is complex and difficult to resolve because of the simultaneous transfer of electrons, ions and water molecules.

"We demonstrate the nature of the redox reaction by examining aqueous electrolytes of varying chao-/kosmotropic character using electrochemical quartz crystal microbalance with dissipation monitoring at a range of timescales," according to researchers in the article.

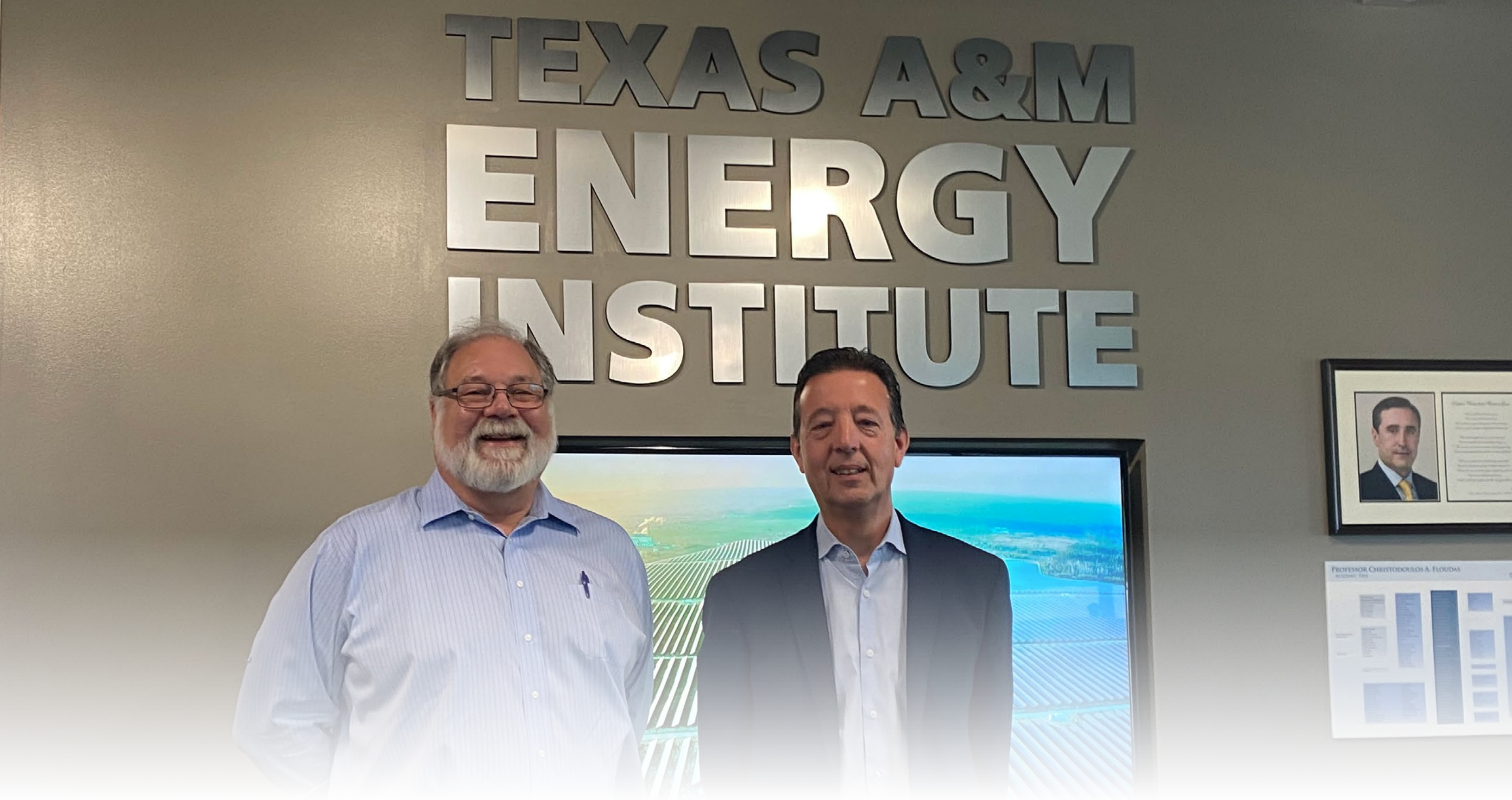
Tabor's research group complemented the experimental efforts with computational simulation and analysis. The simulations gave insights into the microscopic molecular-scale picture of the structure and dynamics.

"Theory and experiment often work closely together to understand these materials. One of the new things that we do computationally in this paper is that we actually charge up the electrode to multiple states of charge and see how the surroundings respond to this charging," Tabor said.

Researchers macroscopically observed if the battery cathode was working better in the presence of certain kinds of salts through measuring exactly how much water and salt is going into the battery as it is operating.

"We would like to expand our simulations to future systems. We needed to have our theory confirmed of what are the forces that are driving that kind of injection of water and solvent," Tabor said. "With this new energy storage technology, this is a push forward to lithium-free batteries. We have a better molecular level picture of what makes some battery electrodes work better than others, and this gives us strong evidence of where to go forward in materials design."

The project is funded by the U.S. Department of Energy and the National Science Foundation through the Texas A&M Engineering Experiment Station.



TEXAS A&M JOINS GLOBAL FIGHT AGAINST **GREENHOUSE EMISSIONS**

In the global pursuit of a more sustainable future, combating the effects of greenhouse gas emissions from heat produced by industrial processes has taken center stage.

Texas A&M University has been named a key partner in a $140 million institute to advance heating processes with a five-year, $70 million grant from the U.S. Department of Energy (DOE) as part of the Manufacturing USA initiative.

This effort to reduce greenhouse gas emissions from industrial process heating is called the Electrified Processes for Industry without Carbon (EPIXC) Institute. Led by Arizona State University (ASU), the institute will operate as a public-private partnership, conducting research, development and deployment of relevant technologies and necessary workforce training.

Drs. Efstratios Pistikopoulos and Mark Barteau, professors in the Artie McFerrin Department of Chemical Engineering, will lead the Texas A&M team, which will focus on advancing the electrification of hard-to-decarbonize heating and manufacturing processes in the chemical and petroleum sectors. By seeking technological advancements and developing new innovations through process modeling, the team will work to reduce greenhouse gas emissions and advance sustainability.

Manufacturing USA institutes are designed to accelerate U.S. advanced manufacturing in critical technology areas.

“This is the third major DOE-funded Manufacturing USA institute brought to Texas A&M,” Pistikopoulos said. “We have always played a pivotal role in Manufacturing USA in modeling and analytics, which is one of our core competencies here at Texas A&M.”

EPIXC’s overall vision is to reach net-zero carbon dioxide (CO_2) emissions from heating in the industrial sector by using clean electricity with cost-effective, high-impact solutions.

"Among different manufacturing industries, chemicals and petroleum actually have the biggest greenhouse gas emissions footprint," Barteau said. "We want the technologies we develop to put as big a dent in that as possible. It's all part of a bigger plan to have more clean renewable energy and be able to utilize it in a way that has a significant impact in reducing our greenhouse gas emissions."

Beyond ASU and Texas A&M, there are nine university partners, three national labs and 37 companies in EPIXC that have committed to match the DOE funding. The Texas A&M portion of the DOE award is anticipated to be $5 million, which A&M will match.

"The Department of Energy wants to see new technologies put into practice," Barteau said. "If we look at trying to get to net-zero emissions, we're going to have to tackle all major sources of emissions. These include manufacturing processes as well as transportation and electric power generation from burning fossil fuels."

Increasing the availability of large amounts of carbon-free electricity is at the heart of the DOE's electrification strategy. According to Dr. Sridhar Seetharaman, vice dean for research and innovation at ASU's Ira A. Fulton Schools of Engineering and director of EPIXC, the expanded use of clean energy for process heating will reduce CO_2 emissions across major industries, including iron and steel, chemicals, petroleum, food and beverage, forest products and cement.

"Part of our strategy is to look at the electrification of endothermic chemical processes, which means they require energy input," Barteau said. "These require higher temperatures that are conventionally achieved by burning hydrocarbon fuels, generating CO_2. One of the challenges is that chemical production involves many process steps — distillation, for example — that operate at different temperatures. Optimization of energy flows among these steps is important, regardless of the energy source. The kinds of tools we have for modeling are critical here and will also be applicable to many of the other manufacturing processes within this institute."

A challenge the Texas A&M team will look to address is minimizing the lifecycle emissions of CO_2 compared to conventional processes. One of the keys to the project will be the ability to incorporate the variations in power from different sources by utilizing digital twins technology.

"Essentially, these are all techniques related to manipulating data, creating digital twins and interrogating those to improve implementations for all kinds of analysis, carbon accounting and better sustainability," Pistikopoulos said. "We think the electrification option is better than current approaches, but you have to look at it from a life cycle analysis and the actual processes. The important mission of creating new technologies is making them as sustainable as possible."

The five-year project will begin in the coming months with a few "jumpstart projects," which aim to quickly advance select technologies that will run for two years.

"We're leading one of the jumpstart projects in the chemical and petroleum area," Barteau said. "I'm the team lead on that, and it looks at the heating of chemical reactors using electromagnetic energy inputs rather than heat from furnaces or steam."

Additional components of the EPIXC program are workforce training and development, the overall impact on local communities and environmental justice.

"Texas A&M has a lot to contribute because of its strengths in outreach education and its professional master's program in energy," Barteau said. "I think that's going to be a great opportunity to involve other faculty, students and industrial partners as we target a lower carbon future."

Professor receives American Institute of Chemical Engineers award

Dr. Mahmoud El-Halwagi, professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, received this year's American Institute of Chemical Engineers' (AIChE) Fuels and Petrochemicals Division Award.

This award is El-Halwagi's third from AIChE for his research in sustainable design of industrial processes and process integration, safety, intensification and simulation. This is the highest honor given by the institute's Fuels and Petrochemicals Division every year to an individual who has made substantial technical contributions to the petrochemical industries, according to the AIChE website.

"It is humbling to receive this award from the chemical engineers' premier organization," El-Halwagi said. "I have been very fortunate to work with brilliant students and colleagues, and I consider that this award is really in recognition of their amazing contributions."

The award recognizes El-Halwagi's research in the design of industrial processes with a focus on sustainability and innovation through systems integration approaches.

Chemical industries produce a wide variety of products such as fuels, energy carriers, chemicals, pharmaceuticals, plastics, fertilizers and engineered materials; because of this, they consume tremendous amounts of natural resources and discharge significant amounts of waste. El-Halwagi's research focuses on the substantial opportunities for making these industries more sustainable by making them more efficient to work better, cheaper, greener and safer by reducing waste and huge amounts of mass and energy.

"My work uses engineering principles and creative insights to generate novel technologies and improved designs that enhance profitability, reduce the consumption of material and energy resources, mitigate the discharge of harmful pollutants and enhance safety and quality," El-Halwagi said.

"I aim to transform this into a science based on the fundamentals of engineering," El-Halwagi said. "I hope this award will bring further attention to the research in the field of sustainable design and systems integration and will ultimately lead to a more sustainable tomorrow with well-guided and substantial actions starting today."

El-Halwagi's previous awards with the AIChE include the Computing in Chemical Engineering Award from the Computing and Systems Technology Division in 2020 and the Research Excellence Award from the Sustainable Engineering Forum in 2009.

"I am thrilled to see Dr. El-Halwagi's contributions to the chemical engineering profession be nationally recognized," said Dr. Victor Ugaz, interim department head and chemical engineering professor at Texas A&M. "His accomplishments exemplify the many ways our faculty are at the forefront of groundbreaking discoveries that improve the quality of life for everyone by providing clean and renewable energy, affordable and sustainable products, and access to abundant food and water."

SUSTAINABLY TRANSFORMING BIOMASS WASTE INTO FUELS AND CHEMICALS

In the last 200 years, society has undergone major energy transitions associated with introducing new energy sources, such as coal, oil and natural gas. To address climate change, the world must experience another energy transition where fuels and chemicals are sourced from sustainable feedstocks.

The only practical, sustainable feedstock is biomass — anything that is biodegradable. Although there are fuels and chemicals currently made from biomass, such as corn, sugar and vegetable oil, these feedstocks are not sufficiently abundant to be scalable. Process innovations are required to access more plentiful biomass feedstocks to achieve feasible, long-term solutions.

Dr. Mark Holtzapple, professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, has spent over three decades creating a method to convert biomass into essential fuels and chemicals, such as jet fuel and acetic acid.

"Rather than disposing of biomass waste in a landfill, we can use this renewable resource as a raw material," said Holtzapple. "This can significantly impact society by providing a valuable way to utilize wastes, which helps the environment, addresses global warming, enhances human health and alleviates the need for fossil fuels."

Holtzapple refers to his method as the MixAlco process. In his process, biomass — waste paper, municipal solid waste, sewage sludge, animal manure, food scraps or purpose-grown energy crops — is added to a plastic or concrete tank. The biomass is inoculated with soil, which naturally contains microorganisms that decompose the biomass into organic acids ranging from two-carbon acetic acid (commonly known as vinegar) to eight-carbon octanoic acid (commonly known as caprylic acid).

According to Holtzapple, the key to the MixAlco process is to add an inhibitor in the tank to prevent methane production, which would normally occur in conventional biomass digesters. As the biomass sits in the tank, organic acids accumulate that can be recovered.

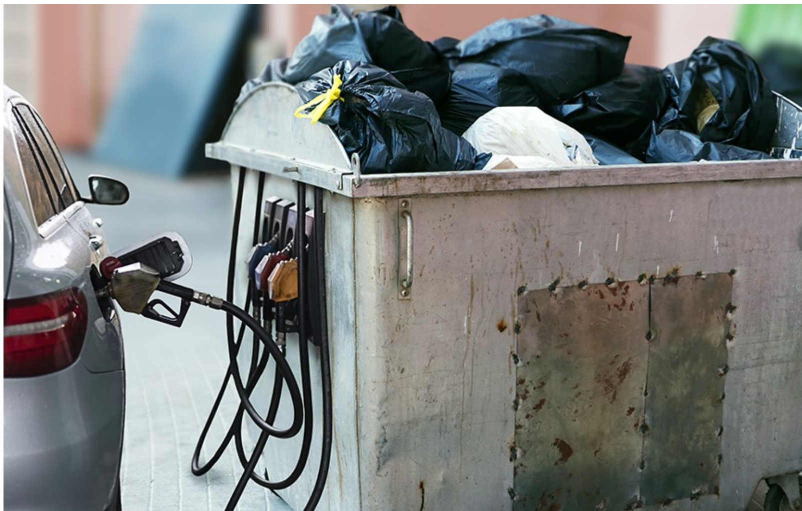
Because the chemistry of converting organic acids into fuels and chemicals has been studied extensively over the past few decades, there are existing methods for chemical conversion. Using these well-known processes, the recovered acids from the MixAlco process can be easily converted into gasoline, jet fuel or industrial chemicals.

In total, this conversion takes about a month, but because the tanks are inexpensive, the process is economical. "This process can transform biomass into almost any fuel or chemical currently made from oil and natural gas," said Holtzapple. "These findings allow us to convert biomass wastes to useful products that benefit the environment and society."

In addition to providing an energy alternative, this natural process has other advantages. If food waste is converted to chemicals, the resulting chemicals are safe for human consumption. Additionally, the products are carbon-neutral, meaning they will not release net carbon into the atmosphere.

Recently, the bio-based ingredients company BioVeritas began commercializing Holtzapple's process. By 2025, the process will be operational, with the goal of producing 20,000 tons of product per year.

"Texas has a lot of land, and it can grow significant amounts of biomass," said Holtzapple. "To be more sustainable, Texas needs to transition our economy by transforming biomass into fuels and chemicals."



GRADUATE STUDENT ASSOCIATION HOSTS RESEARCH SYMPOSIUM

Graduate students in the Artie McFerrin Department of Chemical Engineering at Texas A&M University received the opportunity to connect with industry representatives and showcase their research at the Chemical Engineering Graduate Student Association's (ChEGSA) 10th annual research symposium, held on March 6 at the Memorial Student Center.

"This event caters to graduate students in the department and allows them to present their research in front of professors with the added benefit of showcasing their research in front of industrial visitors," said Anubhav Sarmah, doctoral student and ChEGSA organizing committee president.

Over 100 students participated in the event, which included research poster sessions, oral presentations, panel discussions, specific networking opportunities and keynote speakers.

The first keynote speaker was Dr. Shyamal Bej, senior principal science expert in the process development group at Shell, who supports several projects related to low-carbon renewable fuels, waste plastic to chemicals and carbon dioxide abatement. For over 32 years, he has been involved in the fundamentals of catalysis, reaction engineering, and catalyst and process development.

"Dr. Bej discussed how we can move towards a greener transport sector," Sarmah said. "He talked about the coming up of electric vehicles and how we can transition from what we call fossil or conventional fuels to greener alternatives."

Dr. Dan Hickman is a senior research and development fellow in Dow's engineering and process science department and a technical leader in reaction engineering and process development for numerous reaction systems across many Dow businesses and technologies. He served as the second keynote speaker for the event.

"Dr. Hickman focused on how certain numerical or statistical analyses are very important in research to get repeatable results," Sarmah said. "This is important for grad students who will soon be joining a company or a bigger lab because what we do here is on a small scale, but when we do stuff on a big scale, a simple mistake can lead to disasters or losses for the company."

The panel discussions addressed solutions to current challenges facing the chemical engineering industry and highlighted career options for students upon graduation.

The goal of the ChEGSA is to foster a sense of community for current and former graduate students as well as help their professional development and give students an active voice.

"It's important for students to get out of their labs and see what their peers are doing," Sarmah said. "These companies are actively looking for students with expertise, so it's a good opportunity for them to network with industry representatives, showcase their skills and set up conversations that could lead to a prospective future opportunity."

Chemical undergrads **host** Southwest Student Regional Conference

For the first time in 14 years, Texas A&M University hosted the 2023 American Institute of Chemical Engineers (AIChE) Southwest Student Regional Conference.

The two-day conference, sponsored by LyondellBasell (an international chemical company), is held annually. Students from McNeese State University in Lake Charles, Louisiana; Lamar University in Beaumont, Texas; Tecnológico de Monterrey in Monterrey, Mexico; Texas Tech University in Lubbock, Texas; the University of Texas in Austin; and the University of Houston participated in a series of workshop discussions and challenges, including Jeopardy, a poster contest and a Chem-E-Car Competition.

The competition provided an opportunity for students to showcase the research they had conducted at their respective universities. Spearheading the event for the student-led organization were undergraduate students from the Texas A&M chapter of AIChE, including the Chem-E-Car Competition chair Nathaniel Thomas, president Mikayla Canter and vice president external Andrea Afonso.

For the Chem-E-Car Competition, each participating school had a chemistry-powered car, compact like a shoebox, aiming to travel a distance ranging from 15 to 30 meters.

"The main rule was that you had to power the car using a chemical reaction," Thomas said. "The other one was that you couldn't use electronic timers — you had to use a chemical reaction to time the car to go a specific distance. It wasn't about speed; it was about precision and control."

Some of the chemical reactions included using a zinc and nickel battery that provided the power and then an iodine clock reaction, which provided the timing and the power to control the battery or provide power for the battery and a timing reaction to stop the car.

McNeese entered a hydrogen-powered car that covered the longest distance, reaching 23 meters, earning them a victory in the competition.

"Unfortunately, our team and another weren't able to get our car started because of technical difficulties," Thomas said. "The part I enjoyed most was the competition, in terms of seeing all of the teams putting together their cars, seeing the unique designs and seeing them perform."

After the competition, the Texas A&M team figured out the technical issue. The car had a strong potassium hydroxide solution base, and the container that held it was plastic.

"We believe there was an acid-based neutralization, which just ate away the plastic, and it neutralized the electrolyte, so the battery didn't work anymore," Thomas said. "Then, there was also internal shorting because the structural integrity of the containers was compromised. Over time, this happened to our container."

Initially, the chemical reaction worked well, but over time, the repeated exposures just broke down the container on the day of the competition.

Although they did not get far in the competition, Thomas said the team plans to move forward with the car at next year's competition.

"We are planning on using a modified version of our current design with a new, different battery that doesn't break down," Thomas said. "I've also been looking at expanding our engineering teams; maybe having a second car team would make a difference."

What the team as a whole took away from the competition was real-world experience.

"We gained a unique real-world engineering experience," he said. "You'd be surprised how little you actually get your hands dirty as a student just going through the curriculum. Most people here are going into industry, and they haven't done any engineering at all, really. I strongly believe we need more real-world engineering experience for students today, and this is a great way to do that."

Within the competition, the organization worked with a variety of engineering disciplines beyond chemical engineering.

"The conference served as grounds for all engineering students to learn the significant aspects of being a chemical engineer that they don't typically emphasize in our courses," said Jennifer Ha, Southwest Student Regional Conference chair. "It gave a glimpse into what the industry is and how real-life problems are solved. Surrounded by many diverse minds, this cultivated an environment that allowed everyone to showcase their diverse ideas and also build lasting connections that we otherwise would not have. It was special to see everyone break out of their boundaries to learn and network."

The impact of the conference can be seen not only in the work the students have done but in their future careers.

"This is so important because it can be translated to my future career because everything is teamwork," Afonso said. "Having those good relationships with the people on your team and knowing their strengths is important to efficiently run a project."

Accompanying the career impact is the strong sense of camaraderie with other schools.

"I think the relationships I've built have been super cool, and it was great meeting everyone who came from the different schools," Afonso said. "It was just really cool to see how we all come from different places, but we're all studying chemical engineering and have so many similar interests."

Canter said that overall, the conference served as a valuable learning experience for the participants, fostering teamwork and collaboration within their own organizations and among other engineering groups. It provided them with fresh perspectives on diverse ideas and the ability to integrate into a unified team.

"It was rewarding to see this organization give back," Canter said. "I know that for a lot of our coursework, we work in groups, but how to lead a team and make a team connect is not always taught that way. It's something you kind of have to learn for yourself and learn and work with the team."

Graduate students receive fellowships

During the years as a graduate student, money and tuition become part of the balancing act along with school, internships and jobs.

To help ease their financial strain, 11 students in the Artie McFerrin Department of Chemical Engineering at Texas A&M University were named recipients of various graduate fellowships.

The students include Ahmed Elkady, Anirudh Gairola, Denis Johnson, Dohyun Kim, Harry Escobar, Huaixuan Cao, Jarad Yost, Niranjan Sitapure, Silabrata Pahari, Suyash Oka and Yufend Ouan.

“Every day, our graduate students make groundbreaking discoveries that provide clean and renewable energy, affordable and sustainable products, access to abundant food and water, and state-of-the-art health care,” said Dr. Victor Ugaz, interim department head and chemical engineering professor. “These experiences uniquely equip our students to be at the forefront of efforts that improve the quality of life for everyone.”

Fellowships are crucial for the department because they showcase the students’ accomplishments and inspire them to become leaders in their future academic and professional careers, he said.

“We are truly fortunate to have so many outstanding graduate students in our program,” Ugaz said.

Each of these students has a different connection with the fellowship they received, such as Gairola, who was awarded the Dr. MN Karim Graduate Fellowship.

“This fellowship is special for me since Dr. Karim championed my admission to the Ph.D. program back in 2019, and he was my first Ph.D. co-advisor,” Gairola said. “He already had a big impact in my life

by supporting me. Receiving a fellowship under his name makes me feel even more honored and special."

After completing his doctoral studies, Gairola plans on joining the bio-pharmaceutical industry as a formulation scientist working on drug product development.

"This fellowship has given me a financial and moral boost, further galvanizing me to strive for future goals," Gairola said. "As a Ph.D. researcher, I am working on developing targeted drug delivery systems against infectious bacterial diseases such as tuberculosis."

To receive the fellowships, the students had to submit a research summary of their work and how it ties into their future plans.

Yost, who was awarded the Brunner-Barnes Graduate Fellowship, wrote about his research on microfluidics and electrokinetics and how it is an up-and-coming field because of the COVID pandemic.

"I study microfluidics and electron kinetics, which entails manipulating small amounts of fluid with electricity," Yost said. "I work on both improving sample preparation and improving diagnostics through nucleic acid amplification. COVID is diagnosed through PCR, and my research performs the same thing. There is a clear need for rapid and portable diagnostic tests and being able to take these small devices out to the field."

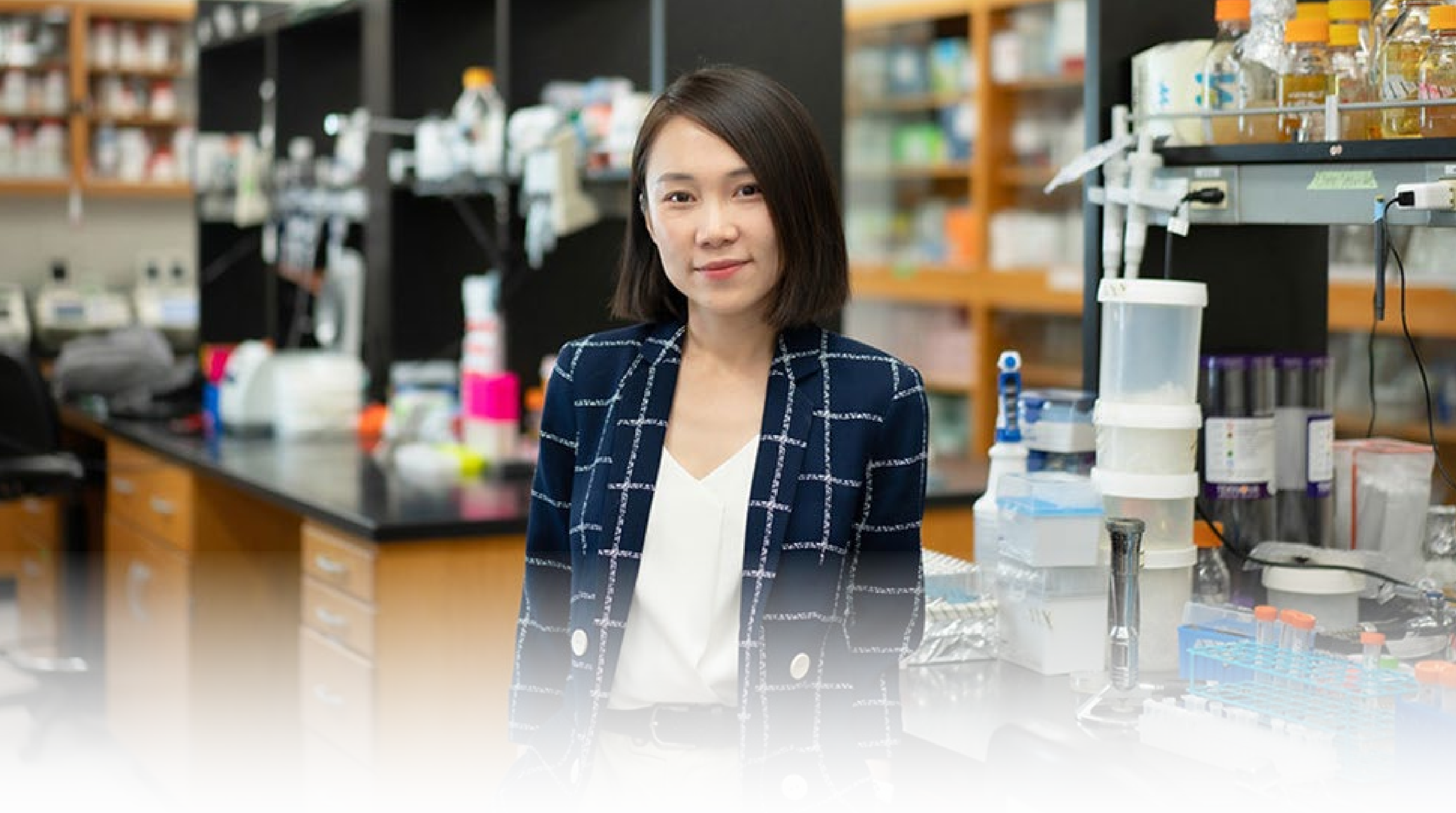
This fellowship has lifted some of the financial burden and has allowed him the peace of mind to focus on his research, he said.

Elkady, who received the Lee (Bender) Coleman '81 and Keith Fellowship, feels that it gives him the ability to make his research his main priority. His research focuses on identifying and assessing the risk factors involved in offshore green hydrogen production to support the growth of emission-free green energy as well as the safety and security of the process.

"Mr. and Mrs. Coleman's generous funds will help me overcome the expenses of living and studying, as well as holster my efforts to make a profound positive impact on the world," he said. "I'm working on the safe and secure remote production of green energy and how to operate similar chemical industries in such a way as to ensure minimum risk to operating personnel, equipment or the environment."

Similarly, Escobar's research addresses safety and sustainability in different applications for the energy transition. He was honored with the Jim and Cathy Holste Graduate Fellowship. Since Escobar will be graduating this fall, the fellowship has allowed him to continue to achieve in his professional and personal pursuits.

"This fellowship honors fundamental and applied research in chemical engineering," Escobar said. "With my work I tie together fundamental computational chemistry with applied industrial safety and sustainability research. It is a great honor to be the 2022 recipient of this fellowship because it signifies how my contributions to the department and to The Texas A&M University System are in line with the values of the Holste family and their contributions to Texas A&M."



Layered feedback mechanisms **add control to engineered cells**

Dr. Chelsea Hu, an assistant professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University and a member of the Accountability, Climate, Equity, and Scholarship (ACES) Faculty Fellows Program, is using synthetic biology to help scientists control genetically engineered cells. Her study is the first to use modeling and a physical experiment to show the effectiveness of layered feedback mechanisms. Hu collaborated with Dr. Richard Murray at the California Institute of Technology.

“Synthetic biology is incredibly useful,” Hu said. “It allows scientists to engineer a cell by turning a specific gene on or off to make the cell behave in a certain way. The problem is that once scientists have created the engineered cell, they have very little control over how it reacts to external factors. My research is about using synthetic biology to implement the needed control mechanisms.” Hu’s research was published in the journal Nature Communications.

“Control is the most vital aspect of engineering,” Hu said. “We can develop anything, but if we can’t control it, it’s not useful to us. The goal of my research is to help scientists have more control over engineered cells by applying feedback mechanisms.”

Engineers regularly use feedback mechanisms to control systems in a way that impacts daily life. Without feedback mechanisms, things like modern aircraft or motor vehicles could not exist.

“The best way to think about a feedback mechanism is to think about your air conditioner,” Hu said. “If you program your air conditioner to 72 degrees, when the temperature rises to 73, the unit will cool the room until it returns to 72 degrees. When the thermostat reaches the set temperature, the unit will shut off.”

However, because not all feedback mechanisms are created equal, adding them will not always improve performance. The mechanisms must be properly combined because there is often a tradeoff between speed and robustness. A quick response is usually frail, and a robust response usually takes more time. Engineers often layer two feedback mechanisms to overcome the tradeoff when designing a fast and robust system. This optimization strategy is largely responsible for the robust performance of most modern technology. Similar layering strategies are also naturally occurring in biology. When a living organism experiences a disturbance, such as an environmental, physical or chemical change, it uses layered feedback mechanisms to return to homeostasis.

“We are trying to determine if it’s a coincidence that evolution and engineering use the same layered feedback design,” Hu said. “We are also researching if layered feedback mechanisms in biology overcome the speed and robustness tradeoff in the same way they do in engineered systems. Most importantly, we are determining if using layered feedback mechanisms is the right path to gain control of synthetic biological systems.”

While layered feedback mechanisms are widely used in modern technology, Hu’s work is the first of its kind to design, model, analyze and engineer this layered architecture in living cells. After creating the living cells with the layered feedback mechanisms, Hu administered disturbances to measure the cells’ response. Her research confirms, both computationally and experimentally, that layered feedback mechanisms improve cell performance over time.

Hu’s research is the first step in figuring out how scientists can have greater control over engineered cells. In the future, this research could have a profound impact on humanity when it is integrated into the biomedical, agricultural, industrial and environmental fields.

“Once we can control engineered cells, we can use them to improve human life,” Hu said. “The cells could be used to help with things like treating bowel inflammation, improving plant growth or cleaning up chemical waste. But control in synthetic biology is still in its infancy, and we have a lot of work to do before this technology is widely integrated into our everyday lives.”

This research was partially funded by the Defense Advanced Research Projects Agency.

National committee looks to maintain environmental sustainability

Earlier this year, Dr. Faruque Hasan was appointed to a national committee on "Atmospheric Methane Removal: Development of a Research Agenda."

This prestigious appointment recognizes his expertise as a thought leader in this area.

"This committee will explore different possibilities and technological pathways for methane removal to achieve net-zero greenhouse gas emissions. My research is relevant to this because I also work on how we reduce greenhouse gas emissions from the energy and chemical manufacturing sectors," said Hasan, associate professor in the Artie McFerrin Department of Chemical Engineering.

The committee was formed by the National Academies of Sciences, Engineering and Medicine with the idea to bring industry and academic experts together to identify different options for removing methane from the atmosphere.

According to the National Academies website, the committee will consider the need and viable options for atmospheric methane removal. Their study will examine opportunities, risks and co-benefits of different atmospheric methane removal approaches and make recommendations for new research that would improve understanding of these technologies and their implications.

"Methane is more potent than carbon dioxide as a greenhouse gas," Hasan said. "A lot of focus has been given on carbon dioxide, but not much on methane."

The committee members are looking into the technical challenges of removing the methane, technology, methods of removal and experiments, and what the consequences will be if it's not removed.

"Removing methane from the atmosphere is a technologically challenging area," Hasan said. "There are many open questions. We need to explore ways we can improve our understanding of atmospheric methane removal."

With research interests in decarbonization, systems and techno-economic analysis, sustainable hydrogen economy, and carbon dioxide capture and utilization, Hasan's work is suited to the committee's goal.

"It's important for me that my research is relevant to this," Hasan said. "My group focuses on developing decarbonization processes and pathways, addressing the techno-economics of different technology options and identifying which are optimal for improving the sustainability of our energy and chemical sectors."

Other factors that will be reviewed include environmental factors, policies and perception, among others.

The first meeting, held in April, included members of the industry, academia and nationwide experts. At the conclusion of the committee study, the members will look to address new practices and policies for the research of removing methane.

Determining how and why cells **make decision**

Cells are constantly making decisions that lead to differentiation. For instance, cells in an embryo make a series of decisions that determine whether they will become neurons in some cases and muscle cells in others. How do cells make these decisions?

Researchers at Texas A&M University and North Carolina State University are determining how cells facilitate decision-making processes. Through this work, they hope to precisely measure the concentrations of specific vital signaling proteins within cell tissues. In addition, they will use the measurements to develop mathematical models that can predict and control cellular differentiation. This study was recently published in ACS Omega.

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"We want to understand differentiation decisions, so we can ultimately harness them," said Dr. Gregory Reeves, an associate professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M. "We are engineering tools to understand cell differentiation and describe the processes through equations. To accomplish these tasks, we need to understand the concentrations of the proteins in live tissues."

However, determining the concentrations of key signaling proteins can be extremely difficult. To combat this issue, Reeves collaborated with North Carolina State University researchers who used an experimental and analytical framework to develop mix-and-read assays. Mix-and-read assays mean that critical reagents are placed in combination with a lysed cell, allowing for luminescence detection if the target protein is present.

Two binder proteins (blue and purple) are engineered to bind a particular target protein (red), such as lysozyme. Only in the presence of the target protein do the two halves of the split luciferase enzyme (yellow) come together to create a bioluminescent signal. By analyzing this interaction, researchers are developing mathematical models that can predict and control differentiation.

The researchers then used a protein engineering technique to create two

proteins that bind strongly to a target protein — in this case, lysozyme. These two protein binders are fused to two halves of luciferase, an enzyme that creates bioluminescence, as you would see in a firefly.

“When the target protein is bound by the two engineered protein binders, it brings the two halves of luciferase together to create bioluminescence, which we can use to take measurements,” Reeves said.

Researchers from Reeves’ lab analyzed a mathematical model of this method to predict how much bioluminescence results from the binding events, allowing them to determine the sensitivity of the assay. This, in turn, will help researchers gain a deeper understanding of how and why cells make differentiation decisions.

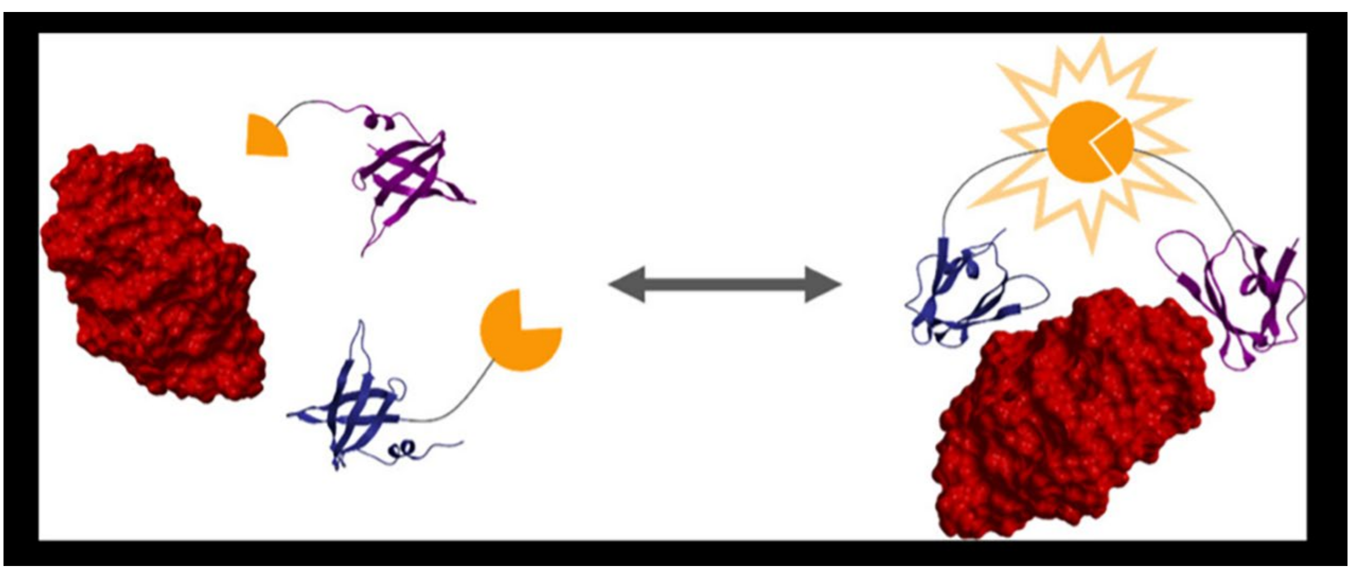
The broader impacts of this study include using this technique to detect the presence of target proteins, such as antibodies or upregulated cancer markers, in a cellular lysate.

“Other applications, which we will use in my lab, include allowing us to cleanly measure some proteins that were not able to be measured previously in live tissues,” said Reeves.

The researchers also hope to further apply these methods to other classes of molecules that are difficult to detect in live tissues, such as mRNA.

This work is in collaboration with the lead author Nikki McArthur, alongside Dr. Balaji Rao, Dr. Carlos Cruz-Teran and Apoorva Thatavarty from the Department of Chemical and Biomolecular Engineering at North Carolina State University. The research was funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development, one of the National Institutes of Health.

The research is now funded through the Texas A&M Engineering Experiment Station, a state agency that solves problems through applied research and development, and collaboration with industry, government and academic partners.



McDivitt Double Effect Evaporator *enhances student learning*

From their own experience as students at Texas A&M University, Kim Tompkins McDivitt '88 and Ascend Performance Materials CEO Phil McDivitt '87 recognize the value of hands-on experimentation and real-world applications. Through the couple's generosity to fund the McDivitt Double Effect Evaporator, students in the Artie McFerrin Department of Chemical Engineering can gain crucial skills in state-of-the-art chemical process technology.

The equipment will be installed in the Common Labs in the Zachry Engineering Education Complex, transforming the education of over 4,000 engineering students each semester. The 30,000 square feet of communal-style labs encourage collaboration across fields of study and provide access to a range of equipment and materials, mimicking real-world scenarios and allowing students to discover real-world solutions.

"Experiments conducted with the McDivitt Double Effect Evaporator will teach our students vital real-world skills," said Dr. Victor Ugaz, interim department head of the chemical engineering department.

The McDivitt Double Effect Evaporator functions through the economic re-use of energy, as vapor generated from the first effect provides the energy used to conduct the second effect. It concentrates a solution consisting of a nonvolatile solute and a volatile solvent. The double effect evaporator is the second piece of equipment in a three-phase experimentation process, following the distillation column and preceding the heat exchanger, which will be purchased and installed in the future.

"The McDivitts' gift ensures that our students continue to receive critical hands-on training in state-of-the-art chemical process technology, placing them at the forefront of innovations that make a difference by improving the quality of life for everyone," Ugaz said. This piece of equipment is not the only gift from the McDivitts, whose consistent support has propelled the chemical engineering department since they graduated from the university over 30 years ago. Their recent significant gifts to the department include a faculty fellowship, a scholarship and an endowment to support the Chemical Engineering Unit Operations Lab. Through each of these funds, their focus has been to enhance the opportunities and experiences of chemical engineering students.

"The unit operations lab brings the concepts taught by our outstanding faculty to life," Phil McDivitt said. "I have talked to many chemical engineering students who greatly value the lessons learned through hands-on experimentation. We are excited to support the double effect evaporator project as an extension of the chemical engineering curriculum."

The McDivitts look back at their experience as students at Texas A&M and value more than just the education and degrees they received. Their giving represents their dedication to the university and is a springboard that allows other Aggies to have similar experiences to what led the McDivitts to professional success.

"Texas A&M has given so much to us beyond just a great education," McDivitt said. "The value system within all aspects of the university provides a great foundation for success after graduation."

Chemical engineers **thrive** in internships, gaining experience and future careers

From collaborating with fellow students across the country to gaining valuable work experience translatable to future careers, internships allow students to hone skills in their field of interest before graduating. Students can network with professionals in as little as three months and create lasting connections between colleagues and mentors.

At Texas A&M University, students are given many opportunities to find the right internship through conferences, student organizations and career fairs. In the Artie McFerrin Department of Chemical Engineering, five Aggies shared what they learned working as interns in labs and prestigious companies in the industry.

Siddhesh Borkar: *Building expertise and teamwork*

Last summer, Siddhesh Borkar interned at one such company, Wolverine Advanced Materials, a polymer manufacturer. The master's graduate traveled to Dearborn, Mich., where he helped researchers and scientists test materials such as rubbers and rubber-coated metals. Additionally, he worked with interns nationwide to problem-solve and collaborate on a group project on safety.

"Coordinating with all of the interns and creating this project was a very good experience because I got to work with a team of people from different backgrounds," Borkar said. "That's how I developed as a team player and as a professional in general. It was also a lot of fun!"

In addition to working with a team, Borkar learned how to work in a restricted environment, completing specific tasks and objectives within a set timeframe while protecting the quality of the work. He conducted research and read literature about polymers and rubbers to add to his technical knowledge, which will help him as he pursues a doctorate in chemical engineering at Texas A&M this fall.

Annie Lee: *From internship to full-time*

Another student realized that internships could lead to full-time careers. After completing her undergraduate degree from the University of Rochester in New York, Annie Lee decided to pursue a doctorate in chemical engineering at Texas A&M. When she attended a career fair, Lee met with representatives from Eli Lilly, a pharmaceutical company, where she found her passion for chemical engineering and biology could be realized.

"Texas A&M has such well-known engineering programs that many companies come here," Lee said. "There are a lot of pros to attending engineering career fairs, such as networking and finding jobs because of the university's big connection to the industry.

After working as an intern, Lee was offered a permanent position at the pharmaceutical company. She saved the company a substantial amount of time and resources by optimizing the sample preparation and imaging steps for scanning transmission electron microscopy (STEM).

"My project involved optimizing the procedures for STEM, imaging different sample types such as nanoparticles and viral vectors for gene delivery systems and providing important physiological characteristics that are crucial in developing these gene delivery systems for the treatment of a variety of diseases with the STEM images," Lee said.

Lee will graduate with her doctorate this summer and begin working full-time for Eli Lilly this fall.

"I think an internship is an excellent experience," Lee said. "I highly recommend it because it's a great time for you to figure out what you like, what you don't like and explore your options rather than committing to a full-time job."

Niranjan Sitapure: *Discovering a passion for consulting*

Niranjan Sitapure discovered his interest in management consulting during a Ph.D. research internship at the Dow Chemical Company, moving away from his initial focus on laboratory work.

At his internship, he tested a simulation software called computational fluid dynamics (CFD), a program used to see how liquids and solids interact.

"Basically, in most chemical reactors, you have a solid, say a catalyst particle, and a liquid, a solvent or some water, and gasses," Sitapure said. "CFD is a way to simulate how these three phases interact and how to optimize the conditions to get the desired operation of the thing.

My job was to test this specific software and benchmark it against the currently established software."

While working for Dow, Sitapure discovered the importance of networking with chemists, business professionals and researchers and the value of peer-to-peer learning, which involves communicating with fellow interns to learn from one another.

"There were a lot of team-building activities for the interns to interact with many different professionals," Sitapure said. "My internship also helped me get more interviews because you gain real hands-on industry experience."

This fall, Sitapure will begin his career as a management consultant at Bain & Company. From working at Dow, he showed his future employers the ability to collaborate with team members to execute tasks to the best of his ability.

Bhavya Jaiswal: *Mastering task execution*

Bhavya Jaiswal learned to effectively execute tasks when he completed a co-op last year at Moderna as a drug product development team member. There, he learned to deal with the pressures of working at a fast-paced company and conducted a temperature excursion study for drug products such as vaccines and therapeutics.

"The drug product is kept inside a freezer," Jaiswal said. "A temperature excursion occurs when the drug product is out of the recommended temperature range. For my study, I had to put the drug product at either room temperature or in a refrigerator for several hours and then test it to see if anything changed, such as the stability or quality of the drug product. At Moderna, I learned how to design my own study, execute it and write a report about it in an industrial setting. I had a lot of freedom, to a certain extent, about what I wanted to do with my project."

He is currently enrolled in the chemical engineering doctoral program at Texas A&M after completing his master's degree in 2022. Jaiswal thanks Texas A&M for offering relevant coursework related to biology and biotechnology, which helped him during his time with Moderna.

Suyash Oka: *Powering internship success*

Suyash Oka found that having an educational background at Texas A&M comes in handy when working for various companies. He accredits the university for preparing him to work well with others and conduct research in a professional setting. Oka is working for Apple this summer

and found that internships reveal the diverse perspectives of others and help develop social skills.

"The chemical engineering department, especially, has a lot of good people to help and guide you on your career path," he said. "That's what helps all the international students as well as the domestic students coming to Texas A&M. I think that's why everyone loves the department as a whole."

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