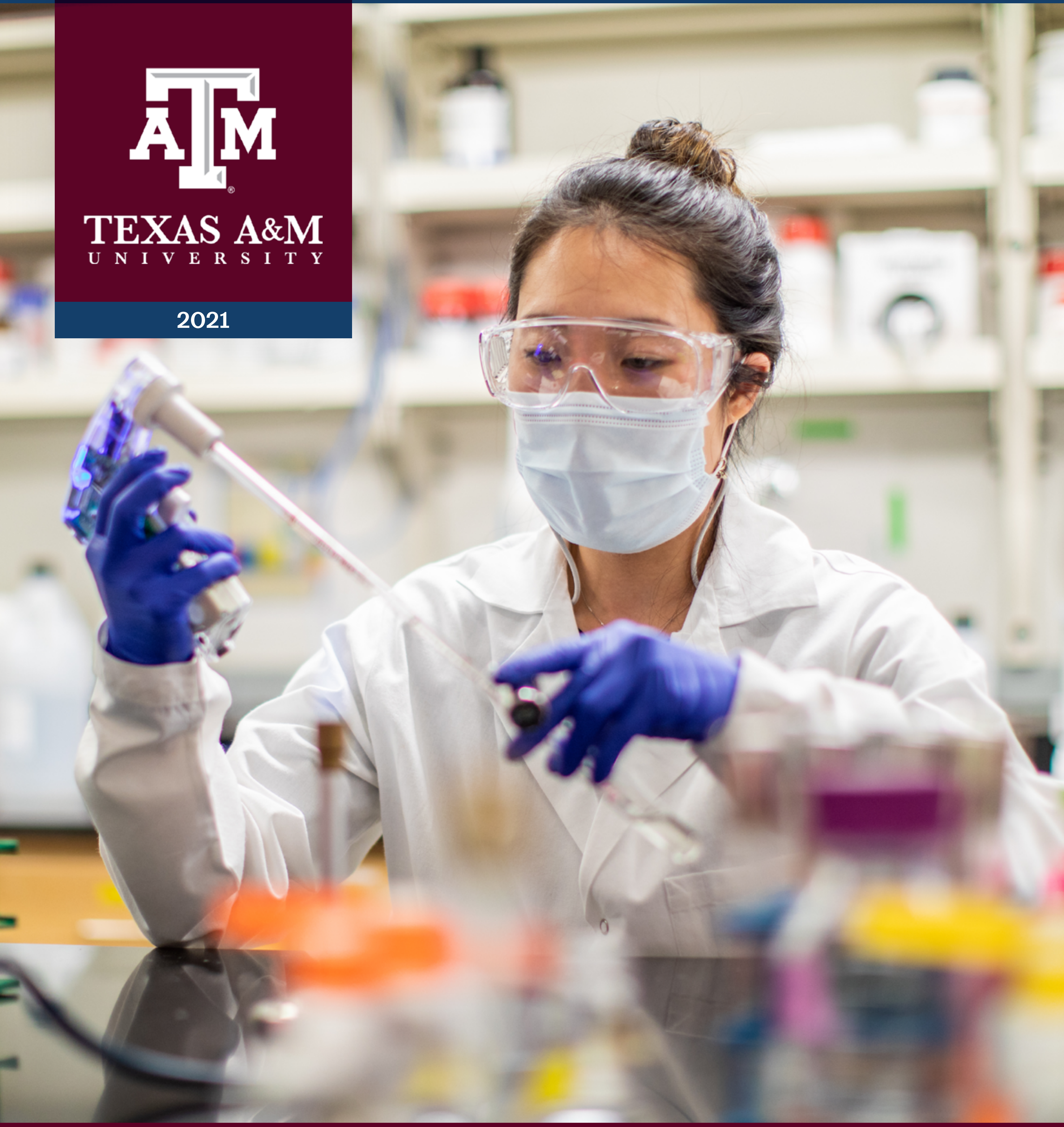


TEXAS A&M UNIVERSITY

2021

ARTIE MCFERRIN DEPARTMENT OF

CHEMICAL ENGINEERING

LETTER FROM THE DEPARTMENT HEAD

Greetings from the Artie McFerrin Department of Chemical Engineering.

Over the past year, we have navigated the challenges of a global pandemic while remaining focused on being a high-impact department recognized for excellence and leadership in continuously advancing chemical engineering science.

Our department remains among the top nationally ranked chemical engineering programs in the United States, due in large part to the caliber of research our faculty is involved in.

Groundbreaking research and transformative innovations from our department this year include a breakthrough technology on a new battery platform that is completely metal free to a framework for synergistic interaction between renewables and carbon capture to understanding the mechanisms behind the motility of carcinogenic bacteria.

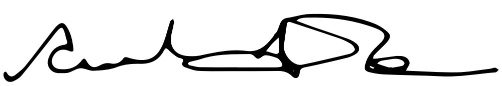
Our faculty have received multiple awards, including the 2021 American Institute of Chemical Engineers Sustainable Engineering Forum Research Award, the 2021 Rising Star award by the American Chemical Society, the 2021 Computing and Systems Technology Division Outstanding Young Researcher Award and being elected fellow to professional societies such as the American Institute of Chemical Engineers and The Academy of Medicine, Engineering and Science of Texas.

Of course, we are nothing without our students. Total student enrollment for 2020-21 topped 1,000, including 819 undergraduate students and 131 doctoral students. We conferred degrees for 231 undergraduate, 29 master's and 28 doctoral students. One of our undergraduates, Marco Solarte '21, was selected as an Outstanding Student Award recipient by the Texas A&M Foundation Board of Trustees.

I would also like to recognize the generosity of our former students, many of whom established scholarships this year. Among those are Janet '84 and Kyle '82 Cuellar, Bryce Alexander '19, Carolyn and Edwin "Ed" H. Moerbe Jr. '61, Loren and Shaw Ottis '00 and Michelle Scudder '80 and Brooks W. Herring '80.

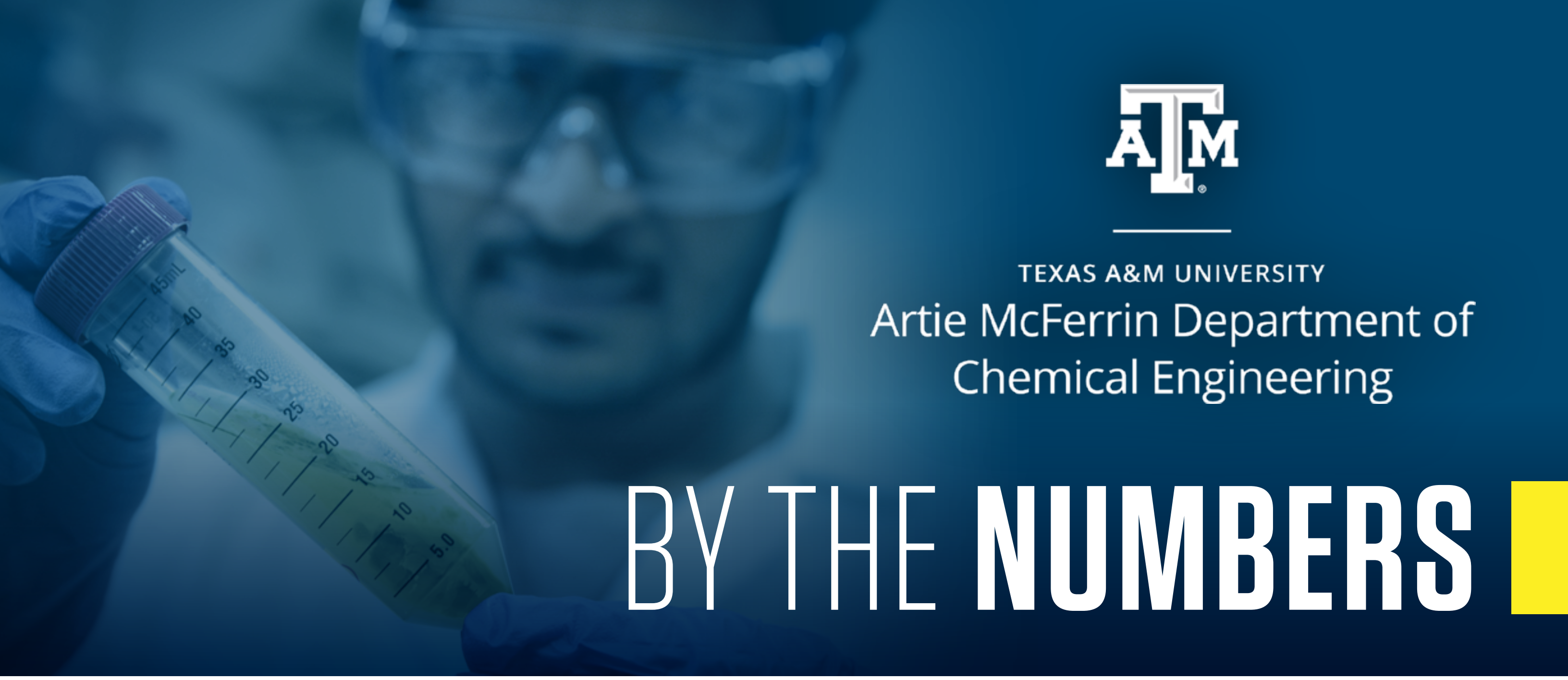
I hope you enjoy this overview of our department.

Sincerely,



Arul Jayaraman

Professor and Department Head
Ray B. Nesbitt Endowed Chair
Presidential Impact Fellow



TEXAS A&M UNIVERSITY

Artie McFerrin Department of Chemical Engineering

BY THE NUMBERS

RANKINGS (2022)

#10 Undergraduate Program Ranked No. 10 (Public) (*U.S. News & World Report*)

#17 Graduate Program Ranked No. 17 (Public) (*U.S. News & World Report*)

ENROLLMENT* (FALL 2021)

*preliminary, 5th class day

1,052 Total

819 Bachelor's

102 Master's

131 Ph.D.

FACULTY

45 Total Faculty

5 Endowed Professorships

8 Chair Holders

4 Endowed Faculty Fellows

DEGREES AWARDED* (AY 2020-21) *preliminary

231 Bachelor's

29 Master's

28 Ph.D.

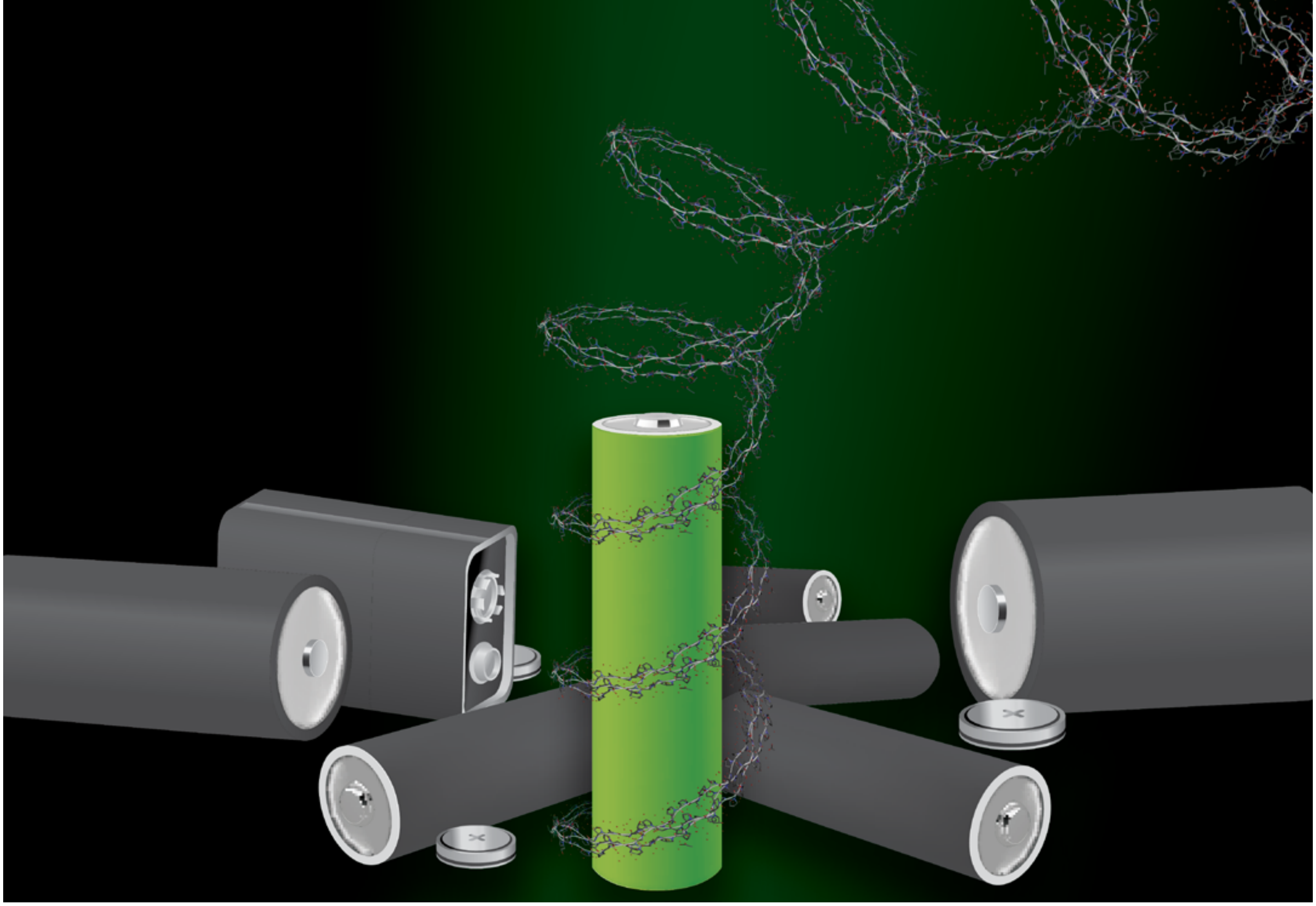
GRADUATE DEGREES

16 M.S. Chemical Engineering

6 MBIOT (Biotechnology)

7 M.S. Safety Engineering

28 Ph.D. Chemical Engineering



DEVELOPING METAL-FREE, RECYCLABLE BATTERY THAT DEGRADES ON DEMAND

A multidisciplinary team of researchers from Texas A&M has made a breakthrough that could lead to battery production moving away from cobalt and marks significant progress toward sustainable, recyclable batteries that minimize dependence on strategic metals.

Current li-ion (lithium-ion) batteries utilize significant amounts of cobalt which, in several well-documented international cases, is mined using child labor in dangerous working environments. Additionally, only a very small percentage of li-ion batteries are recycled, increasing the demand for cobalt and other strategic elements.

In an article published in *Nature*, Dr. Jodie Lutkenhaus, Axalta Coating Systems Chair and professor in the Artie McFerrin Department of Chemical Engineering, and Dr. Karen Wooley, Distinguished Professor in the Department of Chemistry, along with lead author Tan Nguyen, a postdoctoral associate at the University of Michigan, outlined their research into a new battery technology platform that is completely metal free. This technology utilizes a nontoxic polypeptide organic radical construction that also solves the problem of recyclability.

The components of the new battery platform can be degraded on demand in acidic conditions to generate amino acids, other building blocks and degradation products — one of the major breakthroughs in this research.

"The big problem with lithium-ion batteries right now is that they're not recycled to the degree that we are going to need for the future electrified transportation economy," Lutkenhaus said. "The rate of recycling lithium-ion batteries right now is in the single digits. There is valuable material in the lithium-ion battery, but it's very difficult and energy intensive to recover."

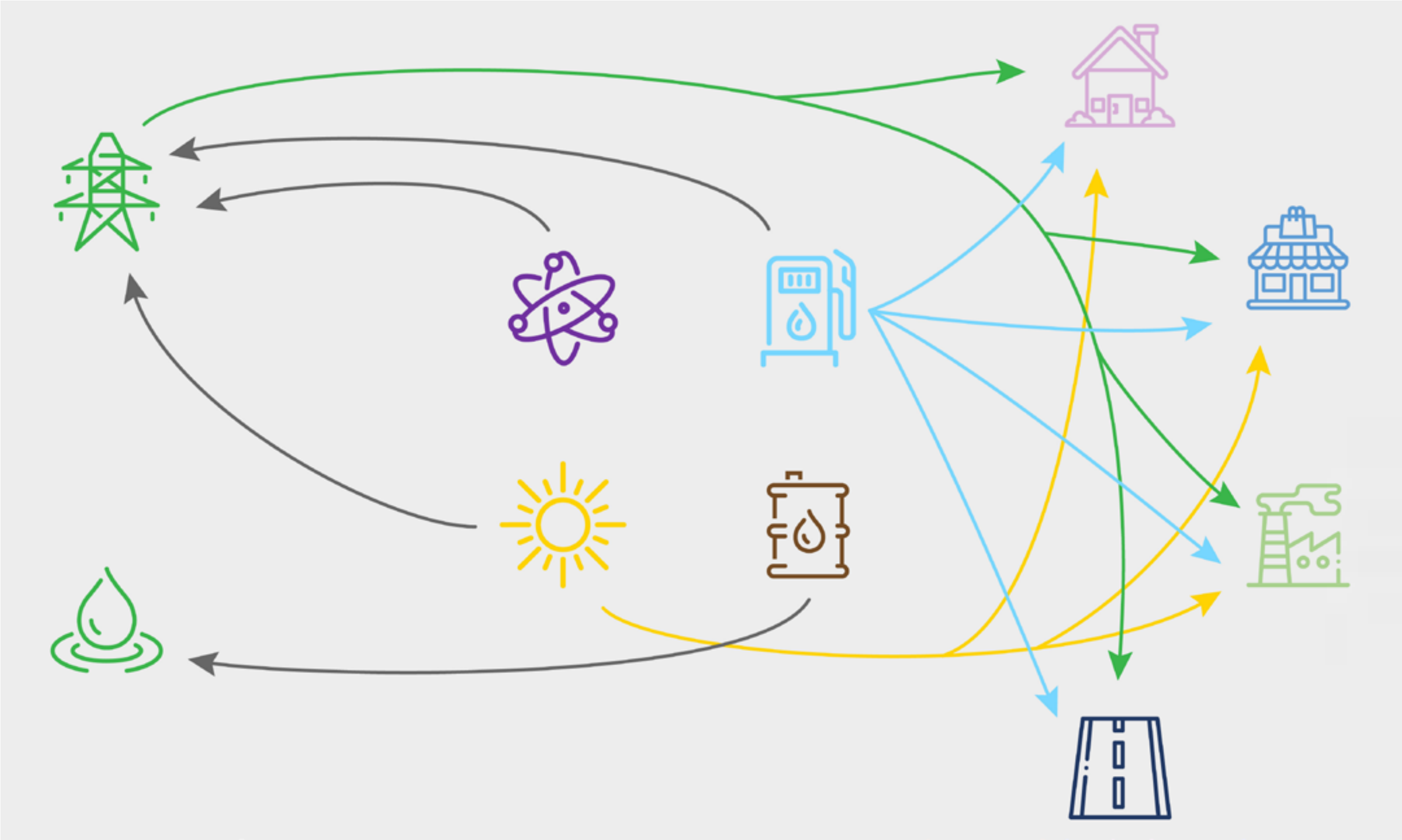
This work was funded by the NSF, the Welch Foundation and the U.S. DOE Office of Science.

FEATURED RESEARCHER

Dr. Jodie Lutkenhaus

Professor
Axalta Coating Systems Chair

SMOOTHING THE TRANSITION TO ENERGY ALTERNATIVES



Since the industrial revolution, fossil fuels have had a dominant footprint in energy production. However, the environmental concerns of fossil fuels use and their inevitable depletion have led to a global shift toward renewable energy sources. This shift raises questions about the best choice of renewables and the impact of investing in these resources on consumer costs.

In a recent study published in the journal *Nature Communications*, researchers at Texas A&M, including Dr. Stratos Pistikopoulos, professor and director of the Texas A&M Energy Institute, have devised a metric to reflect the average price of energy in the United States. Much like how the Dow Jones Industrial Average indicates trends in stock market prices, the researchers' metric reflects the changes in energy prices resulting from the type of energy sources available and their supply chains.

Currently, only around 11% of the total energy landscape comes from renewable sources. Although many countries, including the United States, have committed to using more renewable energy sources, there currently isn't a way to quantitatively and accurately measure the price of energy as a whole.

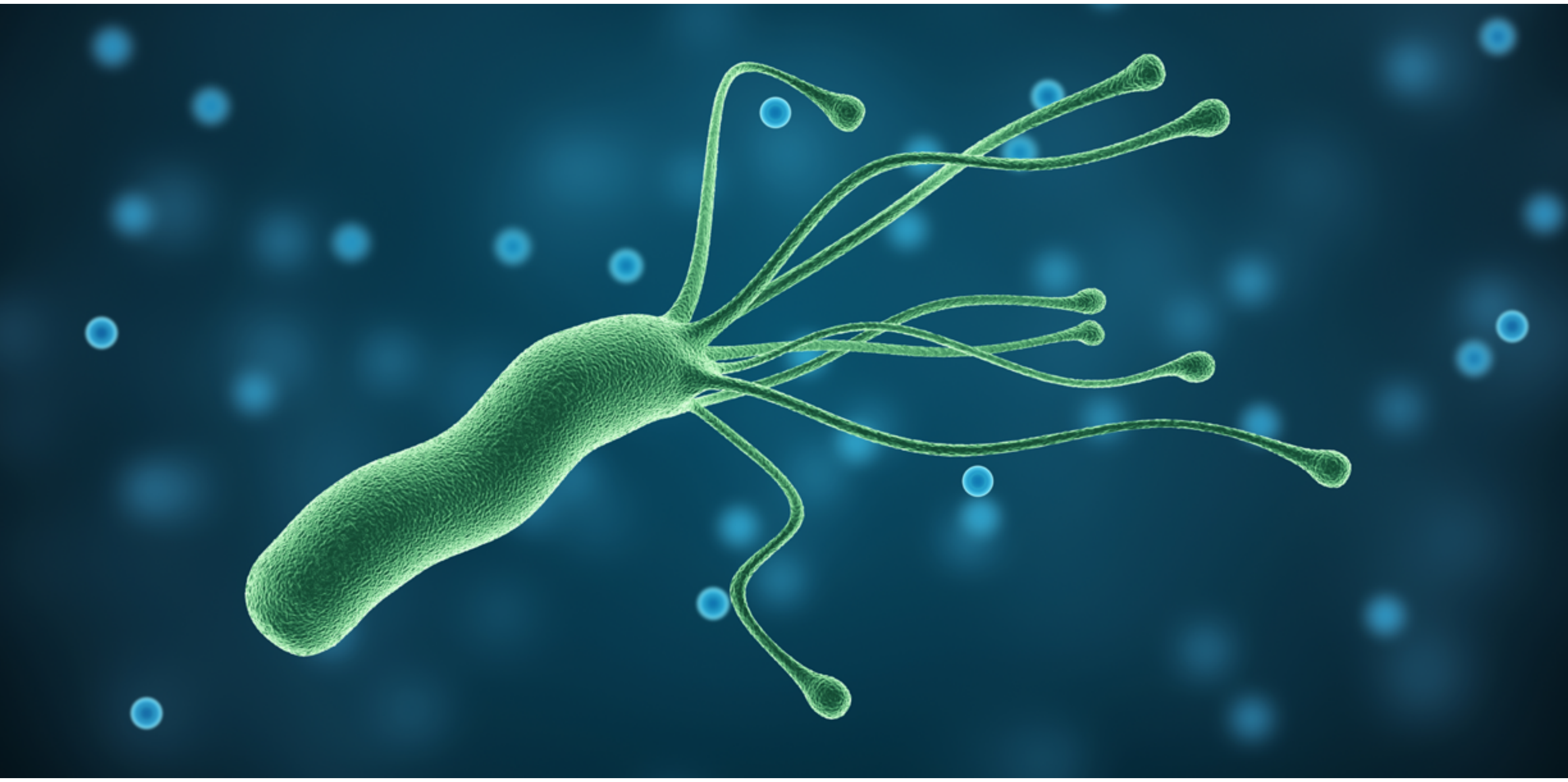
To address this gap, researchers first identified different energy feedstocks, such as crude oil, wind, solar and biomass, and their energy products. Next, they categorized the energy end users as either residential, commercial, industrial or transportation. Finally, they identified the supply chains that connected the energy products to consumers. All this information was used to calculate the average price of energy, called the energy price index, for a given month and forecast energy prices and demands for future months.

As a potential real-world use of this metric, researchers explored several policy case studies. Most notably, they tracked a \$5-per-barrel increase in crude oil tax through the energy price index. They found that around \$148 billion could be generated every four years without a significant monthly cost increase of U.S. household energy.

FEATURED RESEARCHER

Dr. Stratos Pistikopoulos

Professor
Director, Texas A&M Energy Institute
Dow Chemical Chair



HOW CARCINOGENIC BACTERIA FIND THEIR TARGETS

Helicobacter pylori (*H. pylori*), a bacterium linked to an increased risk of gastric cancer and other illnesses such as peptic ulcers and gastritis, colonize a majority of the world population's stomachs. Currently, *H. pylori* infections are treatable with a cocktail of antibiotics, but the rapid emergence of antibiotic resistance in *H. pylori* is a significant concern. To counter these threats, Dr. Pushkar Lele investigated how *H. pylori* locate their ideal environment within a host's stomach.

Motile bacteria, such as *H. pylori*, swim by rotating string-like appendages called flagella. They navigate by sensing chemical signals in their environment, a process known as chemotaxis. An intracellular signaling pathway — the chemotaxis network — aids navigation by controlling the direction of rotation of the flagella. Current understanding of how the chemotaxis network operates is based on studies of *E. coli*, which is a model system for bacterial chemotaxis and motility. The chemotaxis network in *E. coli* modulates the probability of clockwise rotation in otherwise counterclockwise-rotating flagella to help the cell migrate toward favorable chemical environments. How the chemotaxis network modulates flagellar functions in *H. pylori* is not known.

Lele's group pioneered a novel probe-free approach to study flagellar functions in *H. pylori*. In a paper published in *eLife*, Lele and his research team used this approach to report the probability of the clockwise rotation in *H. pylori* for the first time and showed that the chemotaxis network modulates flagellar functions similar to that in *E. coli*.

Lele said the similarity in the form of flagellar control in the two bacterial species is intriguing given that they differ in several key aspects. Whereas *H. pylori* prefer the stomach, *E. coli* are found in the lower gastrointestinal tract. The physical characteristics of *H. pylori* are such that they run forward and reverse, unlike *E. coli*, which run forward and then tumble. As a result, the modulation of the probabilities of clockwise flagellar rotation, which suits *E. coli* very well, is predicted to cause errors in chemotaxis in *H. pylori*. With a greater understanding of the *H. pylori* chemotaxis network, it may be possible to disrupt the network, and in turn the bacterial infections, without the use of antibiotics.

FEATURED RESEARCHER

Dr. Pushkar Lele

Associate Professor

DESIGNING ENERGY-EFFICIENT HEATING & COOLING SYSTEMS

Current heating, ventilation and air conditioning (HVAC) systems, which often come with dehumidifiers, are not particularly energy efficient, using around 76% of the electricity in commercial and residential buildings. A research group led by Dr. Hae-Kwon Jeong has described an organic material, called polyimides, that uses less energy to dry air. Using polyimide-based dehumidifiers can bring down the price of HVAC systems.

"In this study, we took an existing and rather robust polymer and then improved its dehumidification efficiency," said Jeong. "These polymer-based membranes, we think, will help develop the next generation of HVAC and dehumidifier technologies that are not just more efficient than current systems, but also have a smaller carbon footprint."

When Jeong's team tested their enhanced material for dehumidification, they found that their polyimide membrane was highly permeable to water molecules. In other words, the membrane was capable of extracting excess moisture from the air by trapping it in the percolation channels. The researchers noted these membranes could be operated continuously without the need for regeneration since the trapped water molecules leave from the other side by a vacuum pump that is installed within a standard dehumidifier.

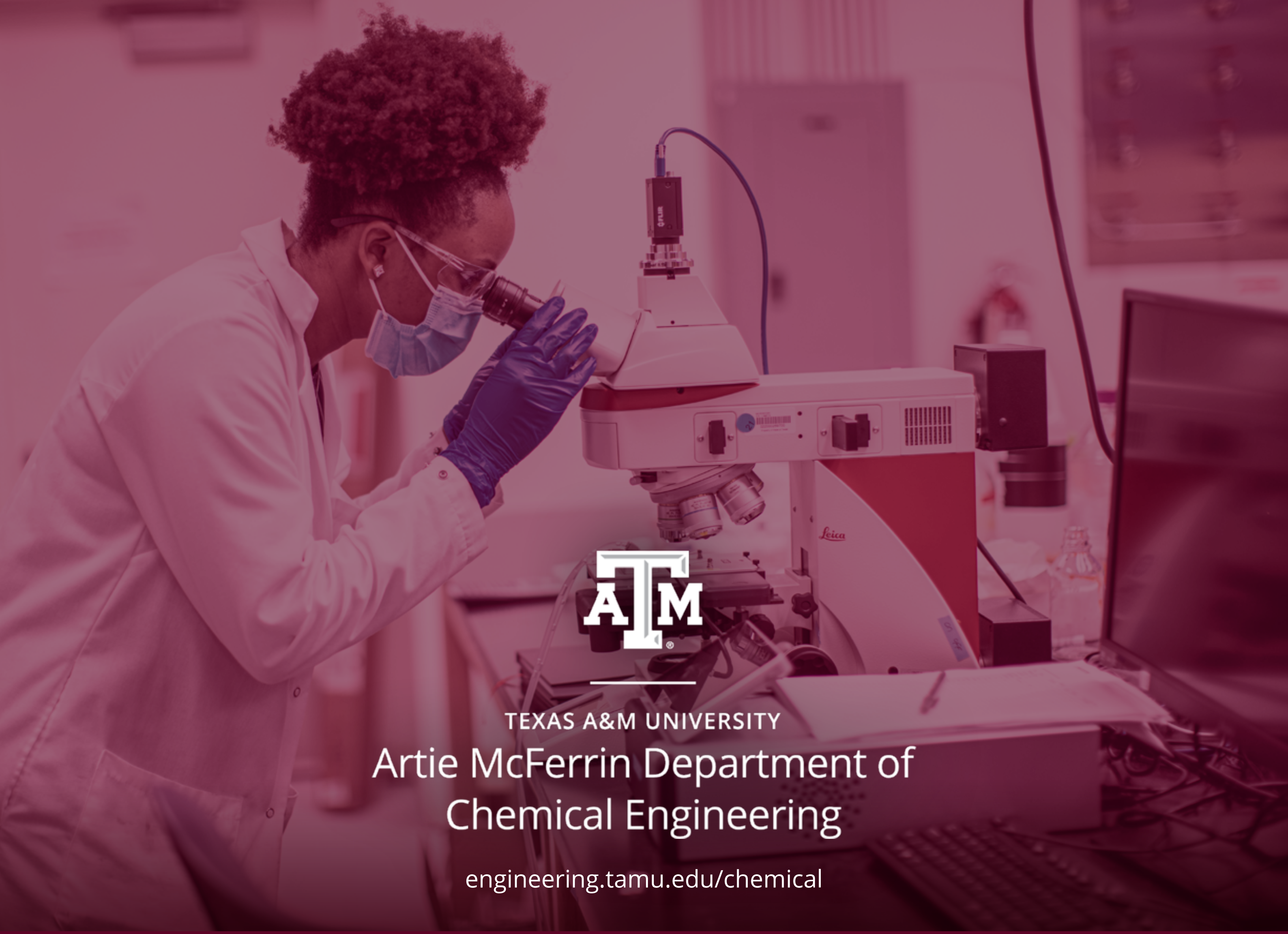
"This is a new approach to improve the property of a polymer for dehumidification, and a lot more optimizations need to be done in order to further enhance the performance of this membrane," said Jeong. "But another key factor for engineering applications is it has to be cheap, especially if you want the technology to be reasonably affordable for homeowners. We are not there yet but are certainly taking strides in that direction."

FEATURED RESEARCHER

Dr. Hae-Kwon Jeong

Professor

McFerrin Professor



ARTIE MCFERRIN DEPARTMENT OF CHEMICAL ENGINEERING

AREAS OF FOCUS

- Biomedicine | Biomolecules
- Biofuels | Biotechnology
- Catalysis
- Complex Fluids | Microfluidics | Soft Matter
- Computational Chemical Engineering
- Energy
- Environmental | Sustainability
- Materials | Microelectronics
- Multiscale Systems Engineering
- Nanotechnology
- Process Control and Process Safety
- Process Systems Engineering
- Reaction Engineering