2023

Impact

The Magazine of the College of Earth and Mineral Sciences

PennState
College of Earth and Mineral Sciences

CONTENTS

Features

Sections

On the cover...

Julia Chen, an undergraduate in materials science and engineering, John Mauro, Dorothy Pate Enright Professor of Materials Science and Engineering, and Nick Clark, a postdoctoral fellow in Mauro's lab.

All photos, unless noted, provided by Penn State.

This publication is available in alternative media on request.

From outer space to interface: EMS innovative research knows no bounds

Researchers in the College of Earth and Mineral Sciences are always pushing the limits of knowledge of the world around us and applying this new knowledge to the solution of societal problems at the local, state, national, and global levels.

This issue gives a glimpse into these activities occurring in each of our five academic departments and our institutes. Geoscientists are carefully looking for clues to the origin of our solar system. Meteorologists are reducing risk from extreme weather events through fundamental research on the origin and evolution of squall lines. An early career faculty member in Energy and Mineral Engineering is trying to find a better way to make lithium-ion batteries. Geographers are exploring the causes and consequences of environmental and social injustices with important consequences for the Chesapeake Bay and citizens of Pennsylvania and beyond. One of the biggest excitements this year is the discovery by Materials Science and Engineering faculty and students of a new kind of glass, dubbed LionGlass, that not only is superior to existing window and bottle glass, but can be manufactured with less energy consumed and a much smaller carbon footprint.

I hope you enjoy the issue and I look forward to hearing from you in the near future.

Lee Kump, John Leone Dean

Impact

John Leone Dean
Lee Kump

Editor/Design
Patricia Craig

Writers
Adrienne Berard, Matthew Carroll, Patricia Craig, Jessica Hallman, Liam Jackson, David Kubarek, Jeff Mulhollem, Krista Pylant, Kaitlyn Toth, Courtney Robinson, Alan Schaffranek

Email
EMSmagazine@psu.edu

Web
www.ems.psu.edu/college-magazine

Correspondence
Impact Magazine
510 Penn State Innovation Hub
123 S. Burrowes Street
State College, PA 16801

Follow Us

facebook.com/psuems

twitter.com/PSUEMS

instagram.com/psu_ems

www.youtube.com/c/PennStateCollegeofEarthandMineralSciences

www.linkedin.com/groups/6781082/

www.flickr.com/photos/psuems/albums

Hotter and drier conditions limit forest recovery from wildfires

Warmer and drier climate conditions in western U.S. forests are making it less likely that trees can regenerate after wildfires, according to research led by Alan Taylor, professor of geography and ecology. Importantly, the research shows that ecologically based forest management can partially offset climate-driven declines in tree regeneration by limiting fire-caused tree death, but only if action is taken quickly. This study provides key information for sustainably managing forests across millions of acres of Western forests in the face of climate change.

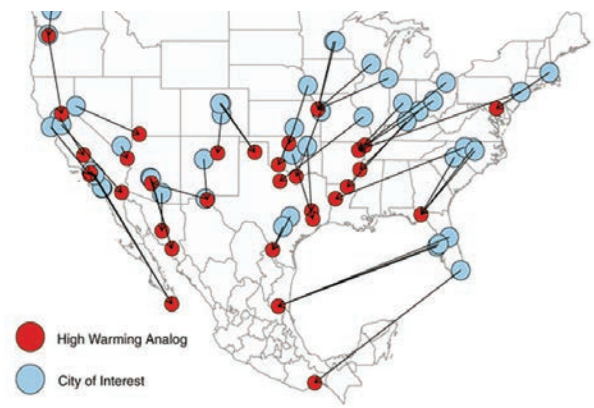
"We have a chance to buffer these climate effects," Taylor said. "By reducing fire severity across the landscape and reducing the potential for large, high-severity fires, we can better equip our forests for the future." http://tinyurl.com/5n6pzujx

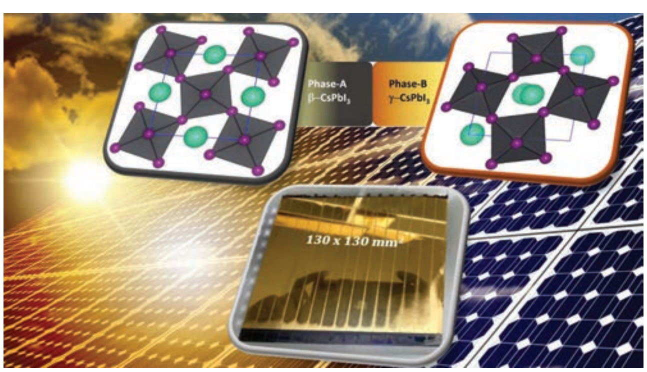
Sister climate cities, utility data predict future water, electricity demands

Modern-day Ciudad Mante, Mexico, could help Tampa, Florida, plan for shifting water and electricity demands due to climate change, according to an international team of researchers. Led by Renee Obringer, assistant professor of energy and mineral engineering at Penn State, the researchers used utilities data and climate analogs—contemporary cities with climates close to what other cities are predicted to experience in the future—to assess how climate change may impact residential water and electricity use across forty-six cities in the United States.

Their computationally efficient model projected strong regional differences for future water and electricity demand, with some cities possibly experiencing increases in summer water and electricity demand of up to 15 percent and 20 percent, respectively, because of climate change.

http://tinyurl.com/23x9xjbc





Scientists develop new method to create stable, efficient next-gen solar cells

Next-generation solar materials are cheaper and more sustainable to produce than traditional silicon solar cells, but hurdles remain in making the devices durable enough to withstand real-world conditions. A new technique developed by a team of international scientists could simplify the development of efficient and stable perovskite solar cells, named for their unique crystalline structure that excels at absorbing visible light. The scientists, including Penn State faculty Nelson Dzade, assistant professor of energy and mineral engineering, developed a new method for creating more durable perovskite solar cells that still achieve a high efficiency of 21.59 percent conversion of sunlight to electricity. http://tinyurl.com/44e53f8m

Kenneth Davis to lead field campaign to study climate in Baltimore area


Image: Pixabay

Kenneth Davis, professor of atmospheric and climate science at Penn State, will lead a team of twenty-three investigators from thirteen research institutions in a new field campaign supported by the U.S. Department of Energy (DOE) to study surface-atmosphere interactions around Baltimore, Maryland, to see how they influence the city's climate. The new campaign, called the Coast-Urban-Rural Atmospheric Gradient Experiment (CoURAGE), is expected to start in October 2024 and run through September 2025.

"It's a city that needs to adapt to thrive in a changing climate," Davis said. "The city also needs sound evidence regarding options for climate change mitigation — options like urban greening. We also need to partner to generate climate science that addresses the priorities of people and neighborhoods in the city that historically have been neglected. Many of our cities face these challenges." http://tinyurl.com/33fs7k8t

Curiosity rover finds new evidence of ancient Mars rivers, a key signal for life

New analysis of data from the Curiosity rover reveals that much of the craters on Mars today could have once been habitable rivers.

"We're finding evidence that Mars was likely a planet of rivers," said Benjamin Cardenas, assistant professor of geosciences and lead author on a new paper announcing the discovery. "We see signs of this all over the planet."


NASA/JPL-Caltech/MSSS

In a study published in Geophysical Research Letters, the researchers used numerical models to simulate erosion on Mars over millennia and found that common crater formations—called bench-and-nose landforms—are most likely remnants of ancient riverbeds.

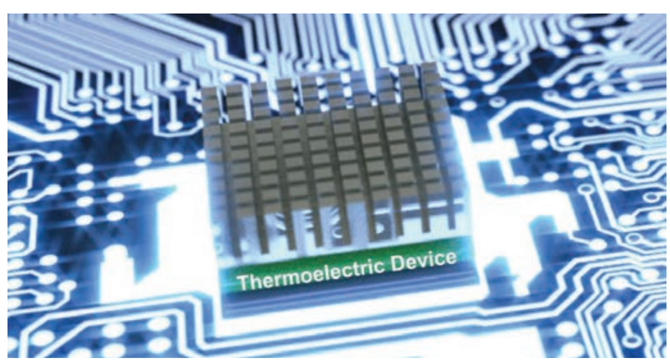
http://tinyurl.com/2y6urc5t

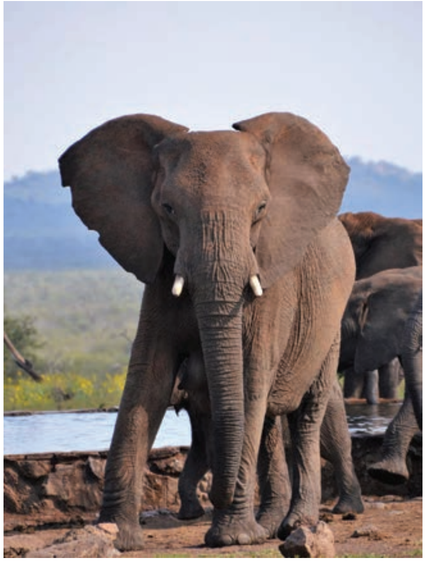
New high-power thermoelectric device may provide cooling in next-gen electronics

Next-generation electronics will feature smaller and more powerful components that require new solutions for cooling. A new thermoelectric cooler developed by Penn State scientists greatly improves the cooling power and efficiency compared to current commercial thermoelectric units and may help control heat in future high-power electronics.

"Our new material can provide thermoelectric devices with very high cooling power density," said Bed Poudel, research professor in the Department of Materials Science and Engineering at Penn State. "We were able to demonstrate that this new device can not only be competitive in terms of technoeconomic measures but outperform the current leading thermoelectric cooling modules. The new generation of electronics will benefit from this development."

http://tinyurl.com/syr66wjk





Better synthesis of geospatial data may help combat poachers

Poaching wild animals poses global environmental risks, from threatening the survival of keystones species to potentially spreading animal-borne diseases to humans. Technology like unmanned aerial vehicles, or drones, can help combat poachers, but finding the best way to use the large amounts of geospatial data generated by these tools remains a challenge, according to Wendy Zeller Zigaitis, a doctoral student in the Department of Geography at Penn State. "Technology can help, but we have to understand how to look at all the data we are collecting and synthesize that information," Zeller Zigaitis said.

"There's a lot of research out there using one particular sensor or another to combat poaching," Zeller Zigaitis said. "But I found most were looking at one piece of the puzzle, not the overall holistic picture. In the end, it's bringing all that data together and making sense of it that that is wanting to help you understand patterns and trends within a particular area." http://tinyurl.com/3ryurd4d

Breakthrough in waste heat to green energy: Materials boost record efficiency

In the effort to reduce our reliance on fossil fuels, one strategy involves harvesting the waste heat that is already being produced by our energy systems. Thermoelectric generators can convert waste heat to clean electricity, and a new design breakthrough may make these devices more efficient than previously possible, according to scientists at Penn State and the National Renewable Energy Laboratory.

"We have developed a unique materials design that can push the conversion efficiency of thermoelectric devices up to 15 percent," said Wenjie Li, assistant research professor in the Department of Materials Science and Engineering at Penn State. "This is the highest efficiency that has been recorded so far using this kind of thermoelectric technology." http://tinyurl.com/5a2vr3vb

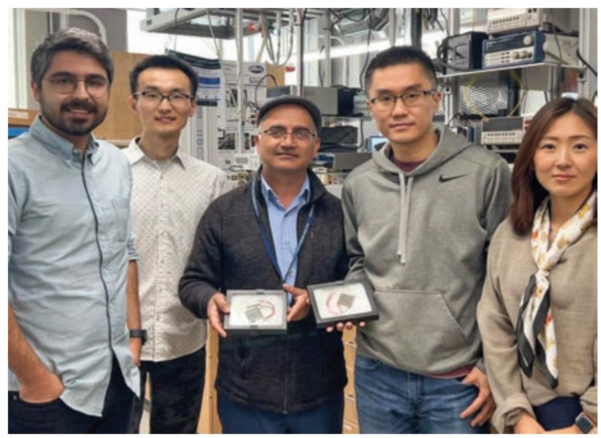


Image: Pixabay

Using machine learning, existing fiber optic cables to track Pittsburgh hazards

Existing fiber optic cables used for high-speed internet and telecommunications, in combination with machine learning, may be able to help scientists track ground hazards in Pittsburgh. The National Science Foundation awarded a $937,000 grant to a team of Penn State and Carnegie Mellon University researchers to further develop the low-cost monitoring approach.

The effort, which is led by Tieyuan Zhu, associate professor of geosciences, relies on prior research that shows hazards such as flooding, landslides, sinkholes, and leaking pipes can be monitored at a fraction of the cost of existing methods. https://tinyurl.com/nhjzmpu4

Earth's crust, tectonic plates gradually formed

The Earth's crust continued a slow process of reworking for billions of years, rather than rapidly slowing its growth some three billion years ago, according to a Penn State research team led by Jesse Reimink, assistant professor of geosciences. The new finding contradicts existing theories that suggest the rapid formation of tectonic plates earlier in Earth's history.

"The work may help answer a fundamental question about our planet and could hold clues as to the formation of other planets," Reimink said. "The dominating theory points to an inflection point some three billion years ago, implying we had a stagnant lid planet with no tectonic activity before a sudden shift to tectonic plates. We've shown that's not the case."
http://tinyurl.com/ye297a7v

Statewide environmental monitoring network launched

Penn State has established a publicly available, environmental monitoring network to provide enhanced surveillance of atmospheric and soil conditions across Pennsylvania. The Pennsylvania Environmental Monitoring Network consists of seventeen stations, with plans soon to more than double that number to fifty stations across the commonwealth. The network consists of monitoring equipment located at Penn State campuses and research facilities, state parks, and airports around the state.

David Stensrud, professor of meteorology and atmospheric science, and Scott Richardson, research professor of meteorology and atmospheric science, are spearheading development of the network along with researchers in the College of Agricultural Sciences. Pennsylvania state climatologist Kyle Imhoff is leading the data-distribution efforts that connect the data to the users. http://tinyurl.com/mtmt4rj6

Melting ice falling snow: Sea ice declines enhance snowfall over West Antarctica

As the world continues to warm, Antarctica is losing ice at an increasing pace, but the loss of sea ice may lead to more snowfall over the ice sheets, partially offsetting contributions to sea level rise, according to Luke Trusel, assistant professor of geography at Penn State.

The research analyzed the impacts of decreased sea ice in the Amundsen Sea in West Antarctica and found the ice-free ocean surface leads to more moisture in the atmosphere and heavier snowfalls on the ice sheet.

"While the additional snowfall is not enough to offset the impacts of melting ice, including it in climate models may improve predictions of things like sea level rise," Trusel said.
http://tinyurl.com/yares32p

Image: Pixabay

No shortcuts: New approach may help extract more heat from geothermal reservoirs

Geothermal heat offers a promising source of renewable energy with almost zero emissions, but it remains a relatively expensive option to generate electricity. A new technique proposed by Arash Dahi Taleghani, professor of petroleum engineering, and a team of Penn State scientists may help prevent "short-circuits" that can cause geothermal power plants to halt production, potentially improving the efficiency of geothermal power, the researchers said.

Enhanced geothermal systems involve injecting cold water into hot dry rock deep underground. The water travels through fractures in the rock and heats up, and production wells then pump the heated liquid to the surface where a power plant turns it into electricity. To prevent "short-circuits" the researchers instead have proposed adding materials or chemicals to the liquid pumped into the reservoir that would autonomously control flow from inside the rock itself. The process, called the fracture conductivity tuning technique, involves adding materials that could change properties with the temperature, hindering cold water and allowing hot water to flow through the fractures. http://tinyurl.com/3vfh2ean

NSF grant to investigate the role of macrobiota in carbon cycling in estuaries

A Penn State-led interdisciplinary team of researchers across six institutions was awarded a $3.5 million grant from the National Science Foundation to investigate the role that macrobiota, such as clams, salt marshes, and seagrasses, play in carbon cycling in estuaries.

"Estuaries are highly productive and diverse ecosystems and hence deserve study in their own right," said Raymond Najjar, professor of oceanography and lead investigator on the project. "But estuaries also play an important role in the global carbon cycle, which regulates atmospheric carbon dioxide, the most important greenhouse gas."
http://tinyurl.com/yrujpxm7

Hydrogen battery: Storing hydrogen in coal may help power clean energy economy

The quest to develop hydrogen as a clean energy source that could curb our dependence on fossil fuels may lead to an unexpected place—coal. Shimin Liu, associate professor of energy and mineral engineering led a team that found that coal may represent a potential way to store hydrogen gas, much like batteries store energy for future use, addressing a major hurdle in developing a clean energy supply chain.

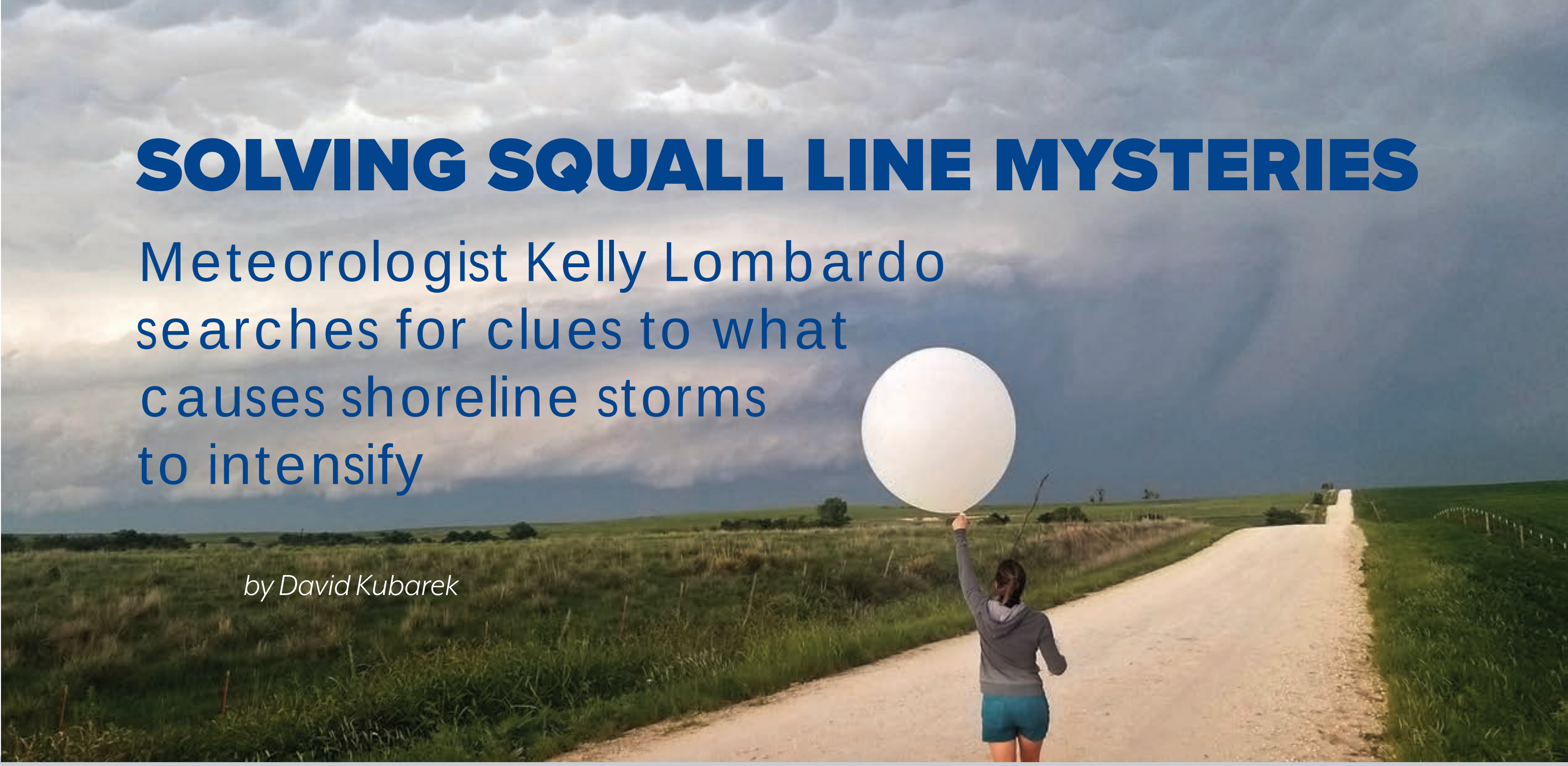
"A lot of people define coal as a rock, but it's really a polymer," Liu said. "It has high carbon content with a lot of small pores that can store much more gas. So coal is like a sponge that can hold many more hydrogen molecules compared to other non-carbon materials."

Developing hydrogen storage in coal mining communities could bring new economic opportunities to these regions while also helping create the nation's hydrogen infrastructure. http://tinyurl.com/2p9jkdm8

SOLVING SQUALL LINE MYSTERIES

Meteorologist Kelly Lombardo searches for clues to what causes shoreline storms to intensify

by David Kubarek



Most times, when associate professor of meteorology and atmospheric science Kelly Lombardo wants to learn something new about severe weather events, she's hunkered down behind a computer, running mathematical models, making precise changes to the model inputs to see how they shape the storms.

But, sometimes she gets to brave the elements. She goes out with her husband, Matthew Kumjian, an associate professor of meteorology, to launch weather balloons and use other tools to garner just a sliver of the many observational data points needed to tell how the storm is changing.

Lombardo is most interested in mesoscale convective systems, or squall lines—so called because of their long, thin shape on the radar—and how they evolve when near coastlines. It's an avenue of research that's little understood yet has the potential to save lives in some of the most heavily populated areas of the globe.

It's a forecasting problem that first came to her while earning a doctorate at Stony Brook University. She was surprised to learn that the National Weather Service, in trying to forecast these squall lines, knew little about what could cause them to weaken or intensify.

Above photo: Kelly Lombardo launching a weather balloon to gather observational data points needed to tell how a storm is changing.

"They didn't know what they should be looking at, what clues they should be searching for that may give them some insight into how the storm will behave," Lombardo said. "It was a forecasting problem that inspired my Ph.D. research".

Once she began her research, she came to realize the difficulty of the scientific problem.

"It's so complex that it's going to easily take me to the end of my career and yet there will still be so much we won't know," she said.

That's the crux for Lombardo. If she could understand the forces at play for what her eyes see as she launches those balloons into the sky, she could solve a career's worth of mysteries. It's all so close, yet so far away.

'Because it's really hard'

At first, the Long Island native was puzzled. Why do forecasters know so little about how coastlines affect storms when so many people live along the coastlines.

So, she asked one of the scientists at the National Center for Atmospheric Research.

"I asked, why hasn't someone looked at this? And he replied: 'Because it's really hard.' With that answer I knew I wanted to focus my research on solving this problem and hopefully become the expert on the behavior of squall lines in coastal environments."

A shelf cloud hovers above the ocean. Shelf clouds are typically seen at the leading edge of a thunderstorm or squall line of thunderstorms.

and tornadoes, they pose risks to the large population clustered along the coastlines.

Observations hold clues to how these storms evolve, but numerical models are critical to fill in the gaps, Lombardo said. Models can show us the processes playing out in the storms—and the importance of each—which can lead to better forecasts. Her group uses both observations and mathematical models to help understand the forces at play during these coastal storms.

Coastal squall line storms are only expected to increase.

"Global circulation models suggest an increase in the frequency of days conducive to severe storms along the eastern U.S. coastline," Lombardo said. "This is especially problematic given the large population clustered along the coastline, which is projected to increase. Our research will reveal how storms may form and behave in these future environments, and help inform response preparations necessary to mitigate future loss in coastal zones."

Lombardo said it can be daunting to tackle a problem so few have tried to solve. She sometimes finds her curiosity getting the best of her. But she's able to break things down into more manageable research pieces.

"You want to answer a lot of questions," Lombardo said. "The curiosity gets to be a bit maddening sometimes because you wish you're able perform all the work necessary to answer the questions you have. Science is exciting, but

Cloudy storm data

Specifically, Lombardo wants to know how storms change as they move from land to water. She looks at environmental conditions and the topography of the land to understand the dynamics at play. Lombardo says these storms are so challenging to study because few observational data points exist, and they're often isolated and rapidly changing.

Coastal storms are sensitive to the surface and atmospheric boundary layer found in coastal regions, including variations in temperature, moisture, and wind across the coastlines, as well as inland coastal topography.

These factors increase the complexity of the physical processes associated with storm development, characteristics, evolution, and intensity, making understanding and forecasting these systems a challenge. Because coastal storms are capable of producing high winds, frequent lighting, heaving rain, flash flooding, hail,

> *"Our research will help inform response preparations necessary to mitigate future loss in coastal zones."*
>
> *~Kelly Lombardo*

it's important to take incremental steps, build on past research and set up the foundation for future scientists."

A home at Penn State

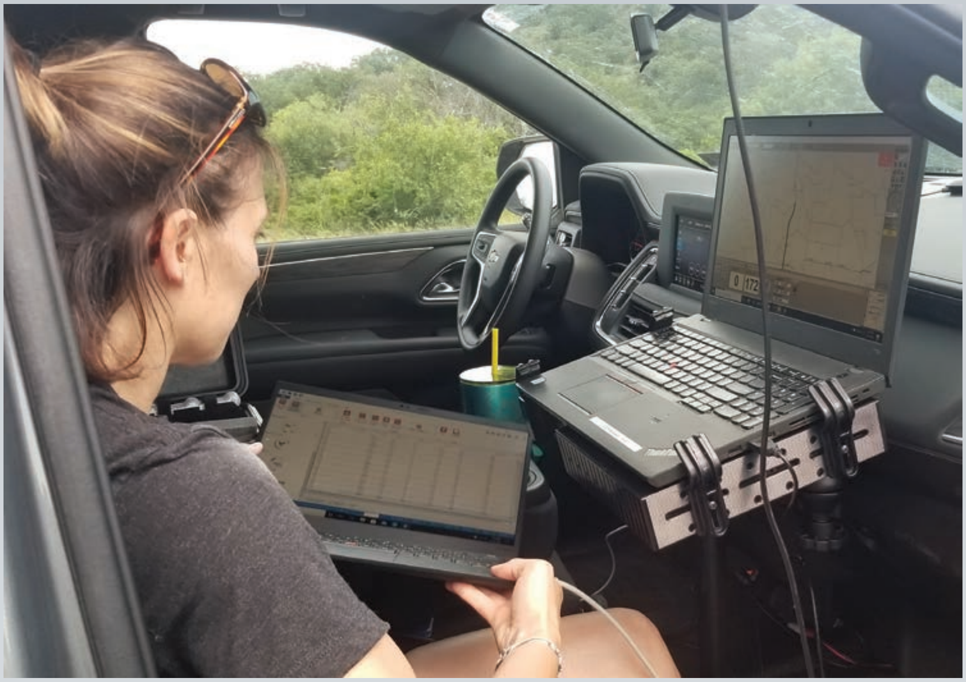
The ability to seek answers to questions that could take an entire career is what drove Lombardo to academia. And doing so surrounded by experts at a top-ranked university for meteorology and atmospheric science is what drove her to Penn State.

"Having the intellectual freedom to go in any direction that your curiosity takes you is very profound," Lombardo said. "I know that I'm very fortunate to have that flexibility and freedom. Of course, there's the constraint of funding. But if something interests me, I'm able to figure out a way to explore it, which is pretty amazing. It's remarkable."

She's also surrounded by those chasing the same goals and with the same mindset.

As she utilizes resources available at Penn State and identifies collaborations within the department, she finds herself surrounded by others who dared to ask questions that take decades to solve. It's science on a scale not often rewarded in the private sector.

"We have deliverables, but they're very different from what a private industry deliverable is," Lombardo said. "I definitely feel fortunate that we get to just ask whatever questions we want to ask and then go down that particular path." ⌘



Above photo: Kelly Lombardo, associate professor of meteorology and atmospheric science, working on her laptop in the field looking at data as it is being received.

Lower photo: Lombardo and her husband, Matthew Kumjian, associate professor of meteorology, doing final check before launching weather balloon.

A NEW GLASS FOR THE FUTURE: TAKING LIONGLASS OUT OF THE LAB AND INTO THE MARKET

The science of inventing and commercializing a glass with ten times the crack resistance and half the carbon footprint of standard glass

by Adrienne Berard

One of the few things scientists know for certain about glass is that its atomic structure is chaos. Neither liquid nor solid, glass is its own phase—a material somewhere between these two states of matter—that owes its existence to the way it is formed.

Glass is made by heating a mixture of materials to molten temperatures and then quickly cooling the scorching hot liquid, a process called “quenching.” Such a rapid transition doesn’t give the atoms enough time or energy to arrange themselves into the highly organized lattice-like structures of solid matter. Instead, they remain disordered, like molecules in a flowing liquid, but frozen in place, rigid like a solid.

LionGlass is at least 10 times as crack resistant as standard soda lime glass and has about half of the carbon footprint

“In many ways, glass is a state of matter all its own,” said John Mauro, Dorothy Pate Enright Professor of Materials Science and Engineering at Penn State. “Any liquid can form a glass if it’s cooled rapidly enough. You can make glass out of water. In fact, physicists believe that most of the water in the universe is probably in glassy form. In movies, they use glass made from sugars for breakable windows, and there are dozens of glasses made from metallic alloys. Anything that can be liquefied can be brought into the glassy state if quenched fast enough to avoid crystallization.”

What the average person thinks of when they picture glass is silica or soda lime silicate glass, Mauro explained. It is the common glass used in everyday items from windows to glass tableware, and it’s made by melting three primary materials: quartz sand, soda ash, and limestone.

(Left photo - Left to right) Julia Chen, an undergraduate in materials science and engineering, John Mauro, Dorothy Pate Enright Professor of Materials Science and Engineering, and Nick Clark, a postdoctoral fellow in Mauro’s lab.

But soda lime silicate glass is just one small family in a long lineage of glass—and only a fraction of those are made by humans. Naturally occurring glass like obsidian exists at volcanic sites around the world. Glass has been discovered within impact craters on Mars. A single-celled algae known as a diatom produces beautifully intricate silica glass shells.

“Glass has been here far longer than we have,” Mauro said. “Since prehistoric times, humans have been using it as a tool—and that tool continues to shape civilization today.”

Time for a change

The recipe for silicate glass has been used for thousands of years. Silicate glass beads appeared in Mesopotamia over 5,000 years ago. Mauro said that’s likely because the composition is made from three of the most abundant minerals on Earth.

“The components are readily available and, if you get the right ratios, they melt nicely and form a durable glass,” Mauro said. “Historically, that mixture has been the basis for humanmade glasses. It’s used for windows and windshields, jars, and the cups you drink from. The composition for common glass hasn’t changed in decades, or even millennia, but we are about to change that.”

Mauro and a team of students and scientists have invented and engineered an entirely new family of glass, called LionGlass, that requires significantly less energy to produce and is much more damage resistant than standard soda lime silicate glass. Unlike other humanmade glasses, the composition for LionGlass is not based on the age-old mixture of quartz sand, soda ash, and limestone.

But the bulk of the carbon emissions come from the energy required to heat furnaces to the high temperatures needed for melting glass—around

2,700 degrees Fahrenheit or 1,480 Celsius. With LionGlass, the melting temperatures are lowered by about 300 to 400 degrees Celsius, Mauro explained, which leads to a roughly 30 percent reduction in energy consumption compared to conventional soda lime glass.

Worldwide, glass manufacturing produces at least 86 million tons of carbon dioxide every year. LionGlass, made without carbon-based materials and at a lower melting point, promises to cut this carbon footprint in half, Mauro said.

"Our goal is to make glass manufacturing sustainable now and for the future," Mauro said. "LionGlass works toward that goal on two fronts. It doesn't have any carbon-containing batch materials, and it significantly lowers the melting temperature of glass."

"Our goal is to make glass manufacturing sustainable now and for the future."

~John Mauro

Mauro recently filed a patent application as a first step toward bringing the product, named after Penn State's Nittany Lion mascot, to market. Its specific recipe is protected information until the patent process is finalized.

The motivating factor for finding a new formula for standard glass was reducing carbon emissions, Mauro said. Soda ash is sodium carbonate and limestone, calcium carbonate, both of which release carbon dioxide, a heat-trapping greenhouse gas. During the glass melting process, the carbonates decompose into oxides and produce carbon dioxide, which gets released into the atmosphere, Mauro explained.

Reflection of progress

Glass has played an integral role in the advancement of industry, arts and culture.

"It has been critical in bringing modern civilization to where it is today," Mauro said. "Consider how often we use glass screens, and data are fed to those devices through thin strands of glass fiber optics. We're sitting in buildings with natural sunlight coming through windows. Even vaccines we've taken to stay healthy have been stored and transported to us in strong, chemically resistant glass packaging. All of this is made possible by glass."

Yet despite its many centuries of use, scientists still don't have a clear understanding of how glass works at the atomic level. Glass falls into a category of matter called a non-crystalline substance, which includes other materials ubiquitous in daily life like plastics, rubber, gels and tar. Its atomic arrangement is more like liquid, but it behaves like a solid, despite the fact that it lacks the crystalline atomic structure common in solids. This juxtaposition makes it difficult to capture glass atoms in action—and it is what makes glass such an elusive material.

"A deeper understanding of the non-crystalline structure of glass could revolutionize technology in the coming years," Mauro said. "Glass is atomically disordered and it's always changing, so no two parts of a piece of glass are the same. Whether it is strength, color or conductivity, every tiny section of glass has its own properties."

Mauro and his team have developed a research theme they are calling "decoding the glass genome" to better predict how a piece of glass behaves, and they plan to eventually quantify and manipulate the ever-changing atomic structure of glass.

They are using modeling and artificial intelligence to help design and understand new compositions, combining the fundamental physics of glass with machine learning to aid in the design of new glasses with improved properties.

"There are so many global challenges that the world is facing, with respect to environmental issues, renewable energy, energy efficiency, health care, and supporting urban development," Mauro said. "Glass plays a critical role in all of those areas."

To market, to market

When it comes to LionGlass, the team is now taking its cues from industry. Since announcing the discovery in July, the lab has built partnerships with corporations around the globe, including major glass manufacturers and customers of the glass industry. Mauro and a team of Penn State students are now working with industry to test the limits of

LionGlass to see how it can be used in the real world.

"Rather than thinking of LionGlass as a specific composition, what we've patented is an entire family of glass," Mauro said. "That means we are exploring the properties of a great range of compositions within that family—and maybe even discovering adjacent families."

Nick Clark, a postdoctoral fellow in Mauro's lab, is leading the team's efforts to better understand the real-world applications of LionGlass. Clark began his research career as an undergraduate in Mauro's lab nearly a decade ago. He's been witness to the entire invention process for LionGlass and is now navigating its transition from a basic scientific discovery to an applied product for everyday use.

"It's been amazing to go from seeing its genesis to testing its practical uses," Clark said. "And, to be clear, we are still in the discovery phase. We are setting the processing conditions and finding compositions and discovering applications for those compositions. It's thrilling to see what LionGlass can do."

Clark has already discovered one thing LionGlass won't do: crack under pressure. It turns out that LionGlass is not only easier on the environment, it's also much stronger than conventional glass. Clark said he was surprised to find that LionGlass possesses significantly higher crack resistance compared to standard glass.

In fact, some of his LionGlass compositions had such a strong crack resistance that the glass would not crack, even under a one kilogram-force load from a Vickers diamond indenter, a scientific instrument used to determine the toughness of materials.


Julia Chen, an undergraduate student in materials science and engineering, places a sample of LionGlass in the annealer in Mauro's lab.

"We kept increasing the weight on LionGlass until we reached the maximum load the equipment will allow," Clark said. "It simply wouldn't crack."

An unbreakable breakthrough

When he crunched the numbers, Clark discovered that LionGlass is at least 10 times as crack resistant as standard soda lime glass, which forms cracks under a load of about 0.1 kilograms force. He added that the limits of LionGlass's crack resistance have not yet been found because they reached the maximum load allowed by the indentation equipment.

"This discovery is very good, because crack resistance is an indicator of long-term mechanical performance," Clark said. "Microcracks and scratches are what cause weak points in glass and eventually cause it to fail. When a piece of glass breaks, it's normally due to these existing microcracks, so if LionGlass is resistant to getting those cracks, it makes for a much stronger material."

Mauro added that stronger glass also means thinner glass, which is more good news for the environment, because LionGlass has the potential to be ten times lighter than conventional glass, requiring far fewer emissions to transport. Clark said he expects to uncover more useful attributes of LionGlass as he works with corporations to test how the material behaves within a range of environments and stressors.

"We're still kind of exploring," Clark said. "We're looking at different problems and seeing what changes and if we have any more surprises out there."

Clark is currently in the process of exposing various compositions of LionGlass to an array of chemical environments to study how it reacts. Soda and wine bottles, for example, have to withstand a highly acidic chemical environment, so he's testing how LionGlass reacts against a variety of pH levels. Windows need to withstand corrosion caused by a wide range of physical and chemical stress, so he's developed a range of experiments to test durability.

"We're at a stage where we are merging the requirements of industry with our own scientific inquiry," Mauro said. "It's a fascinating space to operate in—and one that is especially exciting for students."

Clark regularly interacts with corporate partners to design and tailor experiments to collect data based on the ultimate intended use for the glass. This summer, he was joined by Julia Chen, a Penn State undergraduate materials science and engineering major.

"Because the composition is still in its infancy stage, we did not know too many properties of LionGlass, so we spent the summer conducting experiments to determine them," Chen said.

They conducted chemical durability tests to see how LionGlass would dissolve in water over time and at certain temperatures; measured its hardness and crack resistance; and analyzed the ions released as it dissolved in water. A third-year student, Chen recently joined Penn State's Schreyer Honors College and will be writing her honors thesis on LionGlass. She said she plans to give presentations on sustainability in industry at a variety of conferences this year.

Clark said working with industry has not only increased the lab's professional network; it has generated new avenues of inquiry, taking him to unexpected places in his research.

"What's amazing is I can have an idea for a new composition in my office, walk downstairs to the furnace and create the glass, then head over to our lab and test it, then walk across campus and characterize it," Clark said. "This is all in one day—and only possible in a place like Penn State, where you have what you need to take an idea and make it an invention." ⌘

Hands-on experience: Undergraduate at the forefront of 'cutting-edge innovation'

When Julia Chen, a junior Schreyer Scholar studying materials science and engineering, first joined the Penn State glass research group, she thought she'd have the opportunity to learn a bit about the industry, receive mentorship from experts in the field and learn the art of glassblowing. Little did she know that she'd end up helping to lead research in LionGlass that could make a global impact.

Chen is leading experiments to test the mechanical properties of LionGlass, such as hardness and crack resistance, and conducting chemical durability tests to observe how it dissolves in water over time.

Read full story online at http://tinyurl.com/ycypt585

To Bennu and Back

Bennu asteroid samples may hold clues to the origins the life on Earth

by Matthew Carroll

A group of scientists huddled around a television screen and anxiously watched the live coverage as an object from space streaked through Earth's atmosphere. This wasn't a scene from a disaster movie, but the drama grew as the object sped closer to the Utah desert floor. Then, a parachute opened. And 2,000 miles away, Kate Freeman could breathe.

"We have a rock," said Freeman, Evan Pugh University Professor of Geosciences, amid cheers from colleagues, students, family, and friends gathered in her State College home on a rainy Sunday morning in September.

Floating safely to the ground just west of Salt Lake City was a capsule containing rocks and dust from space—pieces of the asteroid Bennu that may carry clues about the formation of the solar system—and potentially of life on Earth.

The capsule's return in September marked the end of a dramatic chapter for NASA's Origins, Spectral Interpretation, Resource Identification, and Security,-Regolith Explorer, or OSIRIS-Rex, mission.

OSIRIS-Rex launched in 2016, reached Bennu in 2018, collected samples in 2020, and returned the rubble to Earth to the waiting arms of scientists like Freeman, Christopher House, professor of geosciences, and Allison Baczynski, assistant research professor of geosciences at Penn State.

The trio were among a select group of scientists picked to receive a small portion of the asteroid for study. At Penn State, they will analyze the stable isotopes in organic matter and organic molecules found in the samples.

Asteroids are like time capsules, the scientists said, preserving the earliest history of our solar system and chemical signatures of the ancestral building blocks of life. And Bennu is rich in carbon, making it an ideal specimen for this work, the researchers said.

"These are very exciting samples because they are exotic – from very far away," Freeman said. "And we think they contain signatures from before

Above photo: An artist's conception of NASA's OSIRIS-REx spacecraft collecting a sample from the asteroid Bennu
NASA/Goddard/University of Arizona

the solar system was formed and from stuff that happened after. Untangling those two threads is something we as geoscientists are very interested in."

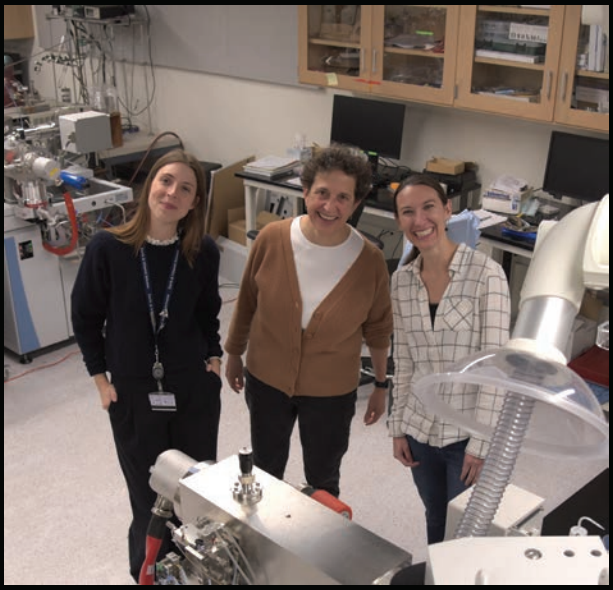
A Spoonful of Asteroid

When collecting your sample requires traveling 200 million miles from Earth and landing on an object about as wide as the Empire State Building, you take what you can get.

For researchers on the OSIRIS-Rex project, that might mean receiving as little as two grams of Bennu material, about the size of a sugar packet.

That's just fine for the Penn State researchers, who have spent parts of their careers developing ever more sensitive equipment that can do more with less material.

"Even just within the arc of my career, I've done a lot of instrument development work, funded by NASA, thinking 'oh, this might be useful for a sample return someday,'" Freeman said. "And now we're using those exact instruments for this project. That's pretty satisfying."



Ophélie Mcintosh, a postdoctoral scholar in the Freeman Lab, Kate Freeman, Evan Pugh University Professor of Geosciences, and Allison Baczynski, assistant research professor in geosciences, in the Peter Deines Isotope Mass Spectrometry Laboratory

Freeman and Baczynski have developed high-precision instruments to analyze isotopes within a wide array of molecules and minerals – equipment that is housed in the Peter Deines Isotope Mass Spectrometry Laboratory in the recently renovated basement of the Deike Building.

Isotopes are atoms of the same element that differ slightly in mass due to having different numbers of neutrons in their nucleus. Certain physical or chemical processes may favor one isotope over another. Living things, for example, use a specific carbon isotope, and analyzing molecules can therefore provide clues on whether a sample's origin is biotic or abiotic – made by living organisms or left behind by things like water or atmosphere.

With their equipment, supported by the NASA-funded Astrobiology Center for Isotopologue Research, the team can measure isotopes at specific locations within molecules, giving clues to how molecules were synthesized.

"That can tell you a little bit about if it's biotic versus abiotic – or if we've acquired any sort of terrestrial contamination or not," Baczynski said. "The isotopes will hopefully give us some insight into where this organic matter that's present on this asteroid came from and at what point in the development of the solar system it emerged."

Ancient Earth and Beyond

While much of her time this fall has been spent getting the laboratory ready for when Penn State receives its Bennu samples, Baczynski's mind has not always been on asteroids and space.

As a doctoral student, she studied molecular fossils from the Bighorn Basin in Wyoming that capture the Paleocene-Eocene Thermal Maximum (PETM), a global warming event 55.5 million years ago that's considered the best analogue for modern climate change.

Molecules left behind from the waxy coating on leaves that fell and became preserved in the rock record hold clues about the conditions ancient trees experienced—the water they took in and the carbon dioxide they breathed from the atmosphere. But the molecules were not in high enough concentrations in the rock record to measure specific biomarkers.

"This particular event I was studying was really lean in terms of organics," Baczynski said. "We were running up against the limits of our instrumentation. So when I came to Penn State, I was working to lower the detection limits of these instruments. Because even on Earth, with terrestrial fossils, we were sample limited."

Baczynski spent parts of four years improving the sensitivity of the equipment by two orders of magnitude, and using that tool, led research that collected the first biomarker record of the PETM from terrestrial core samples.

"And having these tools ended up being interesting to NASA and other places who were saying, 'you know, when we send a spacecraft out and bring a sample back we are also sample limited,'" Baczynski said. "And so we thought we could bring a lot to the mission by having these analytical instruments. And clearly, they thought so too. And that's really exciting."

A teenager's bedroom

Though it took the OSIRIS-REx spacecraft two years to first reach Bennu, the asteroid is actually considered a close neighbor of Earth. Passing near our planet about every six years, it is among a group of near-Earth asteroids that pose a slight risk of someday crashing into us.

"One thing that surprised me when I got involved in this project was how many of these asteroids there are out there," Freeman said. "It kind of looks like a kid's bedroom in adolescence. There's a lot of stuff on the floor."

Asteroids like Bennu may be remnants of the early solar system, which formed from the solar nebula—a hot disk of gas and dust—like hydrogen—that surrounded the early sun.

"You start to condense out from the gas, dusts and grains that ultimately build up to rocks and then into small bodies which are called planetesimals," said Christopher House, director of Penn State's Planetary System Science Center. "That generates what we call primitive material."

According to NASA, scientists think Bennu's present-day composition was already established within ten million years of the solar system's formation—meaning it may have spent the last 4.5 billion years floating though space, not affected by the same processes happening on, for example, Earth.

"So that's the idea—that Bennu is sort of sampling this time period in the early part of the formation of the solar system and it carries organics in it that reflect some interstellar material as well as material processed in the early history of the solar system," Freeman said.

In conducting initial tests of the Bennu samples, NASA scientists found evidence of high carbon content and water, considered building blocks of life on Earth that could offer new clues into how these materials were distributed in the early solar system.

"When we're studying prebiotic chemistry, we are asking where does life come from. It comes from some

organic goo that had an energy source—it started with a set of processes that eventually led to life," Freeman said.

But what were those chemicals? What was in the primordial soup to begin with and how were those ingredients shaped by their history in the solar system?

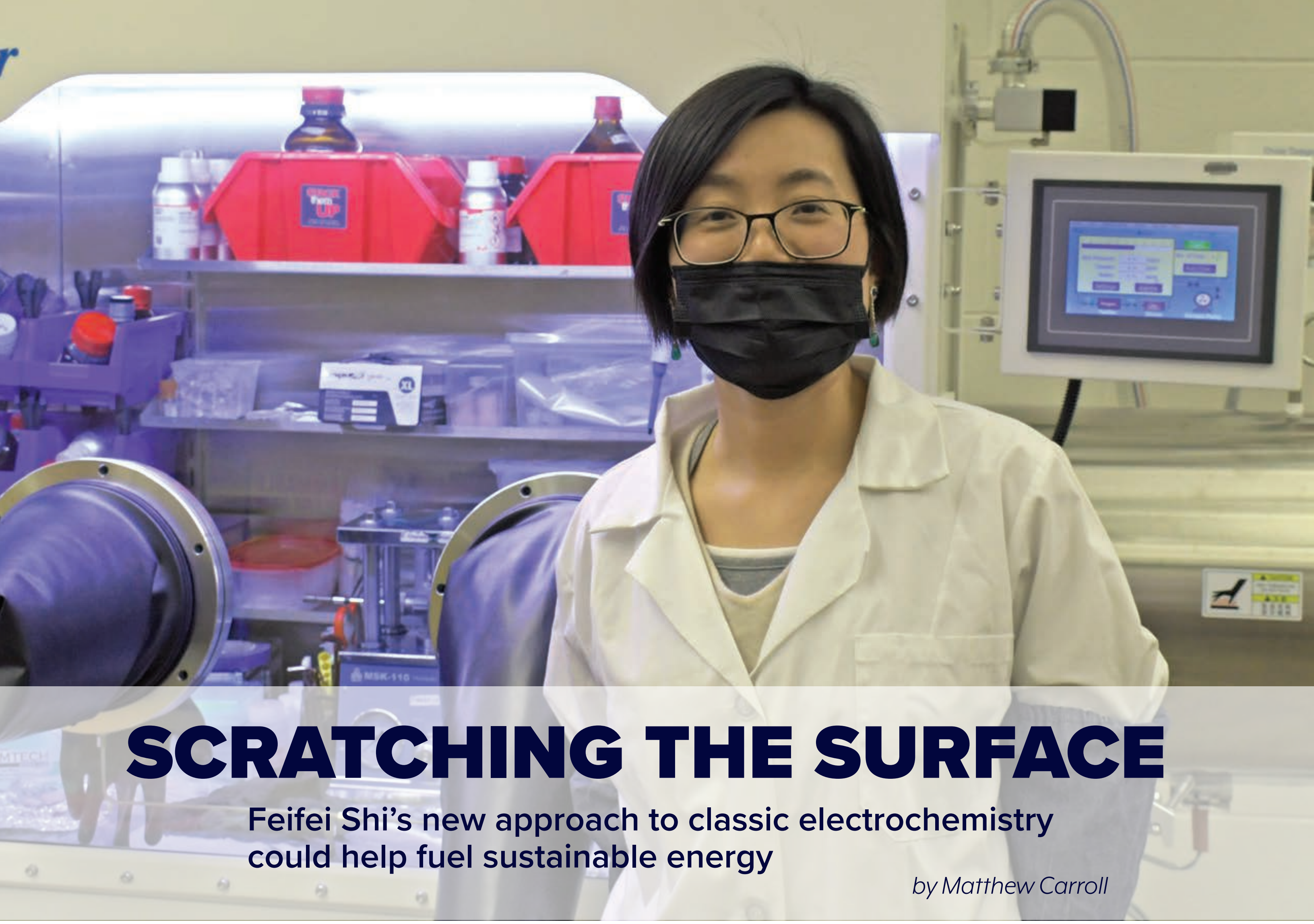
"Those are kind of a core questions," Freeman said. "And this asteroid is a look back in time, because it was formed early in the solar system history, and then hasn't had a lot of planetary process altering it since then. And so it's a way to kind of get back to the early inventory, and grocery store that led to primordial soup." ⌘

Top photo: Sample return capsule from NASA's OSIRIS-REx mission shortly after touching down in the desert, on Sept. 24, 2023, at the Department of Defense's Utah Test and Training Range.

NASA/Keegan Barber

Lower photo: NASA curation team members along with Lockheed Martin recovery specialists look on after the successful removal of the sample return canister lid.

NASA/Robert Markowitz



SCRATCHING THE SURFACE

Feifei Shi's new approach to classic electrochemistry could help fuel sustainable energy

by Matthew Carroll

Whether she is researching ways to improve the lithium-ion batteries that power our laptops, smartphones, and electric vehicles, or investigating corrosive damage caused by molten salt in nuclear salt reactors, Feifei Shi finds herself stuck at the surface.

Shi, an assistant professor of energy engineering in the John and Willie Leone Family Department of Energy and Mineral Engineering, is rethinking electrochemical models that describe what happens at the interface between two substances where an electrical field exists.

Her work could someday help improve how long our smartphone batteries last, or how far our electrical vehicles can travel, and how safe they are.

"This is a very established topic—a lot of great scientists have worked in the area, and it's one of the first things our students learn about it in textbooks," Shi said. "Something I've realized is the most common topic can be the most difficult. Because everyone is so familiar with it, introducing something new can be a big challenge."

Solids and the surface

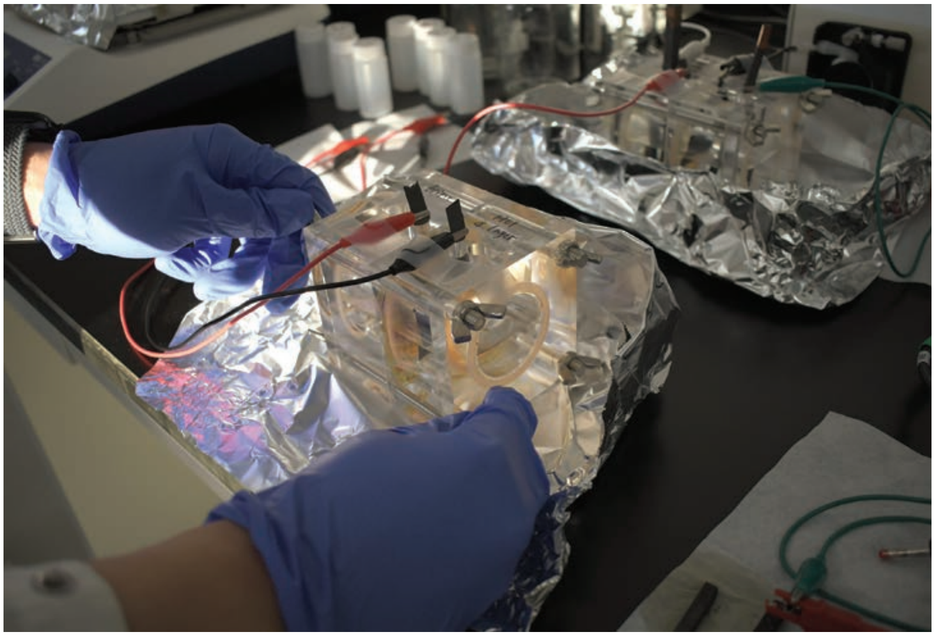
Interactions at the surfaces of materials are notoriously difficult to predict. Just ask Wolfgang Pauli, the Austrian theoretical physicist, pioneer of quantum physics and Nobel prize winner, who notably said, 'God made solids, but surfaces were the work of the devil.'

"People may realize the bulk is easy to predict," Shi said. "But at the surface, it's much different and unpredictable. Unless you do the experiment, you never know how it will go."

This is in part because of the electrical double layer (EDL), the physical phenomena that occurs at the interface between electrolyte and electrode causing a heterogeneous interfacial layer.

The EDL is the most important part of any electrochemical

Above photo: Feifei Shi, assistant professor of energy engineering, in her laboratory.



This equipment, called an electrolyzer, allows researchers in Shi's lab to harvest lithium out of artificial brines.

system because it is where the electron transfer and ion diffusion occur.

"Lithium-ion batteries, fuel cells, and electrochemical catalysis all have these solid-liquid interfaces," Shi said. "Almost all electrochemical devices are greatly influenced by the double layer structures. It's a core tenant or the holy grail for electrochemistry science."

Lithium-ion batteries, for example, traditionally have solid positive and negative electrodes and then a gel or liquid electrolyte solution. The electrolytes contain ions that allow electrons to move back and forth between the ends of the battery, generating power.

Initial models of the EDL were created for dilute salt in aqueous solutions in the early 1900s and today are one of the first concepts students may learn when studying electrochemistry. But those classical models may not work when considering the organic electrolytes in lithium-ion ion batteries, Shi said.

A better understanding of these the ions and how to harness them may help produce higher power and more efficient batteries and other devices, something that's particularly important as countries look to move away from fossil fuels and the carbon dioxide they emit into the atmosphere.

In battery applications, the EDL significantly impacts performance. However, the fundamental knowledge of EDL in batteries is still lacking.

"The key is, how well do we understand the double layer," Shi said. "If we have a better understanding, we may be able to expend limited resources and reap a big reward."

Better batteries

Improvements to lithium-ion batteries have helped revolutionize our daily lives—powering our technology and providing new solutions for energy storage that could help mitigate climate change.

"Today, electrochemical power sources like lithium-ion batteries, fuel cells, and supercapacitors are critical for developing alternatives to fossil fuels and mitigating the impacts of climate change," Shi said.

Hanrui Zhang, a graduate student in Shi's lab, tests the cycling performance of coin cell batteries.

Globally, marketing analysts expect the lithium-ion battery market to grow from $65.9 billion in 2021 to $273.8 billion by 2030. But even as it continues to grow, the industry is hitting obstacles to keep pace with the increasing demand due to the lack of improvements in fundamental battery technology.

Shi recently received a $594,788 Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF) to tackle the problem.

"This is a challenge but improving battery technology is a worthy goal," Shi said. "We have developed our own experimental tools that marry interfacial energy variation with customized in-situ spectroscopy measurements. We would like to combine classical thermodynamic measurements with vibration spectroscopy measurements to have a comprehensive view of properties and structure."

Shi's team has developed new methods to help describe EDL properties by using mercury as an electrode. Mercury's unique properties make it an affordable and easy way to observe and characterize the EDL.

"My ultimate goal is to push the boundary of surface science and electrochemistry," she said.

Sustainability through electrochemistry

Chemistry—it seems—chose Shi and not the other way around. Her mother earned a doctorate in the field and Shi displayed a keen interest from a young age.

Pursing a bachelor's degree in chemistry from Fudan University in China, Shi's first project as a second-year student involved fuel-cell catalysis—a type of electrochemistry.

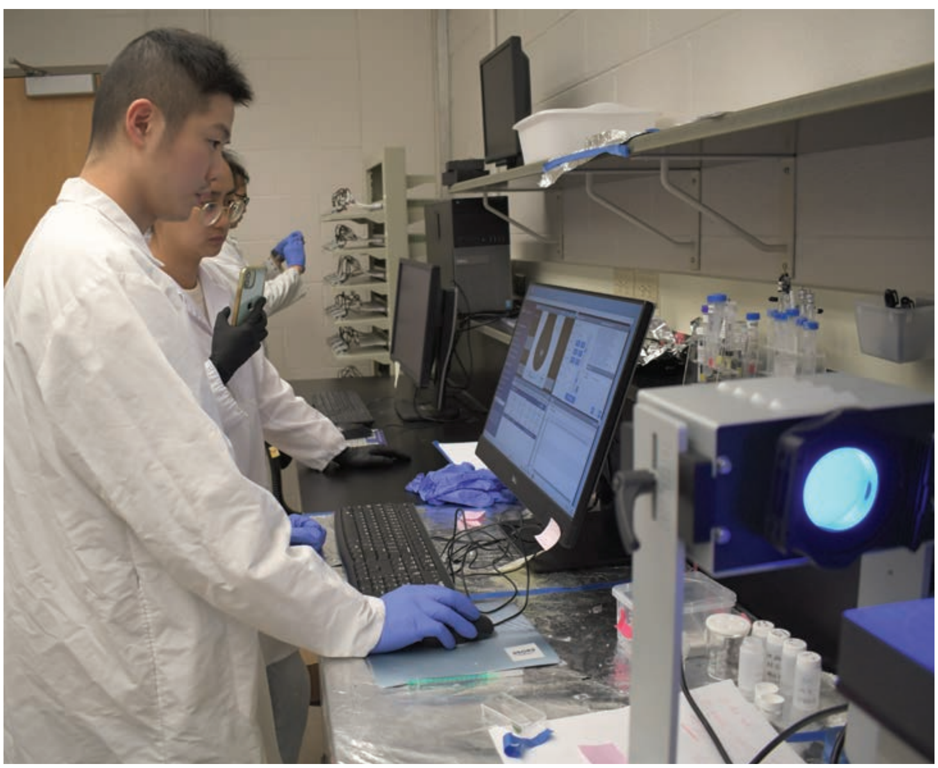
"I felt like it was magic," Shi said. "In traditional chemistry we have to heat things up hundreds to a thousand degrees Celusis to make interesting things happen. But if you apply electricity and just give it several volts, it kicks off reactions. And you save a whole lot of energy."

After graduating, Shi came to the United States to pursue her doctorate in mechanical engineering at the University of California, Berkeley. There she began working on lithium batteries for electric vehicles through the Department of Energy's Vehicle Technologies Office and has continued working to improve batteries ever since.

Today, her work includes efforts with the Battery500 project, a team of scientists from national laboratories, academia, and industry working to develop more reliable, high performing, safe, and less expensive batteries for electric vehicles.

She also works with colleagues in the department to develop new ways to extract critical minerals like lithium needed for battery technology in economical and environmentally friendly ways.

"I'm interested in applying my knowledge of electrochemistry to mining and to help make a lot of processes like extraction more energy efficient and to reduce the environmental impacts," Shi said. "My colleagues are the right partners to help achieve these goals." ⌘



Lingzi Meng (middle) and Jianwei Lai (right), doctoral candidates at Penn State, use equipment to measure interfacial energy.

Geographers add dimension to pressing global problems

by David Kubarek

Left to right: Louisa Holmes, assistant professor of geography and demography, Emily Rosenman, assistant professor of geography, and Kimberly Van Meter, assistant professor of geography.

Geography. It's the assignment of time and place to an infinite number of things. For many geographers, the field is the vehicle that drives research passions, from public health to environmental protection to financial instruments that have a massive grip on real lives.

Name your passion, and geography offers a better way to understand it and to effect change.

A trio of geographers in the College of Earth and Mineral Sciences—Louisa Holmes, Emily Rosenman, and Kim Van Meter—are doing just that.

Kimberly Van Meter

Van Meter's work explores how human interactions have a cumulative effect on water quality, particularly wetlands. Her research is most notable in the Chesapeake Bay Watershed restoration effort.

It's a process that plays out on longer timescales. Things we do today, positive or negative, don't often have immediate results. That means two things, Van Meter said: "Our restoration efforts will take time, and we don't have a lot of time to waste."

"Things we see entering coastal wetlands today aren't necessarily related to what we did today or this year; it may be a function of what we've done for the past five, ten, or fifty years," said Van Meter, who is an assistant professor of geography. "Understanding those legacy effects is important. One of the downsides is realizing that there aren't a lot of quick fixes."

Van Meter said wetlands are important for myriad reasons. They are a necessary habitat for diverse plants and wildlife, they help with flooding, they filter our drinking water, and they sequester and store carbon, lessening the effects of climate change.

The relevance of her work is shown in the diversity of her research funding sources, which include NASA, the National Science Foundation, and the U.S. Department of Agriculture.

Using an interdisciplinary team of researchers at Penn State and beyond, Van Meter wants to get a better idea of these earth systems and which levers pull what. By better understanding these forces, she hopes to spotlight how changes produce both tradeoffs and synergies. That could also show the value of conservation, cleanup efforts, and more sustainable farming methods.

Understanding what's happening is the first step to finding solutions.

"That's something that the government agencies are really keen to want to understand so they know how best to incentivize restoration and conservation programs," Van Meter said. "It allows them to create a blueprint for restoration that gives us the best bang for our buck."

Louisa Holmes

Holmes, an assistant professor of geography and demography, is a health geographer and demographer with a background in public health and public policy. Her passion is using geography to shine a light on pressing public health issues such as the opioid crisis. Holmes looks at opioid deaths and how public policy—things like access to Narcan and treatment centers—can lead to fewer lives lost.

As part of the National Opioid Settlement, Pennsylvania will receive more than $1 billion, which includes funding for research. Holmes is part of an interdisciplinary team of researchers looking at ways to effectively distribute those funds.

Pennsylvania communities are working to address substance related issues across the Commonwealth. Holmes is part of the Elevate Pennsylvania Initiative, which is designed to maximize the impact of these efforts by sharing knowledge and resources, conducting research and evaluations, and coordinating projects to improve community health and safety outcomes. The number of drug related overdose deaths in Pennsylvania has increased 236 percent since 2012, with about 84 percent of the state's 5,044 deaths in 2022 being attributed to opioids, according to Open Data Pennsylvania.

One of the goals of the research is to shed light on corporate strategies to develop counterstrategies for opioid intervention. Holmes and her colleagues are also looking at the Johns Hopkins-UCSF Opioid Industry Documents Archive, a trove of insider documents gleaned from court filings to piece together how the industry targeted new areas for opioid consumer growth. It's a strategy borrowed from Truth Tobacco Industry Documents, produced amid the massive Master Tobacco Agreement settlement decades ago.

In one of many strategies found in the documents, drugmaker Purdue Pharma sought to target women who just received Cesarean sections for prescription pain medications. These areas for expansion, according to the documents, were called "innovative contracts." Others targeted women in general, who Holmes said have been statistically less likely to succumb to opioid overdose, or certain ethnic groups.

"We're interested in interrogating these documents from both a public health and financial standpoint," Holmes said. "We want to evaluate some of the strategies that pharmaceutical companies used to target certain populations and certain geographies to lay out a roadmap for some of the settlement activity while shedding some daylight on some of the practices of corporations responsible for the opioid crisis."

"Geography has totally reprogrammed my brain. That's why I think this field is so magical, and why I also really like teaching it. You can expose people to new ways of thinking and analyzing the world."

~Emily Rosenman

Emily Rosenman

Rosenman, assistant professor of geography, got her start in the financial world right around the time of the 2008 financial collapse. After earning her bachelor's degree in 2006, she worked for a time for a company tasked with helping to fund the rebuilding of New Orleans after Hurricane Katrina.

The urban and economic geographer turned what she had learned on the job to research in graduate school at the University of British Columbia, studying how financial instruments could create such stark winners and losers in the rebuilding process.

"As I was researching the reconstruction efforts post-Hurricane Katrina, so many geographic questions began to emerge: Why do some neighborhoods get rebuilt with huge public support and funds whereas other neighborhoods get nothing?" Rosenman said. "These really are very fundamental questions about inequality and the way that society works, and they were questions I was never able to ask outside of the field of geography."

In her research, Rosenman wants to know how financial decisions can have winners and losers and desirable and undesirable outcomes, particularly for marginalized groups. For example, if policy is made to promote home mortgages—assets being a critical component to upward mobility—does it lead to more homes being sold to disadvantaged groups, or does it simply increase the gap between the haves and have nots?

Rosenman's research also adds accountability to policies and financial backers. If companies are lending in the name of helping to promote upward mobility, her research can add accountability to those claims.

Not having a traditional financial background, Rosenman said, is a feature, not a bug.

"A lot of people who work in the realm of financial geography do not come from an economics background. And I think that's our secret power," Rosenman said. "We look at these systems and we can immediately see what doesn't make sense. This viewpoint can lead to some very interesting and basic questions such as: What was served by these different systems? Who's taking risks? Who's ultimately benefiting from these decisions and policies?"

That superpower, Rosenman said, is why geographers are capable of adding insight to just about any area of study. It's a different way of thinking, a different way of illuminating and resolving a problem.

"Geography has totally reprogrammed my brain," Rosenman said. "That's why I think this field is so magical, and why I also really like teaching it. You can expose people to new ways of thinking and analyzing the world." ⌘

Documentary film on institute's history showcases college's impact on research

The documentary film, "ESSC made EESI," showcases the pioneering research and impact of the Earth Systems Science Institute, which began in 1986 as the Earth System Science Center (ESSC).

"This film tries to document the arc of development of Earth and environmental sciences in the College of Earth and Mineral Sciences," said Susan Brantley, Barnes Professor of Geosciences and Evan Pugh University Professor of Geosciences. "The ESSC, and now EESI, model is for faculty funding to come from a home department as well as an interdisciplinary University center. In this regard, like so many other activities, EESI was the initiator of an idea that went campuswide."

The vision for ESSC began in the early 1980s. Recognizing the need to study the Earth as a whole system, the goal was to bring together faculty from different disciplines to collaborate on systems-level interdisciplinary research in earth system science.

"From the start, ESSC was conceived as a center that would take a holistic and interdisciplinary approach to studying the Earth as a system," said Alan Taylor, professor of geography and ecology and director of the documentary. "A focus on building interdisciplinary research was uncommon back in the 1980s when ESSC was established, and the college developed a clever approach to get buy-in from departments. Positions were co-funded between ESSC and departments, and this brought in exceptional faculty to departments that might not have hired this kind of scholar on their own. This expanded the scope of earth sciences-related research across departments and the co-funding model is now common in research institutes across Penn State." http://tinyurl.com/4jbxf922 Watch documentary online at http://tinyurl.com/43awb59n

Celebration held to honor former dean and director, William Ewart Easterling III

Penn State's College of Earth and Mineral Sciences and the Department of Geography hosted a celebration to honor William Easterling's legacy of leadership to the University. More than one hundred faculty, staff, and former colleagues and students gathered on Nov. 9 at the Penn Stater Hotel and Conference Center to pay tribute to his extraordinary career and accomplishments.

"I think, what I'll miss more than anything and a thread that went through my years as a college administrator, and as a science administrator for the NSF as well, is working with really smart, dedicated, interesting colleagues, and helping create opportunities for them," Easterling said. "At the end of the day, the most rewarding part of your time as a leader is creating opportunities."

Easterling served the University for twenty-six years. He joined the Penn State faculty in 1997 as an associate professor of geography and earth system science. In 2001, he became the founding director of the Institutes of Energy and the Environment, the focal point for interdisciplinary research in energy and environmental science and engineering at Penn State.

In 2007, he was appointed dean of EMS and held that post until 2017 when he was appointed assistant director of the National Science Foundation in charge of the Geosciences Directorate, which supports fundamental research spanning the atmospheric, earth, ocean, and polar sciences.

After serving at the NSF for four years, Easterling resumed his appointment as professor of geography and earth system science on June 1, 2021. He retired earlier in 2023 and is now professor emeritus of geography and dean emeritus of the College of Earth and Mineral Sciences.

"Bill has been especially effective as an ambassador for Penn State and the College of Earth and Mineral Sciences on the national and international scene, as IEE director, EMS dean, and assistant director for the Geosciences Directorate at NSF," said Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences. "That representation continues through his retirement as a dean emeritus as he facilitates connections with his vast STEM leadership network, for me and for others in academic leadership positions."

http://tinyurl.com/498uphma

Top photo: Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences, presented Bill Easterling, professor emeritus of geography and dean emeritus of the College of Earth and Mineral Sciences, with an etching from the Penn State Elms Collection at the celebration of his retirement on Nov. 9.

Above photo: Easterling holding etching of Old Main and the Obelisk.

New name: John A. Dutton Institute for Teaching and Learning Excellence

The John A. Dutton e-Education Institute changed its name to the John A. Dutton Institute for Teaching and Learning Excellence. The institute was originally founded in 2000 as the e-Education Institute to help faculty develop cutting-edge, online educational resources. It was renamed in honor of John A. Dutton, former dean of the college, who had the vision of creating an institute focused on developing the best online courses possible.

"In 2000, when the institute was founded, using the hyphenated e-Education was a great way to describe online education because it was new and different," said Director Ann Taylor. "Now, the term has become outdated. We don't need to differentiate between residential, hybrid, and online; it's all education; it's all teaching. We did not want to lose the John A. Dutton part of the name—we are very proud of being named in our former dean and champion's honor—but we wanted a name that would better reflect what we do. Teaching and learning excellence immediately surfaced as a way to capture our philosophy and mission." http://tinyurl.com/mrye7pvu

New museum director pulls from the past, readies collections for future

Chris Widga was appointed director of the EMS Museum & Art Gallery in August. Before coming to Penn State he was a geology curator at the Illinois State Museum before becoming head curator at the East Tennessee State University Gray Fossil Site and Museum.

The EMS Museum & Art Gallery boasts a vast and varied collection of roughly 20,000 items, from gemstones, to industrial safety equipment, to paintings of industry.

"The collection here is so diverse and unique," Widga said. "I have a strong background in geology and paleontology but this museum also includes fine art and historic artifacts that tell the human side of the story. That really appealed to me."

Widga says the museum is there to serve the interests of the college; it's there to help researchers continue their work. Because it's visited by K-12 students, it's there to help them discover majors within the college. His vision is to advance on these fronts while expanding the collection to better represent modern research in EMS. That includes meteorology and atmospheric science, geography and AI, energy and sustainability, and materials science and engineering.

Widga said he was attracted to the post because of the Penn State culture, and he also knew the museum had a solid foundation. Through his research work, he frequently worked with retired director Russell Graham and Julianne Snider, long-time assistant director for exhibitions and collections who recently retired as interim director. http://tinyurl.com/4htyp3hb

Penn State mourns the loss of Charles L. Hosler

The College of Earth and Mineral Sciences and the Penn State community mourn the loss of Charles L. Hosler, for whom the Hosler Building on the University Park campus and the Hosler Oak at the Penn State Arboretum are named. Hosler died on Oct. 29 at age 99.

Hosler left his mark on Penn State, having spent his entire professional career at the University. He joined the Penn State faculty as an assistant professor of meteorology in 1951. He served as head of the Department of Meteorology from 1961 to 1965; as dean of the College of Earth and Mineral Sciences from 1965 to 1985; as senior vice president for research and dean of the Graduate School from 1985 to 1992; and as acting executive vice president and provost from 1990 to 1991 before retiring in 1992.

Hosler is credited with accelerating the transition of the college from its longtime mineral extraction and processing focus to one including all aspects of the entire earth system.

When Hosler became dean in 1965, the now named College of Earth and Mineral Sciences was known as the College of Mineral Industries. One of Hosler's earliest acts was to support the redesignation of the college as Earth and Mineral Sciences to reflect the importance of the earth-related sciences within the college, with focused attention on its diversity and distinctive blend of disciplines.

"Charlie was dean of the college for twenty years, during a period of tremendous growth and accomplishment," said John Dutton, dean emeritus and professor emeritus of meteorology. "During his tenure, the college's identity as an internationally recognized center of advanced study and research in earth, material, mineral ,and atmospheric sciences matured. Today, Earth and Mineral Sciences is international in outlook and global in its interests, and the college's alumni hold significant positions in all parts of the world. The college's reputation for quality in instruction and research is unquestioned and is a central part of Charlie's legacy."

Hosler was one of the early titans of weather forecasting. He created one of the first television weather shows when he started broadcasting weather forecasts from Penn State in 1957. From there, Hosler's first forecast blossomed into a larger weather program, known as "Weather World."

http://tinyurl.com/2e5cmd92

'Weather World' celebrated 40th anniversary

"Weather World," the Penn State Department of Meteorology and Atmospheric Science's weekday fifteen-minute weather broadcast, celebrated its 40th anniversary in 2023.

The award-winning show, run by faculty and students, delivers forecasts, with regular segments including daily, weekly, and long-range forecasts, as well as weather-breaking news coverage, and student-produced feature pieces.

The show airs across the commonwealth on the Pennsylvania Cable Network (PCN) weekdays at 5:45 p.m. The show can also be viewed on WPSU, a public broadcasting channel, weekdays at 5:30 and 5:45 p.m.

http://tinyurl.com/y9n426p7

New Zealand offers students chance to see path to sustainable energy future

This spring break, Derek Elsworth, G. Albert Shoemaker Chair in Mineral Engineering, took students on a seven-day sustainability tour of New Zealand as part of a three-credit Sustainable Energy in New Zealand course.

Students toured traditional and renewable energy facilities such as a coal-fired power plant, a wind farm, geothermal and hydro energy plants, among others.

"Courses like this are the most important," said Andrew Gilbert, a senior majoring in energy engineering. "Everyone needs to learn thermodynamics, fluid mechanics, and all these extremely important foundational classes. But whenever you get to go out, shake hands, see things in the real world, not just on paper, that gives you a unique opportunity to learn and ask questions in a way that the classroom can't provide. An experience like this in a place like New Zealand is unforgettable."

Elsworth, who has been offering the course for about a decade, said this trip featured a diverse group of students from various backgrounds, including geosciences and various engineering majors such as materials science and engineering, each offering a different perspective on the energy challenges.

"It was a great group of students. They were very engaged and great ambassadors for Penn State and their respective countries," Elsworth said. http://tinyurl.com/mr3ydvvv

Students hone geospatial skills in Europe

Twenty students, including undergraduate students enrolled in the college's Center for Advanced Undergraduate Studies and Experience (CAUSE) program, and graduate students enrolled in online geospatial education courses offered through the Department of Geography, took advantage of an intensive study abroad experience during Maymester as part of the course, "Challenges in Global Geospatial Analytics." Fritz Kessler, teaching professor of geography, and Beth King, associate teaching professor of geography, taught the course.

Penn State students collaborated with students and faculty at the Vienna University of Technology and with European Union professionals in the field, gaining first-hand experience on using geospatial technologies to visualize the COVID-19 pandemic while developing potential solutions to this real-world problem. They traveled to Austria, Slovenia, Germany, and the Czech Republic, visited international planning and mapping organizations, and participated in a unique education-based research and study abroad opportunity. The goal was to learn how geospatial data related to time and space can be used to address a humanitarian crisis.

"Being able to learn first-hand from mapping organizations in these countries allowed students to realize the importance that geospatial data and the mapping tools needed to map that data play in a country's infrastructure, government, and planning," Kessler said. http://tinyurl.com/466fck8d

World Campus student receives 2023 Lt. Michael P. Murphy Award

A U.S. Navy platoon commander who is a Penn State World Campus student has received this year's Lt. Michael P. Murphy Award, which recognizes outstanding contributions to the geospatial intelligence community.

This year's honoree, Lt. Siotame H. Latu, is stationed in San Diego, California, where he serves as a platoon commander. He is also pursuing a graduate degree online in the Master of Professional Studies in Homeland Security program, in the intelligence and geospatial analysis (GEOINT) option.

Penn State established the Lt. Michael P. Murphy Award in honor of Murphy, a Penn State alumnus who was killed in Afghanistan and posthumously awarded the Medal of Honor for his valiant service as a SEAL.

The annual award recognizes a student in one of Penn State's master's degree programs in geospatial education who has served in the U.S. military or within the geospatial intelligence community and demonstrated exceptional contributions to the discipline. At Penn State, those programs are offered online through World Campus by the Department of Geography.

http://tinyurl.com/uv5sncnx

Landscape-U program connects graduate students with Navajo Nation

Over spring break 2023, Penn State graduate students traveled to Arizona to participate in a transformational research experience as part of the Landscape-U program. During the week students visited sites connected to food, energy, and water topics, the focus of the trip. They also visited traditional working landscapes within Navajo Nation and learned firsthand about the Nation's rich culture and history.

Landscape-U is a National Science Foundation Research Traineeship (NRT) program designed to engage graduate students in transdisciplinary activities to find solutions to societal issues around food, energy, and water. Erica Smithwick, distinguished professor of geography and director of Penn State's Earth and Environmental Systems Institute, is the lead investigator on the project.

"The idea to travel to the Navajo Nation arose primarily from Timothy Benally, a member of the Landscape-U graduate student cohort," said Sarah Potter, Landscape-U's education program coordinator. "Tim shared numerous stories about the environmental and societal issues faced by the Navajo Nation with fellow Landscape-U members. He and Erica discussed the value of using transdisciplinary science as an approach to finding solutions. It was from these discussions that the idea for the research trip emerged."

http://tinyurl.com/y5du5csp

Spring break trip to Iceland empowers sustainability leaders of tomorrow

In contrast to the classic spring break trip soaking up sun on a beach, twelve students in the College of Earth and Mineral Sciences capitalized on their time off to gain an exclusive educational experience abroad. The students traveled to Iceland as part of the course "EMSC 299 EMS Study Away with the GREEN Program."

The course, paired with the Global Renewable Energy Education Network (GREEN) Program, provided opportunities for students to learn about sustainability by touring hydropower and geothermal facilities and gaining up-close access to cutting edge technologies.

"After lectures at Reykjavik University, the students toured hydro and geothermal generation facilities and had unfettered access to industry professionals," said Haley Sankey, program coordinator and an assistant teaching professor in the John and Willie Leone Family Department of Energy and Mineral Engineering.

"As part of the GREEN Program experience, students are encouraged to examine alternative ways of applying sustainability concepts and renewable energy technologies to experiment with their own ideas through capstone projects," Sankey said. "The mix of culture, academics, adventure, and experiential learning is perfect and can cement a student's pathway or introduce a new road to be explored."

Karen Marosi, director of student engagement in EMS, said the GREEN program empowers students to grow personally, while providing them the opportunity to explore the complexity of the planet and expand their knowledge of sustainability.

"The GREEN Program blends expert pedagogy and a keen understanding of how to connect with students to create an extraordinary learning experience," Marosi said. "Students return transformed as sustainability scholars with a deeper understanding of their own potential."

http://tinyurl.com/sb7p9erj

Four EMS students receive NSF Graduate Research Fellowships

Four EMS graduate students were among the twenty National Science Foundation (NSF) Graduate Research Fellowship Program (GRFP) recipients for the 2023-24 academic year.

The NSF program supports outstanding graduate students in the science, technology, engineering, and mathematics (STEM) disciplines; those in STEM education and learning research; and those in social and behavioral sciences, who are pursuing research-based master's and doctoral degrees.

Students receiving fellowships were: Juliana Drozd, doctoral student in geosciences, Haley Jones, doctoral student in materials science and engineering, Jessica Sly, doctoral student in materials science and engineering, and Ava Spangler, master's student in geosciences. http://tinyurl.com/bd6d2waz

Luis Ayala, William A. Fustos Family Professor in Petroleum and Natural Gas Engineering, was named head of the John and Willie Leone Family Department of Energy and Mineral Engineering. He also received the Regional Service Award from the SPE.

Allison Beese, associate professor of materials science and engineering, was named co-director of the Center for Innovative Materials Processing through Direct Digital Deposition. She was also appointed associate head for DEI in MatSE.

Cynthia Brewer, professor of geography, was awarded the 2023 Carl Mannerfelt Gold Medal by the International Cartographic Association.

Guido Cervone, E. Willard and Ruby S. Miller Professor of Geography and associate director of the Institute for Computational and Data Sciences, was elected president of the Natural Hazards section of the American Geophysical Union.

Long-Qing Chen, Hamer Professor of Materials Science and Engineering, was elected as a foreign member of the Academia Europaea.

Hamid Emami-Meybodi, associate professor of petroleum of natural gas, was awarded the Distinguished Achievement Award for Petroleum Engineering Faculty from SPE.

Christopher Fowler, associate professor of geography and demography, received the 2023 Penn State Award for Faculty Outreach.

José Fuentes, professor of atmospheric science, was elected as a Fellow of the American Geophysical Union. He also received the AGU Ambassador Award. He also was elected as a Fellow of the AAAS.

Peter Heaney, professor of geosciences, received a 2023 Atherton Award for Excellence in Teaching from Penn State.

Russell Johns, professor of petroleum and natural gas engineering, received the 2023 SPE/AIME Anthony F. Lucas Gold Medal from the International Society of Petroleum Engineers for technical leadership.

Zuleima Karpyn, associate dean for graduate education and research in EMS and Donohue Family Professor of Petroleum and Natural Gas Engineering, was awarded the Reservoir Description and Dynamics Award from SPE.

James Kasting, Evan Pugh University Professor Emeritus of Geosciences at Penn State, was named an Atherton Professor by Penn State.

Brian King, department head and professor of geography, was named a Fellow of the Big Ten Academic Alliance.

Kimberly Lau, assistant professor of geosciences, was awarded a Sloan Research Fellowship.

Wenjie Li, assistant research professor of materials science and engineering, received a 2023 Rustum and Della Roy Innovation in Materials Research Award.

Zi-Kui Liu, Dorothy Pate Enright Professor in MatSE, was recognized by the Minerals, Metals and Materials Society for his impact on the fields of computational materials science and materials design with an honorary symposium.

Jon-Paul Maria, professor of materials science and engineering, received a 2023 Faculty Scholar Medal for Outstanding Achievement from Penn State.

Paul Markowski, distinguished professor of meteorology, was named head of the Department of Meteorology and Atmospheric Science at Penn State.

Dipanjan Pan, Dorothy Foehr Huck & J. Lloyd Huck Chair Professor in Nanomedicine and professor of materials science and engineering, was elected as a Fellow of the American Institute for Medical and Biological Engineering.

Emily Rosenman, assistant professor of geography, was named a Social Science Research Institute Mentored Faculty Fellow for 2023-24.

Erica Smithwick, distinguished professor of geography, was named director of the Earth and Environmental Systems Institute at Penn State.

Sanjay Srinivasan, professor of petroleum and natural gas engineering, was named director of the EMS Energy Institute.

Ezgi Toraman, assistant professor of energy and mineral engineering and chemical engineering, was one of twelve early-career scientists named to *Chemical & Engineering News*' 2023 "Talented 12" list.

Christelle Wauthier, associate professor of geosciences, was elected president president of the Natural Hazards section of the American Geophysical Union.

Peter Wilf, professor of geosciences, was elected as a Fellow of the American Association for the Advancement of Science.

Thank you!

To all of the College of Earth and Mineral Sciences' supporters and friends—thank you! Philanthropy helps provide the college with the resources needed to train our students to become the next generation of leaders, conduct innovative research, hire world-class faculty, and reimagine our laboratories and classrooms.

We rely on your support to ensure the college's success. Whether through support for students or support for faculty, your support is vital.

Learn how you can give to the College of Earth and Mineral Sciences by visiting the following webpage: www.ems.psu.edu/giving/give-college/give-now

If you have any questions, please contact the college directly at development@ems.psu.edu or call 814-863-2289 to explore providing philanthropic support.

Tabbetha Dobbins awarded for advancing science, students

Tabbetha Dobbins, professor, dean of graduate studies and former vice president for research at Rowan University, was the recipient of the college's 2023 Charles L. Hosler Alumni Scholar Medal for her efforts to elevate scientists and students.

Dobbins said she was honored to receive the award from an institution that helped shape her successful career.

"Receiving the Hosler medal means so much to me. My Penn State roots in the College of Earth and Mineral Sciences have fed the branches of my work today," Dobbins said. "I continue to grow from interacting with the EMS and materials science and engineering department at Penn State. With each visit to serve on a committee at Penn State or receive an award, I learn best practices for supporting my current students. Following in the footsteps of those who received the Hosler Medal before me puts me into a network of extremely outstanding individuals."

http://tinyurl.com/55e7nabr

Jerry Berkebile lauded for commitment to students, alumni

Jerry Berkebile, president of Augustin Exploration LLC, in Midland, Texas, is the 2023 recipient of the Colleen Swetland Alumni Achievement Award given by the College of Earth and Mineral Sciences Graduates of EMS (GEMS) Board of Directors.

Berkebile, a 1977 Penn State graduate in petroleum and natural gas engineering, was chosen for his commitment to improving the careers of alumni, his dedication to serving the University, and his efforts to improve the education of current students. The award was renamed in honor of Colleen Swetland, longtime assistant director of alumni relations, who retired in 2021.

"I am honored to receive this award, especially because it is named after Colleen Swetland, who served the College of Earth and Mineral Sciences so well for so many years," Berkebile said. "It has been rewarding to work with many outstanding individuals from the faculty, staff, and fellow alumni. The highlight to me, though, has been my opportunity to meet and talk with so many bright and talented Penn State students who have decided to pursue energy careers."

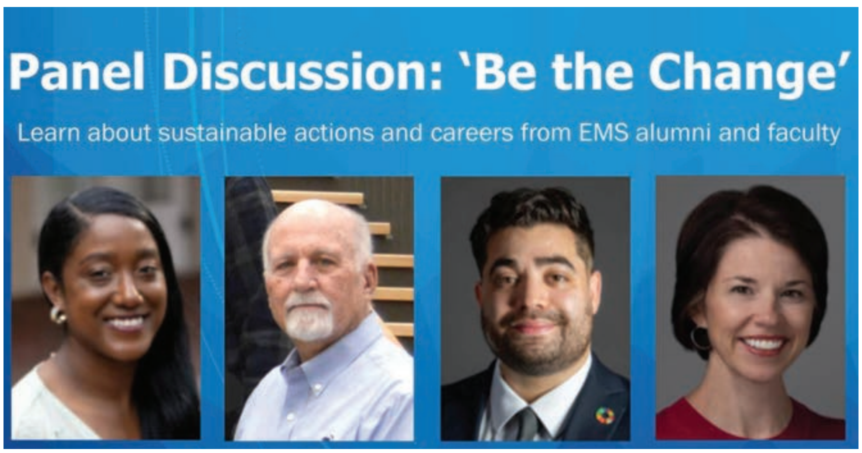
http://tinyurl.com/3vh2wmmx

Shelley Corman-Frisby appointed to Earth and Mineral Sciences alumni board

Shelley Corman-Frisby, a 1985 graduate in mineral economics, has been appointed to the Graduates of Earth and Mineral Sciences (GEMS) board of directors, effective July 1.

Corman-Frisby brings more than thirty-seven years of experience in business development, commercial operations, and regulatory affairs for natural gas transmission assets. She is vice president of business development at Boardwalk Pipeline Partners in Houston.

"We are delighted to welcome Shelley Corman-Frisby to the GEMS board," said Scott Billingsley, president of GEMS. "Her remarkable expertise in business development and regulatory affairs within the natural gas transmission sector will greatly contribute to our organization's strategic direction and success. We look forward to her valuable insights and contributions during her tenure." http://tinyurl.com/4p9dnspx



EMS Sustainability Council hosted first-ever alumni panel discussion

The student committee of the college's Sustainability Council held its first alumni panel discussion, "Be the Change," last February.

"Solutions to climate and energy challenges lie at the heart of an economic revival for human society and the inclusion of diverse global perspectives and actions aimed at solutions will present opportunities for future employment and careers for students," said Harman Singh, member of the student committee and one of the organizers of the event.

The panelists discussed solutions for energy challenges of the future and career paths in sustainability-related fields following graduation.

Panelists included:

- Elizabeth Crisfield, doctorate in geography
- William Irwin, bachelor of science degree in petroleum and natural gas engineering
- Lindsay Jacks, bachelor of science degree in geosciences and bachelor of arts degree in Spanish
- John Lease, bachelor of science degree in earth science and master of science degree in environmental pollution control
- Jason McNew, bachelor of science degree in geo-environmental engineering

The inaugual panel was very well received and the student committee hosted a second one in November.

November panelists included:

- Jasmine Fields, bachelor's degree in geosciences
- John Lease, GEMS liaison to the college's Sustainability Council
- Mark Ortiz, Presidential Postdoctoral Fellow in the Department of Geography
- Bernadette Woods Placky, bachelor's degree in meteorology and a minor in French

"With sustainable development goals at the forefront of the conversation, the student committee of the Sustainability Council strives to inspire students from all walks of life to share their diverse perspectives," said Singh, who is pursuing a doctorate in geography at Penn State.

February panel: http://tinyurl.com/4xxcksd8
November panel: http://tinyurl.com/4evb74wf

PennState
College of Earth
and Mineral Sciences

Impact Magazine
510 Eric J. Barron Innovation Hub
123 S. Burrowes Street
State College, PA 16801