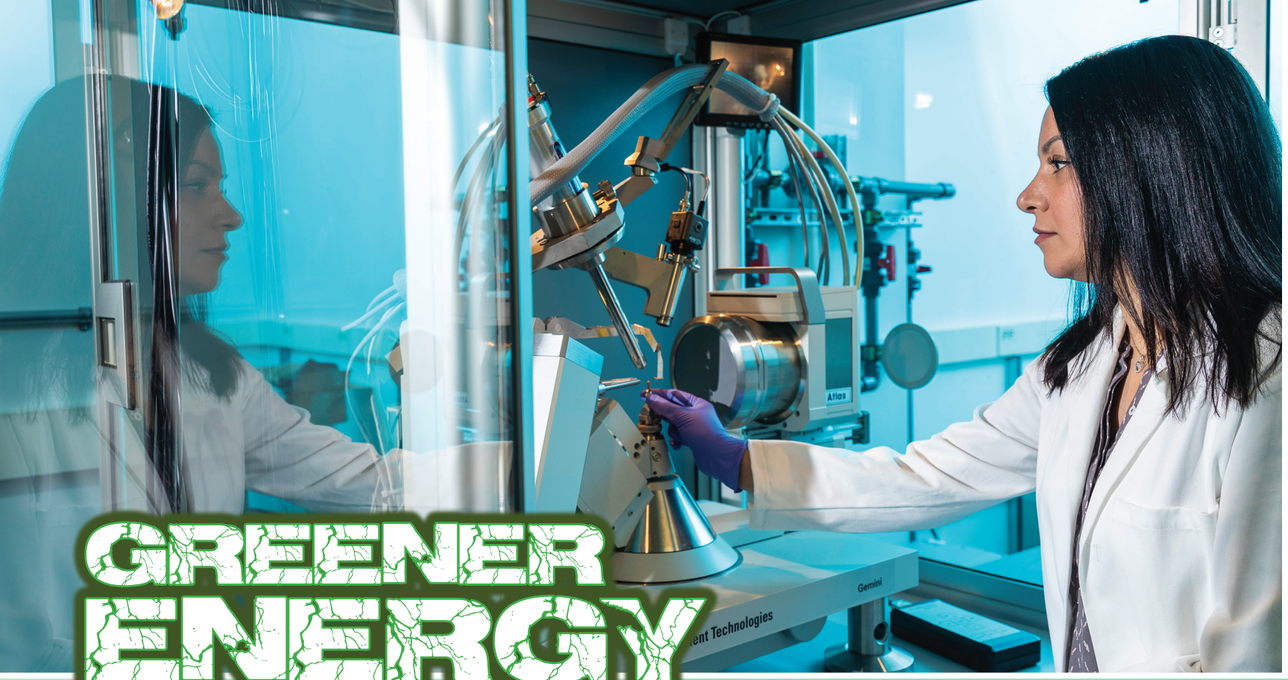


GREENER ENERGY

Harnessing light and air for cleaner processes

From photosynthesis in plants, to every breath we take and every thought we think, life is animated by complex chemical reactions that pass electrons back and forth between molecules.

Dr. Shabnam Hematian has focused her research on the metals — iron, copper, and others — that are foundational to these processes.

"The cool chemistry that happens in your body – metabolism of drugs or hormone biosynthesis – all of them are governed by a series of iron proteins," the Bernard-Glickman Dean's Professor in chemistry and biochemistry says.

Inspired by nature, Hematian is working to understand how light and air, along with common metals, could catalyze industrial reactions, to design more efficient and environmentally friendly technologies.

Understanding how they could be harnessed to drive electron transfers in industry could change the design of high-capacity fuel cells, for example, and allow companies to create them without more expensive and more toxic metals such as platinum or ruthenium.

INSPIRED BY NATURE

As a researcher with expertise in both synthetic chemistry and light-driven biological reactions, Hematian brings a natural process lens to industrial questions.

"Nature started working and figuring out how to do transformations with just the bioavailable elements," she says. "We don't have any enzymes that have ruthenium in them, but we have a lot of enzymes that have iron in them." Those enzymes may provide models for more environmentally friendly reactions.

Light and air are abundant and, Hematian explains, light's color, intensity, and other properties can be precisely controlled. Thus, it has the potential to become a sensitive tool to drive chemical reactions. In the future, she says, adjusting the color of light might allow scientists to activate one part of a molecule but not another.

In the spring of 2022, Hematian was awarded a prestigious two-year $250,000 grant from the National Science Foundation's LEAPS initiative, which is designed to support promising mathematicians and physical scientists early in their careers.

With the funding, Hematian is developing new ways to transform carbon-based materials into oxygenated materials. These kinds of reactive materials, like ethanol, are valuable in industry, but making them currently requires harsh chemicals, high temperatures, and high pressure.

"They're very expensive types of reactions," says Hematian. "We want to develop catalysts that can absorb light to give us the energy for these transformations instead."

In another example of applying natural inspiration to a 21st century challenge, Hematian is looking at molecules found in certain fungi that could be useful in liquid batteries.

The work is emerging from a collaboration with Patricia A. Sullivan Distinguished Professor of Chemistry Nick Oberlies. The natural products chemist and his team assess compounds found in fungi for medicinal applications, but Hematian has recognized the potential in some of their findings for electrochemistry.

Liquid – or "flow" – batteries store more energy than current solid state battery technology and are the wave of the future, she says. "Many startups are currently working on figuring out which compounds are most efficient and durable for use in them."

CATALYZING LEARNING

The NSF LEAPS grant also supports another of Hematian's interests: mentoring students from a variety of backgrounds.

She's recruiting undergraduates, community college students, and even some high school students to work in her lab alongside graduate students. She also wants to involve home-schooled students.

"I'm hoping this is going to connect what they learn in their textbooks to life – now they're doing it in the lab."

The goal is to give students first-hand experience that not only reinforces classroom learning, but also helps them understand how original research is done. "We may get results we don't understand at the beginning. How can we go about handling that?"

The work will expose the students to researchers and science-based career opportunities.

As a researcher who has benefited from strong mentorship and similar opportunities, Hematian says it's important to her to continue that tradition.

"I'm very invested in passing the knowledge to the next generation," she says. "That's my passion: to influence people and the future."

APPLIED POTENTIAL

Even during his first year at UNCG, Marcos Tapia had heard that doing research as an undergraduate could boost his chances of success after graduation. But he had no idea how to get started.

UNCG's First Year Experience course helped him bridge the gap. Tapia, who has always excelled in chemistry and had chosen it as his major, was assigned an informational interview with someone in his field.

He chose Hematian. Tapia was drawn to her focus on environmentally friendly technologies and her background – the bioinorganic chemist is from Iran and learned to navigate American higher education without the benefit of guidance from family with experience in that system.

Within a few weeks of the interview, Hematian had invited Tapia to work with her. She was impressed with his drive.

"In December – during the holidays – he finished all of his safety training and the other things he had to do before starting work in the lab."

Since then, Tapia has become a near daily presence in Hematian's lab. He's also carved out his own area of expertise: doing experiments in electrochemistry using cyclic voltammetry.

In cyclic voltammetry, chemists measure the current produced by a substance under different voltages, giving them insight into how that substance accepts or loses electrons. It's valuable for Hematian's research into how electrons flow in certain materials and chemical reactions, which has the potential to make a wide range of technologies cheaper, more efficient, and environmentally friendly.

Learning the skill also provides Tapia with a skill that's marketable. "Just by knowing that technique you can go get a job," Hematian says. "For example, electrochemistry is foundational to battery science."

Last summer, Tapia attended a three-day cyclic voltammetry bootcamp. He was the youngest

attendee and one of only two undergrads.

"Marcos was one of the most engaged researchers," says UNC Chapel Hill Professor Jillian L. Dempsey, who ran the bootcamp. "He asked deep, probing questions about electrochemistry and the associated theory, a true testament to how deeply engaged he is with his own research project."

In Tapia's current work in the Hematian lab, the focus is on understanding how oxygen atoms can be added to a material, and how reversible that process is. As a freshman, he applied for, and won, funding from UNCG's Undergraduate Research, Scholarship, and Creativity Office to support a research project on oxygen chemistry and copper. Now, as a sophomore, he has his first publication, co-authored with Hematian and other researchers in her lab.

"Being in a research group actually makes you think about what you are doing," Tapia says. "We do these weekly presentations, and we have to take our data and actually present."

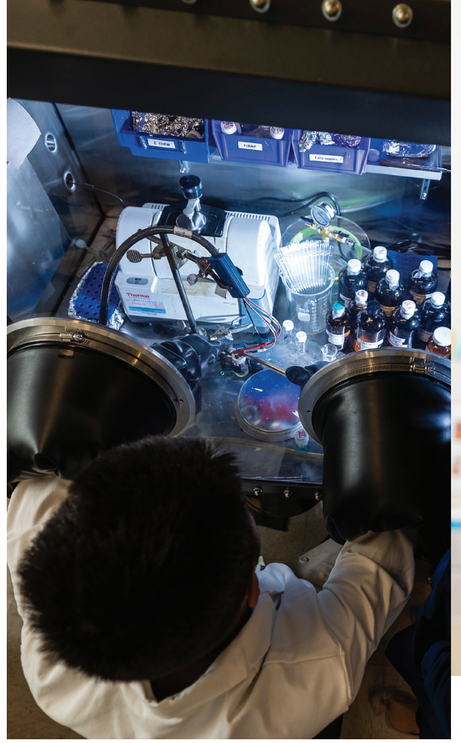
The lab's training prepared him to present his research at conferences, including the Southeastern Regional Meeting of the American Chemical Society in Puerto Rico.

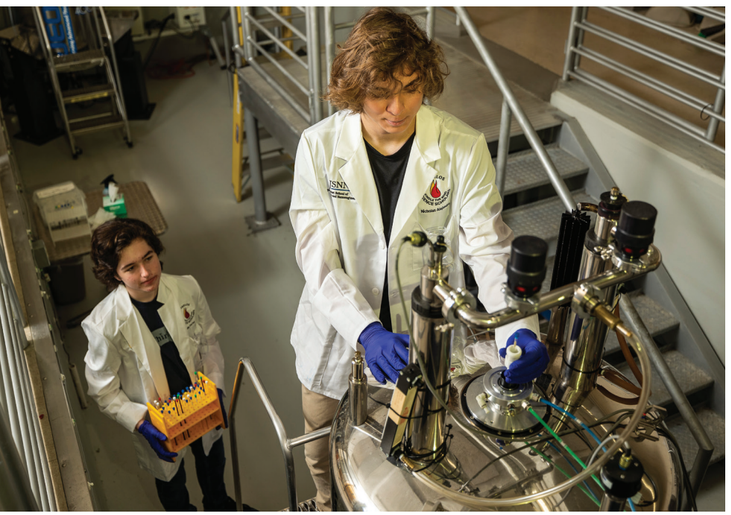
He's also thinking about life after he earns his bachelor's degree. He has dreamed of becoming a doctor but graduate school in chemistry is another option to weigh.

"I'm thinking more about my future – undergraduate research has really helped me out with that because I get to talk to people with PhDs, master's degrees," he says.

"I get to interact with a community of science that I've never been exposed to as a first-generation student."

by Marc Tosczak
learn more at ***chem.uncg.edu/hematian***





DRAELOS SCHOLARS **High school student researchers Fully Porter and Nicholas Alejandro load samples into a nuclear magnetic resonance spectrometer. Learn more at *go.uncg.edu/draelos***

Nurturing the next STEM GENERATION

As part of her mentorship work, Hematian participates in the Draelos Science Scholars Program, which aims to inspire future scientists and engineers to pursue STEM careers. For six weeks each summer, promising Triad-area high school juniors have the opportunity to don white coats and work in university research labs.

More than 100 high school students have been through the program – a brainchild of local doctors Zoe and Michael Draelos – and it grows each year. Aidan Hunt, now a third-year student majoring in computer science and linguistics at UNC Chapel Hill, says his 2019 Draelos experience working with Hematian gave him an inside look at the life of a scientist.

"I learned more about what it meant to be doing research at that level," he says. "What it meant to actually choose research as a career, what the grad students and professors in the lab were doing."

SPEAKING SCIENCE

BILINGUALTEK **Méndez and La Paro lead a training for Head Start teachers.**

Sitting criss-cross in a circle, five preschoolers reach out to touch pieces of fabric their teacher spreads in front of them. As the children pat the leather, denim, and cotton, she starts a conversation about which they like best. "Do you wear clothes that feel like these fabrics?" she asks.

The teacher then shows her students a turkey baster filled with water. "What do you think will happen if we get the fabrics wet?" she wonders aloud. In a matter of minutes, she introduces her students to two new words: "absorb" and "repel."

Even though English isn't their first language – and they're not yet familiar with the scientific process of observing, forming a hypothesis, and experimenting and analyzing – the children relate to these concepts.

"Everybody wears clothes, so the experience is naturally engaging," says Dr. Lucía I. Méndez, a UNCG communication sciences and disorders researcher. Her team designed the activity as part of Bilingualtek, a research program that incorporates language and science to support young dual-language learners.

This is year two of her $1.6 million National Science Foundation-funded project. To develop Bilingualtek, Méndez brought together a multi-institution team that includes science education researchers from East Carolina University and NC State University, as well as UNCG human development and family studies researcher Dr. Karen La Paro.

Over the next two years, the team will continue to refine Bilingualtek and gather evidence for an integrated language-science approach to instructing Latino preschoolers.

"Language is so important for science learning because, in order to even think about science concepts, you also need the words," Méndez says. "Children with limited vocabularies face challenges with science, reading, or math – especially by the time they get to the 4th grade. They may read fluently, but if they don't sufficiently understand what they're reading, they can experience difficulties learning."

Dual language preschoolers who receive English-only instruction may be missing early science learning opportunities, she says. "In our country, we have an increased number of Latino dual language learners entering preschools, a shortage of bilingual childhood educators, and limited science training for teachers at this level." As a result, low-income Latino preschoolers are at a higher risk of being left behind in STEM.

Bilingualtek gives monolingual teachers the tools they need to help bilingual children engage with and talk about their natural world – thus increasing their scientific vocabulary going into elementary school.

As part of a unit exploring recycling, for example, the team created an ebook about a Latino family celebrating their abuela's birthday. Children in the story catch fish for a special birthday dish of ceviche and reuse found objects to make a gift. As students and teachers read together, they take advantage of specially designed sections with Spanish narration and animations to illustrate science concepts.

The culturally responsive elements also give children a sense of pride. "It helps teachers appreciate their students' home language and culture," Méndez explains.

That matters, as these students bring important knowledge and skills to the table. "Their cultural and linguistic experiences enrich their learning and the classroom environment," Méndez says. "Different languages have different ways of expressing concepts, and having access to that opens our minds and gives us a better understanding of the world."

by Robin Sutton Anders
learn more at go.uncg.edu/ChildLanguageLab