Kennedy College of Sciences
University of Massachusetts Lowell
One University Ave.
Lowell, MA 01854

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A PUBLICATION OF THE KENNEDY COLLEGE OF SCIENCES

ELEMENTS OF SCIENCE

FACING OFF AGAINST COVID-19

Eight Faculty Research Projects Take Aim at the Deadly Virus

THE UNIVERSITY OF MASSACHUSETTS LOWELL

A LETTER FROM THE DEAN

Dear Alumni, Colleagues and Friends:

Welcome to the third edition of Elements of Science, the magazine of the Kennedy College of Sciences. In this issue, we share with you a glimpse of how our students, faculty and alumni have responded to the unique challenges of the COVID-19 pandemic, whether they are finding new ways to teach and learn, advancing our understanding of the coronavirus through their research or developing new products to help diagnose or treat the virus. As dean of the college, I could not be more proud.

You will also read about how our faculty continue to break important new ground in other areas, including a study, the results of which were published in Nature, on the fundamental aspects of atoms and their nuclei, offering new insight into the building blocks of the universe.

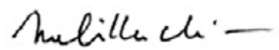
Reflecting on the past year, it has never been more clear that in a complex and fast-paced world, our students, faculty and alumni must continually adapt to changing circumstances. Kennedy College students face these challenges while also navigating the transition from high school to college or from college or graduate school to the workplace. Many of our students are also the first in their families to attend college or are balancing their education with full- or part-time jobs.

These hardworking and motivated students have the ability to create a better future for all of us. We must remain focused on providing them with a supportive environment, robust educational experiences and hands-on learning opportunities outside the classroom so they can apply what they learn during their time at UMass Lowell to make the world a better place. They can do it. We can help them do it.

I hope you enjoy the stories in this issue. Should you have any suggestions or comments, please do not hesitate to contact me at sciences@uml.edu. I am always happy to hear from you.

I send my best wishes to you and your families for good health and continued success.

Sincerely,



NOUREDDINE MELIKECHI, D. PHIL.
Fellow, American Association for the Advancement of Science
Fellow, Optical Society of America
Fellow, American Physical Society
Dean, Kennedy College of Sciences
Professor of Physics
University of Massachusetts Lowell

In this issue

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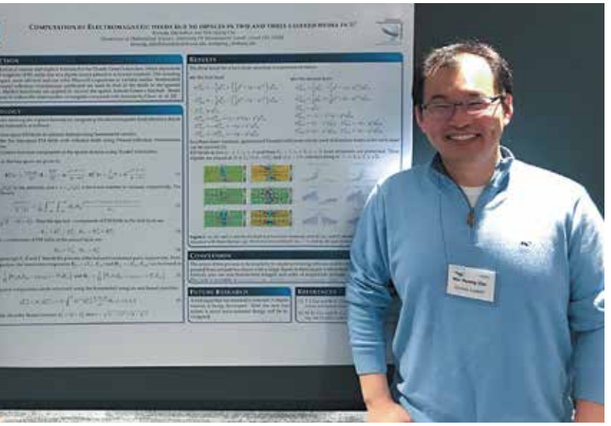
DIRECTOR OF EDITORIAL SERVICES
Sarah Corbett

EDITOR
Jill Gambon

DESIGNER
Karen Hoots

CONTRIBUTING WRITERS
Edwin L. Aguirre
Ed Brennen
David Perry
Katharine Webster

CONTRIBUTING PHOTOGRAPHERS
Edwin L. Aguirre
Ed Brennen
Joson Images
Katharine Webster
Tory Wesnofske



Math Faculty Win NSF Grants

Asst. Profs. Min Hyung Cho and Nilabja Guha of the Department of Mathematical Sciences won grants totaling nearly $340,000 from the National Science Foundation (NSF) for research that could impact a range of disciplines, from high-resolution imaging to economics and finance.

Cho was awarded $199,405 for a project that aims to resolve computational challenges in interaction models, which are becoming a powerful mathematical tool for researching problems in science, engineering and other fields.

Guha received a $140,000 grant for his project, which will try to fill a gap in the statistical tools used in the analysis of changes in data. He will use the Bayesian method—a mathematical technique that applies probabilities or distributions to statistical problems and allows people to revise and update their assumptions after obtaining new experimental data—for analyzing change points in data.

Chemistry Student Honored with MLK Award

Chemistry major Benedicta Agyemang-Brantuo found inspiration in the words of the Rev. Martin Luther King Jr. that injustice in health care is the most inhumane of all inequalities. So Agyemang-Brantuo, an Honors College student who is on a pre-med track, founded Advocates of Health Equity for Minorities, a campus club dedicated to supporting students of color who are preparing for careers in health care.

The organization is one of many that Agyemang-Brantuo is involved with on campus. She's also a senator in student government, a Kennedy College of Sciences student ambassador and a participant in UMass Lowell's DifferenceMaker student entrepreneurship program.

Her advocacy on behalf of others earned her UML's 2021 Martin Luther King Jr. Distinguished Service Award, which honors recipients for commitment to social change, community service and engagement.

RESEARCHERS DEVELOP COMPUTER SCIENCE CURRICULUM FOR MIDDLE SCHOOLS

Schoolchildren may be digital natives, but many of them aren't learning computer science skills in school.

A team of researchers from UMass Lowell and SUNY Albany is trying to change that with a three-year, $1 million grant from the NSF to create computer science curriculum for middle schools in collaboration with school districts in Lowell and Methuen, Massachusetts, and Schenectady, New York.

Called CS Pathways, the project aims to develop inclusive, culturally responsive and sustainable computer science education programs. Computer Science Prof. Fred Martin is the principal investigator on the project for UMass Lowell.

The grant builds on Martin's previous NSF-funded work, in which students in two Massachusetts school districts learned programming skills by creating mobile apps, including some that were designed to combat cyberbullying.

RESEARCH TARGETS BIRTH DEFECTS OF HEAD AND FACE

Asst. Prof. Jennifer L. Fish of the Department of Biological Sciences was awarded federal funding to study how genetic mutations cause cleft lip and cleft palate and other birth defects of the head, face and mouth.

Fish won a pair of three-year grants totaling more than $612,000 from the National Institute of Dental and Craniofacial Research for her work. She wants to understand the molecular and cellular mechanisms that are responsible in patients who have mutations in their genes, and why the severity of the defects varies from individual to individual.

"Such variation contributes to difficulties in the diagnosis and treatment of craniofacial malformations," she says.

The research could lead to the development of new treatment options for craniofacial and bone defects.

Recent Alum Lands Dream Job

Lena Dziechowski '19, '20 took the circuitous route to meteorology, working in retail and hospitality and studying business part-time at a community college for several years.

But once she decided to pursue meteorology, she made up for lost time, transferring into UMass Lowell as a sophomore majoring in atmospheric science. She earned both bachelor's and master's degrees in four years.

Three months after graduating, Dziechowski landed a television job as a freelance meteorologist at Western Mass News in Springfield, Massachusetts. That quickly turned into a full-time position. She is now the station's weekend meteorologist and is a multimedia journalist during the week. It's a dream job for her.

"From the second I stepped into the newsroom, the energy was undeniable," she says. "I loved it. I knew that this is where I want to be."

KCS DEAN HELPING TO LOOK FOR SIGNS OF ANCIENT LIFE ON MARS

When the Mars rover Perseverance touched down in February, Noureddine Melikechi, dean of the Kennedy College of Sciences and a professor in the Department of Physics and Applied Physics, was paying close attention.

Melikechi is a member of the science team for SuperCam, one of the main instruments on board Perseverance that will be conducting experiments on the surface of Mars, looking for signs of ancient life and clues to the planet's geology and climate.

SuperCam will use a remote-sensing technique called laser-induced breakdown spectroscopy, or LIBS, to study the chemical and mineral composition of Martian rocks and soils by zapping them with a powerful infrared laser.

The data collected will be transmitted back to Earth for analysis by Melikechi, who is an expert on optics and laser spectroscopy, and other members of the science team.

PROFESSOR HOPES SIMULATION LEADS TO REAL CHANGE ON CLIMATE

Researchers from UMass Lowell are helping policymakers better understand the threat of climate change.

The university's Climate Change Initiative (CCI) has partnered with the MIT Sloan Sustainability Initiative and Climate Interactive on the Climate Pathways Project, which uses interactive computer simulations and role-playing exercises to show how policy decisions can affect the future of the planet.

CCI Director Juliette Rooney-Varga, a professor of environmental science, helped develop the Climate Action Simulation and accompanying En-ROADS computer model that have already been used by thousands of people around the world. The Climate Pathways Project recently introduced the simulation to a new wave of national and state policymakers. Follow up research will measure the impact of their experiences.

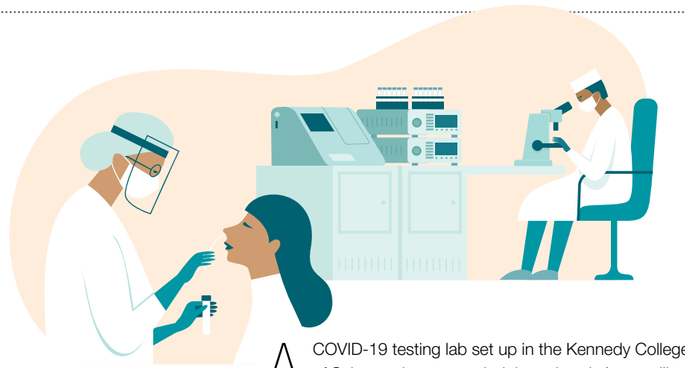
Rooney-Varga's previous research has shown that participation in the simulation leads to greater feelings of urgency and hope about climate change.

PROMOTING DIVERSITY IN STEM

Find mentors and sponsors who will back you up. Look for a supportive environment where you can do your best work. Develop confidence and communications skills that will help you advance your research.

Those are some things that can help people from underrepresented backgrounds flourish in their careers, according to panelists in a recent "Diversity in STEM" virtual discussion that was cohosted by the organization Women Accelerators and UMass Lowell's Innovation Hub.

Alumna Evana Gizzi '13, '14, who earned bachelor's and master's degrees in math from KCS, served as the event's moderator. Gizzi, now a Ph.D. candidate at Tufts University, works for NASA's Goddard Space Flight center, where she researches artificial intelligence. Based on her experience, people need to be "brave enough" to have difficult conversations with colleagues from different backgrounds, she said.

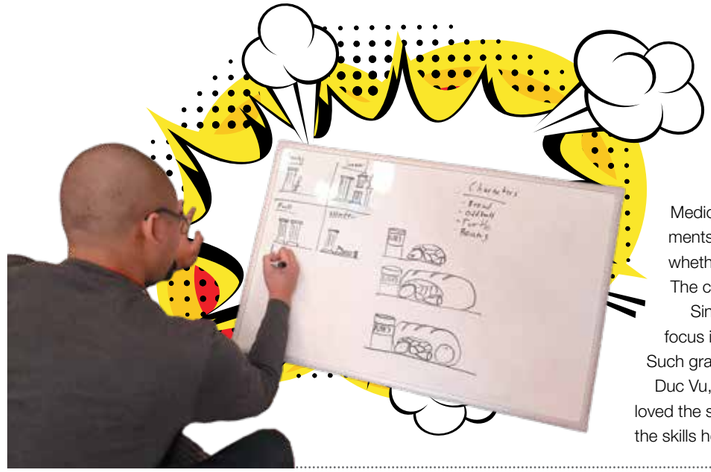


KCS Students and Faculty Help Expand On-campus COVID Testing

A COVID-19 testing lab set up in the Kennedy College of Sciences has expanded the university's surveillance testing efforts and created hands-on work opportunities for students.

The lab, which opened in February under the direction of Assoc. Prof. of Chemistry Matthew Gage, is capable of processing up to 700 swabs a day from students, faculty and staff who are on campus.

Nearly 20 students have been hired and trained to work in the lab so far. "I want to go to medical school, so this opportunity is just an amazing experience. I feel very proud to be a part of it," says Surbhi Mavi, who earned a bachelor's degree in biology last year and is pursuing a master's degree in biotechnology.



Graphic Novels Help Students Learn the Art of Storytelling

A new Honors College seminar combines scientific knowledge with visual storytelling to help students improve their communications skills.

In the course Graphic Novels in Science and Medicine, students analyze story structure and complete assignments, such as writing about and drawing something they fear, whether it's COVID-19 or exposure to dangerous chemicals. The class is taught by Assoc. Prof. of Art and Design Karen Roehr.

Since the class is not aimed at art majors, Roehr says her main focus is on students' ability to tell compelling stories, step by step. Such graphic stories are an important educational tool, she says.

Duc Vu, a chemistry major who plans on becoming a teacher, says he loved the storytelling aspect of the assignments and expects that the skills he learned will come in handy when he's leading a classroom.

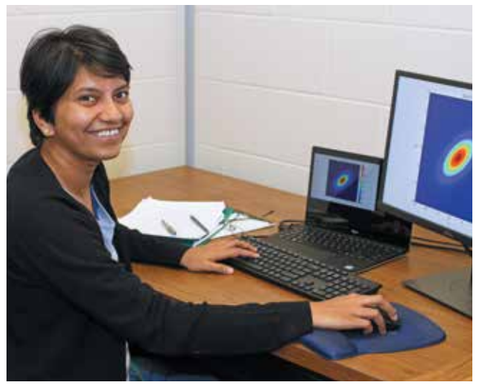
PHYSICS PROFESSOR WINS $1M FOR QUANTUM SYSTEMS RESEARCH

Asst. Prof. Archana Kamal of the Department of Physics and Applied Physics has won two early career awards totaling $1 million from the U.S. Air Force and the NSF for her research on quantum information processing with open quantum systems.

The Air Force Office of Scientific Research recognized Kamal with a Young Investigator Program award—worth $450,000 over three years—for her work on tunable quantum dissipation, which can be used to develop autonomous quantum error correction protocols.

She was awarded a five-year NSF CAREER grant totaling $550,000 to support her work on investigating entanglement dynamics in the presence of non-trivial noise.

The research supported by the grants could lead to advances in applications of quantum information processing, including quantum computing, quantum sensing, quantum communication and cryptography.



Study Looks at Impact of Coastal Storms

Powerful coastal storms can wreak havoc on the shoreline, eroding beaches and causing floods. What's less obvious is how such storms affect underground water near the ocean.

Asst. Prof. James Heiss of the Department of Environmental, Earth and Atmospheric Sciences is part of a research team that is studying how coastal storms affect the fresh water flowing below ground along the seashore.

Heiss and the Woods Hole Oceanographic Institution were awarded a three-year, $784,000 NSF grant for their research, which includes monitoring beach aquifers, the underground layer of rocks and other materials that holds water.

Beach aquifers provide a valuable ecological service by filtering groundwater contaminants prior to discharge to the ocean. Increasing salinity due to storms is likely to affect the aquifer's ability to remove pollutants, Heiss says.

FACING OFF AGAINST COVID-19

Eight Faculty Research Projects Take Aim at the Deadly Virus

BY EDWIN L. AGUIRRE

Just as the world was starting to see a glimmer of hope in the yearlong fight against the COVID-19 pandemic—with the successful rollout of the Pfizer, Moderna and other vaccines—new wrinkles surfaced.

Three new variants of SARS-CoV-2 (the virus that causes COVID-19) that emerged in the U.K., South Africa and Brazil had taken foothold here in the United States.

Although viruses are known to change constantly through mutation, and new variants of a virus are expected to occur over time, the swift arrival of the coronavirus variants caught the U.S. ill prepared. According to the Centers for Disease Control and Prevention, the new strains appear to be more contagious, which could lead to more hospitalizations, further strain on the health care system and potentially more deaths. There is also some concern about the effectiveness of the current vaccines against the new variants.

Even with the original strain of SARS-CoV-2, the pandemic's toll on the country was already staggering—more than a half million dead, 31 million infected and trillions of dollars in economic losses. The arrival of the variants raised the stakes for researchers racing to develop solutions to better defend against or treat the disease.

"We still don't know everything about COVID-19; there's still a lot to learn about the disease. That is why it is very important to continue to conduct research on the coronavirus even though vaccines have already been developed for it," says Chemistry Prof. Mingdi Yan.

Scientists still need to understand how the virus and its variants work to develop ways to control and mitigate their spread, Yan says.

"This is the only way that the U.S. and the world can return to normalcy and prevent future outbreaks," she says.

Yan is one of dozens of faculty researchers from the Kennedy College of Sciences and other colleges across campus who were awarded seed funding by the university's Office of Research and Innovation to conduct studies designed to address the pandemic. The projects involve a wide range of disciplines and explore everything from using gold-based drugs to kill SARS-CoV-2 to zapping blood samples with a laser to test for antibodies to the coronavirus. Many of the projects build on the researchers' previous work.

"Our goal for funding these research projects is to boost interdisciplinary collaborations and partnerships, which could lead to breakthroughs in understanding COVID-19," says Vice Chancellor for Research and Economic Development Julie Chen. "The projects harness the complementary expertise of our faculty researchers, augment existing research and increase the likelihood of obtaining external funding."

Chemistry Prof. Mingdi Yan, right, and Ph.D. student William Ndugire examine a vial containing gold nanoclusters.

1 USING GOLD-BASED COMPOUNDS TO FIGHT THE CORONAVIRUS

Yan's team—which includes Prof. of Chemistry Olof Ramström and Dr. Robert Finberg of the UMass Medical School's Department of Medicine—was awarded $10,000 to test the antiviral effects of gold compounds and gold nanoparticles on live SARS-CoV-2.

According to Yan, gold compounds have been used to treat tuberculosis, syphilis and inflammatory rheumatoid diseases. Auranofin, a gold salt, is used to treat rheumatoid arthritis, ovarian cancer, diseases caused by parasites and bacteria, and other illnesses.

Yan says auranofin has shown strong potential as an antiviral agent. "Promising effects have been demonstrated in treating AIDS caused by the human immunodeficiency virus and liver fibrosis caused by the hepatitis C virus, as well as in targeting the Zika, chikungunya and vaccinia viruses," she says.

"We believe that gold compounds can be made effective against SARS-CoV-2, based on our strong preliminary data," says Yan. "They showed excellent activities against difficult-to-treat, gram-negative pathogens and showed low toxicities to human cells. Auranofin can be repurposed to broadly treat viral infections."

In addition to COVID-19 research, Yan, who is an expert in the chemistry of antimicrobial nanomaterials and nanoantibiotics, is currently working on two projects supported by grants totaling nearly $875,000 from the National Institutes of Health—to use bacterium-specific sugars in drug delivery as well as to design and synthesize gold nanoclusters with chemically attached sugars and evaluate their antimicrobial activities.

"The more tools we have available in our toolbox—from new vaccines, biologics and therapeutics to advanced diagnostics—the better prepared we will be when the virus comes back in the future in another form," she says.

2 ANALYZING GENETIC MARKERS IN COVID-19 PATIENTS

Chemistry Assoc. Prof. Matthew Gage is leading a team that received $10,000 to use cutting-edge DNA sequencing techniques to analyze potential differences in gene expression between patients that have severe symptoms and those with milder symptoms.

According to Gage, understanding gene expression markers will ultimately help physicians determine the best course for treatment.

"This information is critical to shortening hospital stays and for lowering hospital inpatient admissions, freeing up resources for those patients who truly need hospital admission and ICU care," he says.

While current data suggests that the patient's age, gender and pre-existing medical conditions are contributing factors in the severity of the disease, little is known about the molecular mechanisms that correlate with disease progression and severity, Gage notes.

"If hospitals are able to have better resolution on which patient does and does not need to be admitted, based on a simple blood test or oral swab that probes for these markers, it would drastically decrease the burden on the health care system and make beds and ventilators available to those who need them," he says.

Chemistry Assoc. Prof. Matthew Gage, far right, prepares the COVID-19 test processing lab at Olney Science Center with worker Surbhi Mavi and lab co-manager Austin Boesch.

Other members of the team include Jack Lepine of the UML Next Generation Sequencing and Genomics Lab and Ph.D. students Pabodha Hettige and Prabath Meemaduma, as well as researchers from Lowell General Hospital, Versatope Therapeutics and MRN Diagnostics (a company headed up by alumnus Gregory Chiklis '92; see page 18).

In a separate project, Gage established a COVID-19 testing lab on campus that has allowed the university to expand its surveillance testing program to screen asymptomatic students, faculty and staff. The lab, which opened in February, can conduct polymerase chain reaction (PCR) tests on up to 700 nasal swab samples a day.

3 A QUICK AND SIMPLE ANTIBODY TEST

Noureddine Melikechi, professor of physics and dean of the Kennedy College of Sciences, is heading a team of researchers from UMass Lowell, McGill University in Montreal, Boston University and MRN Diagnostics to evaluate the use of laser in detecting antibodies to SARS-CoV-2. The team received $8,000 in seed funding to conduct the study.

"Our goal is to test whether the antibodies and the antigens can be successfully and reliably detected in human blood using a technique called laser-induced breakdown spectroscopy, or LIBS," says Melikechi.

According to Melikechi, the current numbers of confirmed cases worldwide do not accurately reflect the true number of infections.

"More serological testing is needed to screen greater segments of the population and get a more accurate picture of the spread of the virus. This information is critical as lockdown measures are being eased in various countries, including the U.S.," he says.

LIBS is a rapid, sensitive and cost-effective method that is used in a wide range of applications, including geology, biology, manufacturing, the food industry and forensic science. Melikechi and his research group have successfully demonstrated the use of LIBS in detecting biomarkers for both ovarian cancer and melanoma through a single drop of blood, as well as in analyzing the surface composition of the planet Mars.

LIBS uses intense pulses of laser to vaporize a small portion of the sample and produce plasma,which emits light that is read by a detector.

"The benefits of LIBS are that it requires only a very small blood sample and it's fast, with the potential to analyze up to hundreds of samples in an hour," says Melikechi.

Sciences Dean Noureddine Melikechi, left, with postdoctoral researcher Rosalba Gaudiuso in the laser spectroscopy lab prior to the pandemic.

"UML RESEARCHERS ARE FINDING **COVID-19'S INFLUENCES IN AREAS WE DIDN'T PREDICT WHEN THE PANDEMIC STARTED.** THAT'S WHY FUNDAMENTAL RESEARCH AT PUBLIC RESEARCH UNIVERSITIES LIKE UMASS LOWELL IS SO VITAL TO OUR SOCIETY."

—ANNE MAGLIA, ASSOCIATE VICE CHANCELLOR FOR RESEARCH ADMINISTRATION AND INTEGRITY

"IF HOSPITALS ARE ABLE TO HAVE BETTER RESOLUTION ON **WHICH PATIENT DOES AND DOES NOT NEED TO BE ADMITTED, BASED ON A SIMPLE BLOOD TEST OR ORAL SWAB** THAT PROBES FOR GENETIC MARKERS, IT WOULD DRASTICALLY DECREASE THE BURDEN ON THE HEALTH CARE SYSTEM."

—MATTHEW GAGE, ASSOC. PROF., CHEMISTRY

Chemistry Asst. Prof. Manos Gkikas, right, with Ph.D. student Shayesteh Tafazoli, who is holding a vial of gold-based nanoparticle contrast agent for use in X-ray spectral CT.

4 DETECTING COVID-19 THROUGH CT SCANS, NANOPARTICLES AND MACHINE LEARNING

A $9,000 seed grant was awarded to Chemistry Asst. Prof. Manos Gkikas, who is leading a consortium that is developing an advanced X-ray imaging technique to detect COVID-19.

The group, which includes researchers from UMass Lowell, UMass Medical School, Rensselaer Polytechnic Institute and MARS Bioimaging Ltd., based in Christchurch, New Zealand, is designing metal-based nanomaterial X-ray contrast agents that are detectable in CT scanners used in hospitals.

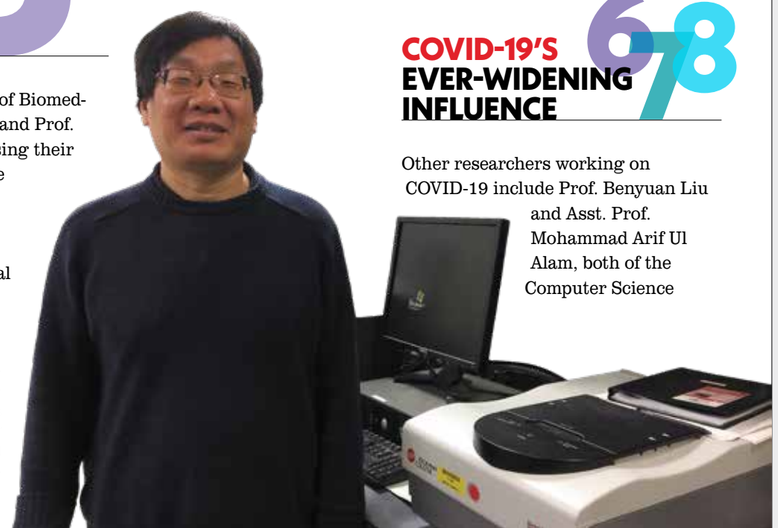
The contrast agents, which accumulate in the lungs based on molecular recognition, could significantly enhance the signal for early lung injury or COVID detection when imaged with a special, state-of-the-art type of CT scan, called "photon-counting spectral CT." Combined with machine learning, the resulting multicolor, 3D X-ray images generated by spectral CT could be used by radiologists and physicians to track the progress of lung inflammation–from mild symptoms to severe illness.

"There is currently no detection method that could monitor the progress of lung inflammation in patients from the moment of positive COVID diagnosis to severe illness," Gkikas says.

Gkikas is also using the same noninvasive imaging technology to improve the detection and diagnosis of breast cancer. The project, which is funded with a three-year, $750,000 grant from the Massachusetts Life Sciences Center, will use contrast agents that are specifically designed to recognize breast cancer cells and bind to them. The contrast agents will amplify the X-ray signal for tumors, enhancing their visibility in spectral CT scans.

5 ANTIVIRAL TREATMENT FOR PPE

Assoc. Prof. Nancy Goodyear of Biomedical and Nutritional Sciences and Prof. Yuyu Sun of Chemistry are using their $10,000 seed grant to test the effectiveness of N-halamine, a compound with proven antibacterial and antifungal properties, in treating personal protective equipment (PPE) for hospital workers.



Chemistry Prof. Yuyu Sun, shown here, is collaborating with Biomedical and Nutritional Sciences Assoc. Prof.Nancy Goodyear in developing germ-killing fabrics for hospital workers.

"PPE plays a vital role in protecting health care workers against COVID-19," says Goodyear.

Goodyear and Sun used the MS2 bacteriophage, a low-risk virus, as a surrogate to the coronavirus to test the effectiveness of N-halamine-treated PPE under simulated working conditions. The seed grant builds on the work the researchers have been conducting under a $417,000 grant from the National Institute of Occupational Safety and Health.

Contaminated hospital garments worn by nurses and other personnel, as well as linens, pillows, towels and privacy curtains, have been identified as sources of health care-associated infections.

"All of these have the potential to be contaminated with SARS-CoV-2 and serve as a source of transmission," says Goodyear. "Thus, reducing pathogens on textile surfaces should be an integral component of infection prevention to significantly minimize the burden of exposure."

"Preliminary results show that N-halamine fabrics do have antiviral effects against the MS2 surrogate," notes Sun.

6 7 8 COVID-19'S EVER-WIDENING INFLUENCE

Other researchers working on COVID-19 include Prof. Benyuan Liu and Asst. Prof. Mohammad Arif Ul Alam, both of the Computer Science Department. They are collaborating with the Solomont School of Nursing on a $10,000 grant to examine the experiences of frontline nurses by analyzing their posts in Facebook groups created by health-care professionals. The goal is to document the pandemic from nurses' perspectives and help inform future policy discussions related to nursing.

Biology Asst. Prof. Frederic Chain is working with researchers from the Francis College of Engineering, Zuckerberg College of Health Sciences and College of Fine Arts, Humanities and Social Sciences on a $15,000 grant to use advanced genetic sequencing and analytical techniques to track and monitor the prevalence of COVID-19 in the Greater Lowell region. The team will apply wastewater-based epidemiology to detect viral and human biomarkers of SARS-CoV-2 in raw sewage samples.

Jong Soo Lee, an associate professor of mathematical sciences, is part of a team led by Zuckerberg College of Health Sciences researchers that is developing a real-time tracking system of COVID-19 cases within the Veterans Affairs' health care database. The seed funding, which totals $15,000, will enable preliminary analysis of acute symptoms, patient characteristics and treatment outcomes.

"It's clear from the seed grants that UMass Lowell researchers are finding COVID-19's influences in areas we didn't predict when the pandemic started," says Anne Maglia, associate vice chancellor for research administration and integrity. "That's why fundamental research at public research universities like UMass Lowell is so vital to our society."

RESEARCH CHALLENGES IN A CHALLENGING TIME

From the campus shutdown to new lab restrictions to supply chain disruptions, researchers have faced a host of challenges in the race against time to combat the pandemic.

"All our projects are affected. We tried our best to do them concurrently and arrange time accordingly. Nevertheless, some projects are delayed, and we are grateful that our funding agencies are supportive and have been flexible, and granted us no-cost extensions for our studies," Sun says.

He also notes that some chemicals, replacement parts for lab instruments and other supplies are on extended backorder.

Gage says that though much of his team's work has been unaffected by the pandemic, as it involves data analysis conducted via a server, there is also a hands-on portion requiring extra vigilance.

"We have to take precautions in handling samples from COVID-19 patients prior to extracting the RNA we use for sequencing due to the highly infectious nature of the disease," he says.

Yan says UMass Lowell doesn't have the facility to handle live SARS-CoV-2, so she has to rely on her collaborators at UMass Medical School, home to one of the few labs in New England that can test the live virus.

"UMass Lowell's research committee has allowed us to work in the lab, initially at a very small capacity and then gradually to 25% capacity," says Gkikas. "University labs have plenty of space, which helps to maintain social distancing while working."

Gkikas never envisioned working on COVID-19 research, but the pandemic has become a priority.

"We saw the potential to help people and save lives," he says.

YOUR DROSOPHILA EMBRYOS ARE IN THE MAIL

KCS FACULTY AND STUDENTS FIND WAYS TO NAVIGATE REMOTE LEARNING IN THE WAKE OF COVID-19

BY ED BRENNEN

AS SHE PREPARED TO TEACH Developmental Biology remotely for the first time last fall, Asst. Prof. Jennifer Fish put together "care packages" for the 19 students enrolled in the lecture and corresponding lab.

Instead of candy, cookies and chips, though, these care packages included test tubes filled with fruit fly (drosophila) embroyos and dead fruit flies. They also included a Petri dish and a kit to make something called a "Foldscope," a simple but powerful $3 microscope made out of paper and a lens.

"I wanted students to be able to do something with their hands," says Fish, who mailed the packages to students who couldn't drop by campus to pick them up in person. "This pandemic is a challenging time for everyone, and I think students were appreciative of the attempt to make things interactive."

Foldscopes are just one of the innovative teaching tools that Kennedy College of Sciences faculty members adopted to make remote learning more hands-on and engaging for students during the COVID-19 crisis.

In his Honors Physics I lab, for instance, Assoc. Teaching Prof. Nikolay Lepeshkin had students use the video cameras on their smartphones to record objects, such as a bouncing basketball, and then analyze the motion on a program called Tracker.

Ekaterina Vorotnikova and Ekaterina Zagriadskaia, both assistant teaching professors of biology, had students conduct experiments on Labster, an interactive lab simulator that incorporates games and storytelling.

And for students in her Soil Science lab, Assoc. Teaching Prof. Lori Weeden organized a pair of socially distanced field trips with the help of Prof. Daniel Obrist, chair of the Environmental, Earth and Atmospheric Sciences Department.

Combating Zoom Fatigue

Last year, when COVID-19 unexpectedly forced the shutdown of campus midway through the spring semester, the university had just 10 days to move 2,700 courses online. It was a quick pivot for faculty and students to a learning platform that was new territory to many. Research conducted by the university found that before last spring's switch to remote learning, 48% of students surveyed had never taken an online course before.

Fish had students go out in their yards and scrape some lichen off a tree or rock, then rehydrate it in a Petri dish and examine it with their Foldscopes. Jamie Trimper, a master's student in biomedical engineering and biotechnology, found A TARDIGRADE, or water bear, which are known to have survived on Earth for millennia.

With the pandemic forcing students to absorb so much information on screens, finding ways to keep them engaged with their coursework—and also with one another—has become critical for faculty and administrators.

"I think all the students, as well as professors, are tired of Zoom," says Vorotnikova, who until this fall had never taught online in her 18 years at the university. "But what can we do? We are all learning how to manage together."

Eric Fan, a junior computer science major from Westford, Massachusetts, led a Student Government Association survey about online learning last fall. He says while 59% rated their remote learning experience positively, many students also expressed concerns about a lack of engagement and interaction in virtual classes.

"Most students clearly prefer an on-campus experience, but many plan to remain virtual until it is safe to be on campus because they value safety during this time," says Fan, who presented the survey findings to nearly 100 faculty members from across campus during a Provost's Excellence in Learning & Teaching (PELT) workshop over winter break.

Faculty Do Their Homework

Lepeshkin was among the nearly 400 faculty members who attended PELT workshops last summer to help prepare for the fall semester. He also received an iPad from the university to use while teaching from home—although he prefers to write out equations in chalk on the old-fashioned blackboard that's set up in his home office.

Although he felt more prepared heading into the fall, one challenging aspect was not meeting the 30 first-year students in his Honors Physics I course in person. Moving to remote learning in March 2020 was "quite a shock," Lepeshkin says, "but we had the advantage of in-person instruction for two solid months, so we knew the students."

To encourage interaction among his students—and ensure they were reading the textbook—he tried an online platform called Perusall, a collaborative e-book reader developed by researchers at Harvard University. Each week, he posted a chapter from the course's open-source textbook to Perusall, where students could read it and post questions and comments in a social media-style discussion board.

"I'm not big on social media, but it was a nice tool we can use to engage students," says Lepeshkin, who plans to continue using Perusall in future courses as a complement to the university's Blackboard learning management system.

Experimenting with Hands-on Learning

While smartphones are usually considered a distraction in the classroom, Lepeshkin encouraged his students to use them in a variety of experiments at home. In addition to recording videos, he showed them how to use their phones' GPS and other physical sensors to record and analyze their motion while taking a walk around their neighborhood.

"With GPS data, you get so much information to analyze," says Lepeshkin, who adds that having students conduct even simple experiments at home, like seeing if a full or empty can rolls faster down an incline, is "critical, because they get to make mistakes and correct them, which is what learning is all about."

Students even learn something by recording their own motion videos, he says.

"When they watch a video, they get everything digested. It's perfect and it works out. But if they try to make a simple video of some kind of motion, they discover how difficult it is," he says. "Once they make their own videos and analyze them, they get a sense of ownership."

Junior biology major Shelbi Gill, who took Fish's Developmental Biology course last fall, understands that sense of ownership. When Fish held a contest to see which student could get the best photo of a drosophila embryo with their Foldscope, Gill spent an hour trying to get the perfect shot. She won the contest and earned extra credit.

"Honestly, I didn't have a lot of hope for using the Foldscope, but I ended up getting a really good photo. It was amazing," Gill says.

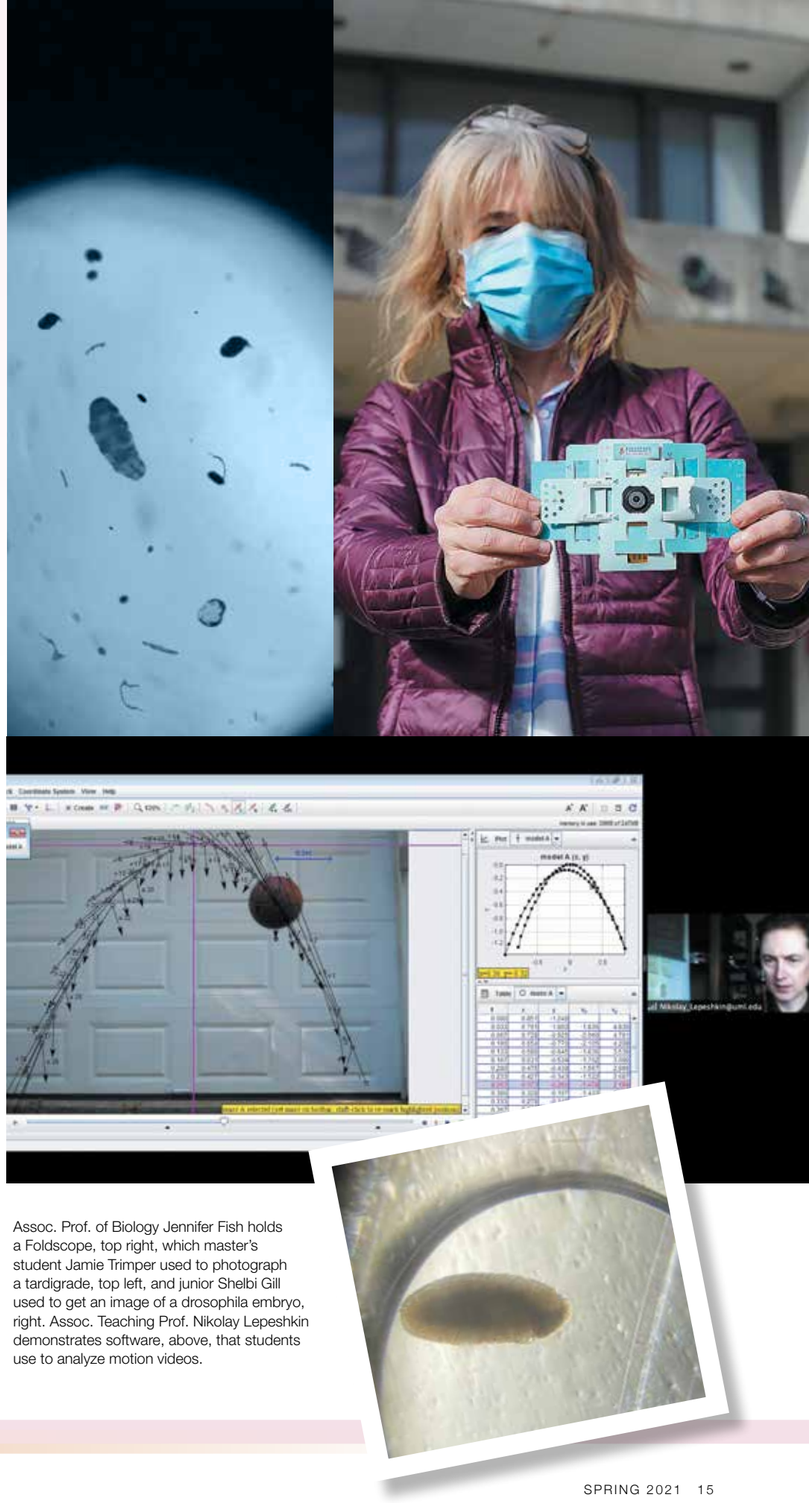
In another experiment, Fish had students go out in their yards and scrape some lichen off a tree or rock, then rehydrate it in a Petri dish and examine it with their Foldscopes. Jamie Trimper, a master's student in biomedical engineering and biotechnology, found a tardigrade, or water bear, which are known to have survived on Earth for millennia.

"Just to know you can find those in your backyard, people don't think about that," says Fish.

Now that Fish has been thrown into the deep end of online teaching, she says it's something she'd consider doing more of in the future.

"It had been in the back of my head, so in that regard, it has been very educational about how I would build an online class," she says, adding that she has learned that short modules are key. "When you're home with all these distractions, sitting for 45 minutes and listening on the computer doesn't work. It's better to say, 'Here's a 5- to 10-minute video on one concept, here's 5 to 10 minutes on the next.'"

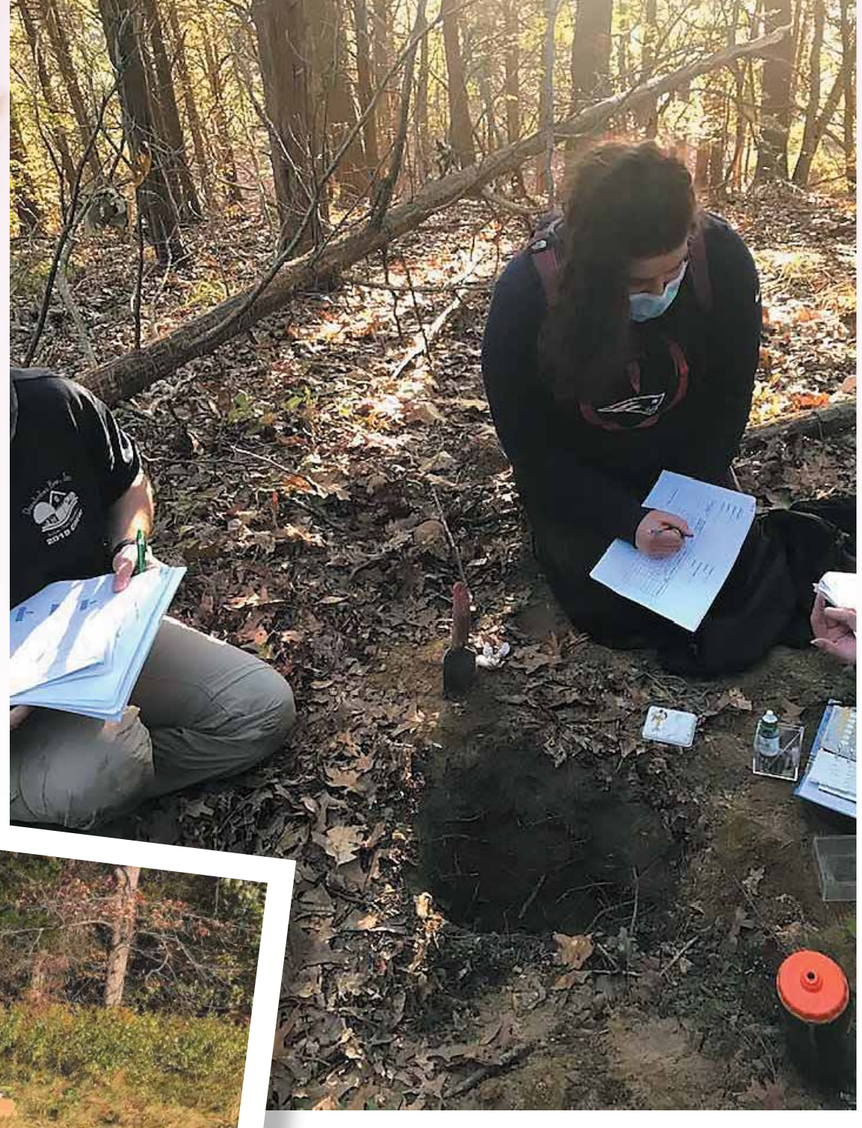
Gill, who took two other labs in the fall from her home in Acton, Massachusetts, says she appreciates how Fish encouraged students to get outside and explore their surroundings.



Assoc. Prof. of Biology Jennifer Fish holds a Foldscope, top right, which master's student Jamie Trimper used to photograph a tardigrade, top left, and junior Shelbi Gill used to get an image of a drosophila embryo, right. Assoc. Teaching Prof. Nikolay Lepeshkin demonstrates software, above, that students use to analyze motion videos.

"The students were like little kids in elementary school. They were so excited TO BE OUTSIDE. Everybody was masked up and distanced but they could still get in and do pH tests to see the differences in the soil."

—LORI WEEDEN



Soil sciences students Hayley Beal, above, and Sean Mooney and Paige Mead, left, take notes on collected samples during a field trip to a salt marsh in Newburyport, Massachusetts.

"We're given a lot of difficult work, and that's fine, but Dr. Fish did an amazing job of recognizing how different it is online and finding a solution to that," Gill says. "I hope other professors are able to find ways to engage students beyond just being in their rooms."

Digging Soil Science

While Soil Sciences was one of the labs held in-person on campus in the fall, Weeden says a half-dozen of the 30 enrolled students elected to take it remotely from home because of COVID concerns. So she made it a hybrid lab, with groups of 10 students alternating in the lab each week.

"Ensuring that students get the same thing out of labs both in person and online is a challenge," says Weeden, who found herself making instructional videos in her backyard for students, including one on how to take core soil samples with an empty tomato sauce can for a lab on bulk density.

The two field trips—to Hawk Valley Farm in Lowell and a salt marsh in Newburyport, Massachusetts—were "a great experience for everybody," Weeden says.

"The students were like little kids in elementary school. They were so excited to be outside," says Weeden, who took care to keep the groups small and spread apart.

"Everybody was masked up and distanced, but they could still get in and do pH tests to see the differences in the soil," she says.

Simulating Experiences

Weeden's students weren't the only ones getting their hands dirty. When Orrin McGrath arrived at the "crime scene," he found the murder victim lying on the floor in a pool of blood. After collecting the DNA samples he needed, McGrath went back to the lab to isolate and analyze the samples with a polymerase chain reaction (PCR) kit and a thermocycler.

"With the lab assistant, I had to go through each of the individual steps," says the senior biology major from Uxbridge, Massachusetts.

McGrath wasn't investigating a real-life murder, of course. He was completing a virtual lab simulation on Labster as part of his Biochemistry Techniques course with Zagriadskaia. Between that lab and his Immunology lab with Vorotnikova, he estimates he completed close to 20 Labster simulations during the fall semester.

"It was a very useful tool," says McGrath, who enjoys how the simulations actually take students inside the lab equipment they are using. "You get to see the molecular components and how the reaction is actually occurring."

And since some of those machines, like a flow cytometer or high-performance liquid chromatography system, can cost tens of thousands of dollars, it's equipment they might not get to use on campus.

Vorotnikova began using Labster three years ago in her microbiology lab to give students a safe way to work with dangerous viruses that they might encounter in a biosafety lab.

"They are the materials they will need in their future careers but that we cannot show them in the lab," says Vorotnikova, who decided to use Labster for the first time with the 58 students in her immunology labs last fall.

"Students love doing the simulations because it's like playing a game," she says. "But at the same time, they're answering questions, solving problems and diagnosing patients."

And while learning in a virtual laboratory can never replace the actual hands-on experience of using a pipette or properly staining a slide for a microscope, faculty in the Kennedy College of Sciences know that they will have to continue to be innovative until it's safe for everyone to return to campus.

"The main thing I've learned is you have to be adaptable—always," Fish says. "Even if you think you've planned what you're doing, the internet can go out or something won't work. Patience and flexibility are always great tools for any teacher."

"I think it's made me a better teacher," adds Vorotnikova. "We know more tools for teaching now, and we've expanded our minds for different kinds of teaching."

GREGORY CHIKLIS '92

BIOTECH EXEC FIGHTS COVD19 USING TOOLS HONED AT UML

BY DAVID PERRY

Gregory Chiklis has never been so busy.

The CEO and chief scientific officer of biotech company MRN Diagnostics, Chiklis has seen business skyrocket during the COVID-19 pandemic. The company, a provider of research products and services for diagnostic development, manufacturing and commercialization, has focused all of its efforts on COVID-related work for the past year.

"We pivoted the whole company," says Chiklis, who earned a Ph.D. in biochemistry from UMass Lowell in 1992. "Everything we do now is about helping people with COVID."

Just weeks into the pandemic, MRN joined forces with another company to work on a rapid COVID test. Developed in a matter of weeks, the resulting test is used to identify disease-fighting antibodies in those infected by the virus. It was quick and efficient and helped provide scientists with a far better picture of the progression of infection and recovery from the virus.

MRN, which is based in Franklin, Massachusetts, is now working with about 20 different companies to develop COVID diagnostics across multiple testing formats and technologies. It has expanded its lab space to meet increased demand. The growth is faster than anything Chiklis has experienced in his career.

"It's a matter of keeping up with orders of thousands of COVID antigen control packs each week," he says. "These are going out to pharmacies, doctors' offices and laboratories all over the country to calibrate instruments, train employees and control the quality of the COVID rapid testing results."

Gregory Chiklis (above) and with his wife Fadwah '91 (inset).

The company is also operating one of the busiest collection sites for convalescent plasma in the country. To date, it has gathered plasma from thousands of people who have recovered from COVID-19. Their plasma has antibodies that may help critically ill COVID patients fight the virus. MRN's efforts translate into 450 treatments added to the national stockpile of convalescent plasma each day, Chiklis says.

MRN also monitors COVID-19 testing in commercial labs to ensure the accuracy of results. The company sends blinded COVID sample panels to 1,500 labs across the globe a few times a year to test for correct measurements of antigen and antibody samples.

LIFE BEFORE COVID-19

Chiklis joined MRN in 2018, after 14 years as president and CEO of ZeptoMetrix Corp. His first job after earning his Ph.D. was with the start-up Hemagen Diagnostics.

During his career, Chiklis has developed thousands of research products and quality controls and played a role in the development of hundreds of diagnostic tests for various diseases and in the validation of millions of test results. He has worked on some of the most pressing global health crises, from severe acute respiratory syndrome to the West Nile virus to human immunodeficiency virus, work that helped prepare him for the COVID-19 pandemic.

Chiklis' roots in River Hawk nation run deep. His parents, Joan '54 and Charles '55, '56, '64 Chiklis, met while undergrads. His father earned bachelor's, master's and Ph.D. degrees in chemistry from the university. His mother earned a bachelor's degree in education.

Chiklis met his wife, Fadwah '91, on North Campus as he was starting to work on his doctorate. She was a senior majoring in chemistry with a class across the hall from his lab. He asked her out, and hoping to make a splash, he concocted a story that he was throwing a birthday bash for his roommate. The chemistry was right. They got engaged a year later.

"It's a matter of keeping up with orders of thousands of COVID antigen control packs each week. These are going out to pharmacies, doctors' offices and laboratories all over the country to calibrate instruments, train employees and control the quality of the COVID rapid testing results."

–GREGORY CHIKLIS

"I defended my thesis, started my first job and got married within two weeks," says Chiklis.

The couple has four children: Charles, 25, Alexander, 23, Victoria, 18 and Elizabeth, 9.

Chiklis grew up in Lexington, Massachusetts, which he describes as "a great community." The town's high school prepared him well for UMass Amherst, where he earned a bachelor of science in biochemistry in 1986.

When he was a student, Chiklis' father advised him to be good at "a lot of things, rather than being expert in one area."

He found a mentor at UMass Lowell in Prof. Edwin Jahngen, who helped him accomplish that.

"I wanted to make myself marketable for industry, and Ed showed me how to do that. I feel like he prepared me for so many things, and helped me prepare myself. He also taught me things about life, including taking time for my family and myself," he says.

Jahngen recalls that Chiklis wanted to "get moving."

He breezed through the coursework, but "the amazing transition occurred as he progressed in his research. He became more and more a scientist than a technician. It was a great transition to watch," Jahngen says.

Chiklis remains deeply involved with the university, serving on the Kennedy College of Sciences Advisory Board. He and Fadwah established an endowment in memory of his parents to provide scholarships to chemistry students. The couple was recognized in 2020 with University Alumni Awards.

Fadwah worked at Thermo Fisher Scientific before getting into the interior design business; she put the latter on pause during the pandemic when their daughter's school switched to remote learning.

Education has always been a priority for Chiklis and his family. He credits his years at UML with preparing him for career challenges, especially the unexpected ones like COVID-19.

"UMass Lowell has played a role in everything I've done," he says.

SHAKIRA FEDNA ‘23

FINDING A PATHWAY TO MEDICAL SCHOOL

BY KATHARINE WEBSTER

Biology major Shakira Fedna always aspired to be a doctor because of her mother’s struggles with diabetes and hypertension.

As a high school student, she sought out jobs where she could learn about health care, working as a sales clerk at a local drugstore and then as a pharmacy technician, a job she still holds.

When she was applying to colleges, one of the things that attracted her to UMass Lowell was the River Hawk Scholars Academy (RHSA), a supportive program for first-year, first-generation college students.

“I felt like I could find somewhere to fit in … and meet people with similar stories and similar backgrounds who could help me understand and navigate higher education, because I didn’t have anybody at home who could help me do that,” she says.

She got involved with other campus organizations for socializing and support, and joined MAGIC, the Medical Profession Admission Gap Initiative and Collaboration, a new program in the Kennedy College of Sciences, directed by Assoc. Teaching Prof. Khalilah Reddie, that aims to help students from groups that are underrepresented in the health professions.

Now, with Reddie’s encouragement, Fedna has won admission to the Baccalaureate M.D. Pathway Program that prepares UMass undergraduates who are first-generation, low-income or from underrepresented groups to go to UMass Medical School.

Fedna feels like she has found her calling.

“The doctor career fits my personality so well because I’m always looking to learn something new,” she says. “Doctors have to be lifelong learners. With every virus that comes out, every new disease and all the new medications, you learn something new every day.”

SHANICE KELLY ‘21

STELLAR STUDENT REACHES FOR THE STARS

BY KATHARINE WEBSTER

Shanice Kelly is devoted to stellar astrophysics, aerospace engineering and UMass Lowell’s space science program. She also cares deeply about getting more students of color involved in science, technology, engineering and math.

Kelly, a senior, is a leader in multiple student organizations, serving as president of Students for the Exploration and Development of Space and as vice president of the UMass Lowell Astronomy Club. She’s also an active member of the National Society of Black Engineers and the Black Student Union.

“I’ve been in leadership roles since high school. If I want to see certain things happen, it doesn’t seem right to leave it to other people to do them,” she says.

A first-generation college student, Kelly transferred to UMass Lowell after earning an associate degree in engineering at a community college. She started at UMass Lowell as a mechanical engineering student and then added a major in physics so she can apply to physics Ph.D. programs. She also added a minor in aerospace studies.

As a result, she had to extend her undergraduate career by a semester, but it’s worth it to her. And she can afford it, thanks to an Oprah Winfrey Scholarship that made it possible for her to come here.

Kelly also joined the UMass Lowell Honors College. In an honors seminar on space mission design, she designed a small satellite to NASA specifications.

“I loved that class,” Kelly says. “I designed a CubeSat with a CR-39 nuclear track detector to detect galactic cosmic rays, to get information to use for future space travel.”

Alumni and best friends Richard Giadone ’15 and Taylor Matte ’15, ’17 were part of a research team at the Center for Regenerative Medicine at Boston University’s Medical Campus that developed a rapid COVID-19 in just a week.

RICHARD GIADONE ’15, TAYLOR MATTE ’15, ’17

FORMER CLASSMATES HELP DESIGN QUICKER COVID TEST

BY DAVID PERRY

When it came time for Richard Giadone ’15 to defend his doctoral thesis at Boston University School of Medicine last year, he was flat-out exhausted.

Giadone had spent the previous week working around the clock with a team from BU’s Center for Regenerative Medicine developing a fast, simple and accurate test to detect COVID-19. It was March 2020, and the virus was taking hold across the country. Hospitals faced shortages of tests for the virus. Labs were overwhelmed.

“I was toast,” says Giadone, who was working on a Ph.D. in molecular and translational medicine.

One of Giadone’s coworkers on the project was his best friend and fellow River Hawk, Taylor Matte. The pair graduated from UMass Lowell with bachelor’s degrees in biology in 2015. Matte earned a master’s degree in biology from UML in 2017.

As part of the 50-person research team at BU, Giadone and Matte worked with people from across the university and Boston Medical Center, the primary teaching affiliate for BU School of Medicine, to come up with a test that produced results within 24 hours. It allowed the medical center staff to make quicker, better decisions about care for the growing number of COVID patients.

“The state of testing was a nightmare,” recalls Matte, now a Ph.D. student at BU’s School of Medicine. The best tests were taking five to seven days to yield results, leading to what he calls “insane backlogs.”

Working nonstop for a week, the research team developed a test that won emergency approval from the Food and Drug Administration. The test is simple. A health care provider does a nasal swab, then places the sample into a small amount of liquid. It goes to the lab, and the liquid is interrogated for its ribonucleic acid (RNA) and the possible presence of SARS-CoV-2, the virus known to cause COVID-19. This is performed through quantitative PCR, a method used by research labs across the globe.

“We had this collaborative come together, going from sample processing then testing, then interpreting the results and reporting directly to physicians,” says Matte, who wrote the software that allows the staff to read the results almost instantly. Delivering test results quickly helped doctors determine the best path for treatment. “The ICU physicians would know which patients to keep in the COVID unit and which would go to the non-COVID unit,” he says.

BONDED BY SCIENCE

Matte joined the BU research team in February 2017 after Giadone told him about an opening. A year later, Matte started the Ph.D. program. He expects to finish in 2023. His friendship with Giadone predates their time together at UMass Lowell. They were high school classmates in Dracut, Massachusetts.

The two merged like a covalent bond in an Advanced Placement Biology class. They sat in front, side-by-side, juniors in a sea of seniors. A mutual love of science made them best friends.

“I knew in preschool that I wanted to be a scientist,” Giadone says. “I always idolized scientists and had to know who they were.”

Both cite Biological Sciences Associate Teaching Professor Naomi Wernick as a mentor during their time at UML.

Wernick says she is “immensely proud” of Matte and Giadone, calling them “great guys and great students.”

“Taylor and Rich are two of my most memorable students, in the best way possible. They both are intelligent and incredibly hardworking,” she says.

Giadone, by the way, found a way to defend his dissertation without sleep. He is now enrolled in a post-doctoral program at Harvard.

PHYSICISTS MAKE SURPRISING DISCOVERY ABOUT NUCLEAR STRUCTURE

Research into Neutron Stars May Lead to Better Understanding of Universe

BY KATHARINE WEBSTER

Research Associate Daniel Hoff, left, and Assoc. Prof. Andrew Rogers at Argonne National Laboratory (March 12, 2020).

PHOTO BY SANJANEE WANIGANETHTHI

A funny thing happened to the strontium-73 nucleus on its way through the particle accelerator–and UMass Lowell researchers discovered it.

A research team led by Assoc. Prof. of Physics Andrew Rogers designed an experiment to learn more about a key isotope created during X-ray bursts on neutron stars—the dense, stellar objects formed by supernovae explosions of certain giant stars. In the process, they found evidence that the atomic nucleus of strontium-73, an isotope of the element strontium, has a different configuration than the nucleus of its "mirror partner," bromine-73.

It's the first time that such asymmetry has been found between a mirror pair of isotopes in their "ground state," or most stable, lowest-energy state. The discovery could help scientists better understand the make-up of the universe.

"The more we study the workings of neutron stars, the nature of these X-ray bursts, and also the properties of all of the isotopes that drive these explosions, the more we understand about the universe and its building blocks," Rogers says.

Mirror Pairs

In a mirror pair of isotopes, the total number of protons and neutrons in each nucleus is the same, with the number of protons in one the same as the number of neutrons in the other, and vice versa.

Although protons carry a positive charge and neutrons have no charge, they are otherwise nearly identical—so much so that both are referred to as nucleons. The forces that bind nucleons together into atomic nuclei are incredibly strong and symmetrical, and they are almost the same whether the individual components are protons or neutrons.

So the research team's finding of a different, asymmetrical configuration of protons and neutrons in the ground states of two isotopes that contain the same total number of nucleons presents an intriguing puzzle for nuclear theory, Rogers says.

"This experiment is pushing the boundaries of what we know about these exotic isotopes," he says. "In this case, the unexpected violation of mirror symmetry that we observed turned out to be very interesting."

The discovery was published in Nature in April 2020. Daniel Hoff, a post-doctoral research associate in the UMass Lowell Nuclear Physics Group who is now working at Lawrence Livermore National Laboratory was the lead author. The research, conducted at the National Superconducting Cyclotron Laboratory at Michigan State University, was supported by a $1.2 million grant from the U.S. Department of Energy.

The Nature article was followed by another in the American Physical Society's nuclear physics journal, Physical Review C, about the main focus of the research: The effect of rubidium-73, an isotope that results from the decay of strontium-73, on the crusts of accreting neutron stars.

Eight days at the Cyclotron

An accreting neutron star is one that is sometimes paired in a binary orbit with a more normal companion star. As they orbit around each other, the neutron star's strong gravity pulls hydrogen and helium from its stellar companion. This fuel continues to accumulate and burn until a runaway thermonuclear explosion ignites over the entire surface of the neutron star. The energy released in this massive explosion emits a burst of X-ray radiation, and these X-ray bursts create exotic and short-lived isotopes of certain elements.

Working around the clock over eight days at the cyclotron, a type of particle accelerator, the research team created more than 400 strontium-73 nuclei and then captured them inside a detector so that they could observe their behavior.

As strontium-73 decays, a proton in its nucleus changes to a neutron, creating rubidium-73, which is so unstable that it instantaneously sheds a proton and stabilizes as krypton-72.

The main goal of the research was to determine the mass of rubidium-73 by measuring the energy released when it flings off the extra proton. The mass of rubidium-73 helps determine the composition of the ash resulting from the thermonuclear explosion on an accreting neutron star.

The ash becomes part of the star's crust and affects its ability to conduct heat, so understanding its properties is important to astrophysics as well as to nuclear science, Rogers says. "The experiment helps us improve models of these X-ray bursts and of the atomic nucleus," he says. "It's one small piece of a bigger puzzle."

Other UMass Lowell members of the research team included Asst. Prof. Peter Bender, Emeritus Prof. C.J. Lister, former UML research associate Chris Morse, and graduate students Emery Doucet and Sanjanee Waniganeththi. The research team also included scientists from Michigan State, Ohio University and Argonne National Laboratory.

Evolutionary Biologist Asks a Lot about the Axolotl

Revered Mexican Salamanders Offer Clues to Evolution

BY KATHARINE WEBSTER

The Aztecs worshipped axolotls, salamanders native only to Mexico's Lake Xochimilco, as avatars of the god Xolotl, who transformed himself into a "water monster" to escape being sacrificed.

Scientists today prize axolotls (pronounced ax-uh-LOT-uhls) for their unique characteristics, says Biology Asst. Prof. Nicolai Konow. The amphibious creatures, which can grow up to 18 inches long, can regenerate almost any damaged body part; they have one of the largest and most complex genomes yet studied; they have lungs as well as feathery gills; and their pectoral and pelvic limbs have toes that help them scoot along the lake bottom.

(Left) Asst. Prof. Nicolai Konow describes the axolotl as the "linchpin in the evolution of land-based life." (Right, next page) Senior Mateo Rull works in the lab on axolotl research.

Axolotls have become popular exotic pets, but they are critically endangered in the wild. Although they are amphibians, nearly all axolotls spend their lives—up to 15 years—underwater in the larval stage, and never metamorphose into land-based adults.

Yet on rare occasions in the wild or under carefully controlled lab conditions, they can transition to live on land. They shed their feathery gills as their lungs mature; their back and tail fins shrink; and their skin color changes from speckled mud-green to a bright camouflage pattern remarkably similar to that of their close cousin, the tiger salamander.

Konow says it's like watching evolution on fast forward. As researchers study how the axolotl adapts and transforms, they can fill in gaps in our understanding of how the first creatures were able to leave the water and survive on land.

"This is a linchpin in the evolution of land-based life," Konow says.

At least three major systems must transform for axolotls and other amphibians to make that transition, Konow says: how they move, how they breathe and how they eat. Most functional biologists study changes in locomotion and lungs. Konow is breaking new ground by researching nutrition—how they capture their prey, break it down and then swallow it.

Using an X-ray video camera, Konow and his student researchers film the axolotls as they eat, focusing on the movements of the tongue and the muscles and tendons in the mouth floor. He then compares the feeding movements of pre- and post-metamorphosis axolotls to those of African lungfish, a distantly related group from a slightly earlier stage of evolution, and tiger salamanders, which evolved later and which axolotls so closely resemble in both life stages.

"We study how muscles contract, skeletons move and tendons stretch and recoil," he says. "The mature axolotl has to learn to capture, process and transfer food without water as an aid. From an engineering standpoint, that's a major threshold because water and air are so different—yet the axolotls have to use the same group of bones, muscles and tendons."

The larval axolotl eats much like the lungfish, using its tongue as a piston to suck in water and prey, push that prey in and out while slowly crushing it with its jaw and tongue, and then swallow it bit by bit. The adult axolotl eats more like the mature tiger salamander, snatching its prey from the air with a lightning-fast snap of the jaw and tongue, mashing it against the roof of its mouth with its tongue, and swallowing it in a couple of quick gulps.

Konow says the evidence his team has gathered so far points to a fascinating conclusion: As amphibians mature, the biggest adaptation involves how their tendons expand and contract, with smaller modifications in their muscles. It's marvelously efficient, he says, requiring fewer changes than if the muscles had to develop differently or the brain had to instruct them to "fire" in a different order.

His lab's latest research on axolotls was published in Journal of the Royal Society B. The lead author was honors biology and psychology student Mateo Rull, now a senior.

Rull, who grew up in Monterrey, Mexico, feels a special connection to the axolotls, which he cares for in the lab. "I fell in love with the axolotls, and that's what drew me into the research at first," he says. "They're so beautiful and so fascinating, and the Aztecs really revered them."

Faculty Success

ASST. PROF. REZA AHMADZADEH, Department of Computer Science, was awarded a $1.5 million grant from the Army Research Lab for the project, "Trust-NEARCHAT: Trust Network Emergence Amongst Resource-Constrained Human-Agent Teams."

ASST. PROF. REZA AHMADZADEH, PROF. HOLLY YANCO, AND ADAM NORTON, Department of Computer Science, received $1.2 million in funding from the U.S. Army Combat Capabilities Development Command.

PROF. MATHEW BARLOW AND ASST. PROF. CHRISTOPHER SKINNER, Department of Environmental, Earth and Atmospheric Sciences, received a $478,000 grant from the National Oceanic and Atmospheric Administration for "Observed and Modeled Interactions Between Droughts and Heat Waves for the Northeast U.S."

PROF. MIN HYUNG CHO, Department of Mathematical Sciences, was awarded $199,405 from the NSF for "Collaborative Research: On Some Fundamental Computational Issues in Simulating Interaction Models."

ASST. PROF. JENNIFER FISH, Department of Biological Sciences, received two grants in the amount of $612,440 from the National Institute for Dental and Craniofacial Research to continue oral disease and disorder research.

ASST. PROF. RICHARD GASCHNIG, Department of Environmental, Earth and Atmospheric Sciences, was awarded $284,610 from the NSF for "Collaborative Research: Tracking Novel Metal Isotope Signatures During Subduction Metamorphism."

–Gaschnig also received a $229,677 NSF award for the project "Resolving Mesoproterozoic Supercontinent Configuration with an Integrated Multi-tool Approach to Sedimentary Provenance Analysis."

ASST. PROF. NILHABJA GUPTA of the Department of Mathematical Sciences has received an NSF award of $139,984 for the project "New Directions in Bayesian Change-Point Analysis."

ASST. PROF. JAMES HEISS, Department of Environmental, Earth and Atmospheric Sciences has received $497,000 NSF grant for "Collaborative Research: Hydrologic Dynamics in a Coastal Aquifer During an Extreme Multi-Hazard Coastal Storm."

ASST. PROF. ARCHANA KAMAL of the Department of Physics and Applied Physics was named one of the Air Force Research Laboratory's 2021 Young Investigator Program awardees. She received a three-year grant totaling $450,000.

PROF. BENYUAN LIU, Department of Computer Science, received a $150,000 NSF grant for his research on "SCC-PG: Community-based Approach to Address Heavy Metal Contamination in Drinking Water Using Cloud-connected Smart Electrochemical Sensors."

ASST. PROF. FARHAD POURKAMALI, Department of Computer Science, was awarded $45,060 from the NSF for "Data Science Supplement for GOALI: Experimental and Computational Approaches to Tailor Properties of Additively Manufactured Semi-Crystalline Polymers."

–Pourkamali also received $35,334 from the NSF for "SBIR Phase I: Extrusion Quality Inspection with Machine Learning."

ASST. PROF. MICHAEL ROSS, Department of Chemistry, was awarded $379,505 from the Office of Naval Research for "Design of Resilient Materials for On-Demand H2-Generation from Potable, Grey, and Saline Water Flexibly Powered by Diverse Energy Sources." Co-PI is Chemistry Prof. David Ryan.

PROF. MARINA RUTHS of the Department of Chemistry was co-PI on supplemental (COVID-19-related) research within the NSF-funded Making WAVES: Disrupting Microaggressions to Propagate Institutional Transformation. The award amount was $229,635.

PROF. HOLLY YANCO was elected as senior member, IEEE and:

–named council member of the Computer Research Association's Computer Community Consortium.

–awarded $628,272 from the NSF for "Collaborative Research: CHS: Medium: Fabric-embedded Dynamic Sensing for Adaptive Exoskeleton Assistance."

–awarded $94,179 from the National Institute of Standards and Technology for "Development of Metrics and Test Methods for Characterization of Industrial Robot Perception and Adaptation."

–awarded $1,130,929 for "UA-1: DECISIVE: Development and Execution of Comprehensive Evaluations" from the U. S. Army Natick Soldier Systems Center.

–awarded $298,144 from the U.S. Army Combat Capabilities Development Command Soldier Center for "SLIMMER-3 (Soldier Lightweight Integrated Multifunctional Materials and Exoskeleton Research): EX5 - Mitigating Impacts of Explosive Ordnance Disposal (EOD) Personal Protective Equipment (PPE) on Wearer Performance via Exoskeleton Integration."

Publications

ASST. PROF. JUAN ARTES VIVANCOS, Department of Chemistry, co-author, "Unraveling the Excited-State Dynamics and Light-Harvesting Functions of Xanthophylls in Light-Harvesting Complex II Using Femtosecond," Journal of the American Chemical Society.

PROF. MATHEW BARLOW, Department of Environmental, Earth and Atmospheric Sciences, co-author, "Hydrometeorological Conditions Preceding Extreme Streamflow for the Charles and Mystic River Basins of Eastern Massachusetts," Journal of Hydrometeorology-American Meteorological Society.

ASST. PROF. FREDERIC CHAIN, Department of Biological Sciences, co-author, "crispRdesignR: A Versatile Guide RNA Design Package in R for CRISPR/Cas9 Applications," Journal of Genomics.

ASSOC. PROF. MATTHEW GAGE, Department of Chemistry, "The Poly-E motif in Titin's PEVK Region Undergoes pH Dependent Conformational Changes," Biochemistry and Biophysics Reports.

–Co-author: "Comparative Analysis of the Transcriptomes of EDL, Psoas and Soleus Suscles," BMC Genomics.

ASST. PROF. JAMES HEISS, Department of Environmental, Earth and Atmospheric Sciences, "Denitrification hotspots in intertidal mixing zones linked to geological heterogeneity," Environmental Research Letters.

ASST. PROF. RICK HOCHBERG, Department of Biological Sciences, co-author:

–"Elemental Enrichment of the Exoskeleton in Three Species of Tick," The Journal of Parasitology.

–"Remodeling of the Nervous System of the Indirectly Developing Rotifer Cupelopagis Vorax," Invertebrate Biology.

–"Modeling the Life History of Sessile Rotifers: Larval Substratum Selection Through Reproduction," Hydrobiologia.

PROF. ALEX KHEIFETS, Department of Mathematical Sciences, co-author, "Functions of Fuchsian Groups and Character Automorphic Subspaces of the Hardy Space in the Upper Half Plane," Operator Theory: Advances and Applications.

PROF. BENYUAN LIU, Department of Computer Science, co-author:
"Implementing a Socio-technical System for Computer-aided Tuberculosis Diagnosis in Peru: A Field Trial among Health Professionals in Resource-constraint Settings," Health Informatics Journal.

–"eRx – A Technological Advance to Speed-up TB Diagnostics," Smart Health.

–"Revenue Sharing in Edge-cloud Systems: A Game-theoretic Perspective," Computer Networks.

ASST. PROF. RACHEL MELAMED, Department of Biological Sciences, "Using Indication Embeddings to Represent Patient Health for Drug Safety Studies," JAMIA Open.

PROF. MATTHEW NUGENT, Department of Biological Sciences, co-author, "Lipid Raft Association Stabilizes VEGF Receptor 2 in Endothelial Cells, Molecular Pathology, Diagnostics, and Therapeutics," Advances in Endothelial Cell Biology.

PROF. DANIEL OBRIST, Department of Environmental, Earth and Atmospheric Sciences, co-author, "Environmental Controls on Ecosystem-scale Cold-season Methane and Carbon Dioxide Fluxes in an Arctic Tundra Ecosystem," BioGeosciences.

PROF. VIKTOR PODOLSKIY, Department of Physics and Applied Physics, co-author, "Subdiffraction Limited Photonic Funneling of Light," Advanced Optical Materials.

ASST. PROF. FARHAD POURKAMALI, Department of Computer Science, "Kernel Ridge Regression Using Importance Sampling with Application to Seismic Response Prediction," IEEE International Conference on Machine Learning and Applications.

–Co-author: "Scalable Spectral Clustering with Nystrom Approximation: Practical and Theoretical Aspects," IEEE Open Journal of Signal Processing.

–Co-author: "A Unified NMPC Scheme for MAVs Navigation with 3D Collision Avoidance under Position Uncertainty," IEEE Robotics and Automation Letters.

ASSOC. PROF. ANDREW ROGERS, Department of Physics and Applied Physics, co-author, "Mirror-symmetry Violation in Bound Nuclear Ground States," Nature.

PROF. JULIETTE ROONEY-VARGA, Department of Environmental, Earth and Atmospheric Sciences, co-author, "The Climate Action Simulation," Simulation and Gaming.

ASST. PROF. MICHAEL ROSS, Department of Chemistry, co-author, "Cu-Ag Tandem Catalysts for High-rate CO2 Electrolysis Toward Multicarbons," Joule.

PROF. MARINA RUTHS, Department of Chemistry, co-author:

–"Low-cost Visible-light Photosynthesis of Water and Adsorbed Carbon Dioxide into Long-chain Hydrocarbons," Chemical Physics Letters.

–"Bioinspired Self-assembled 3D Patterned Polymer Textures as Skin Coating Models: Tribology and Tactile Behavior," Biotribology.

PROF. ERNO SAJO, Department of Physics and Applied Physics, co-author, "Nanoparticle Enhanced Radiation Therapy—Principles, Methods and Applications."

PROF. KUNNAT SEBASTIAN, Department of Physics and Applied Physics, co-author, "Theoretical Models of Highly Magnetic White Dwarf Stars with Non-polytropic Equation of State," Journal of Modern Physics.

PROF. THOMAS SHEA, Department of Biological Sciences, "Tau Interferes with Axonal Neurite Stabilization and Cytoskeletal Composition Independently of its Ability to Associate with Microtubules," Biology Open.

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PROF. MENGYAN SHEN, Department of Physics and Applied Physics, "Conversion of Water and Carbon Dioxide to Methanol with Solar Energy on Au/Co Nanostructured Surfaces," Material Research Express.

–Co-author: "Carbon Isotope Effects in the Artificial Photosynthesis Reactions Catalyzed by Nanostructured Co/CoO," Chemical Physics Letters.

ASST. PROF. CHRISTOPHER SKINNER, Department of Environmental, Earth and Atmospheric Sciences, "Atmospheric River Changes Shaped Mid-latitude Hydroclimate Since the Mid-Holocene," Earth and Planetary Science Letters.

PROF. HOLLY YANCO, Department of Computer Science, co-author, "Building The Foundation of Robot Explanation Generation Using Behavior Trees," ACM Transactions on Human-Robot Interaction.

PROF. HOLLY YANCO AND ADAM NORTON, NERVE Center, co-authors:

–"Benchmarking Protocols for Evaluating Grasp Strength, Grasp Cycle Time, Finger Strength, and Finger Repeatability of Robot End-effectors," IEEE Robotics and Automation Letters.

–"A Standard Test Method for Evaluating Navigation and Obstacle Avoidance Capabilities of AGVs and AMRs," ASTM Journal of Smart and Sustainable Manufacturing Systems

–"Advancing Capabilities of Industrial Robots Through Evaluation, Benchmarking, and Characterization," "Recent Advances in Industrial Robotics.

ASSOC. PROF. ANNA YAROSLAVSKY, Department of Biological Sciences, co-author, "Temperature Induced Changes in the Optical Properties of Skin In Vivo," Nature.

Presentations

ASST. PROF. ARCHANA KAMAL, Department of Physics & Applied Physics, TEDx Talk, "Coming of Age with Quantum Mechanics," September 2020.

–IBM QisKit Seminar, "Generating and Characterizing Quantum Correlations in NISQ systems," December 2020.

ASSOC. PROF. RICK HOCHBERG, Department of Biological Sciences, presented "Preliminary Observations of the Schizomid Exoskeleton," the American Arachnological Society, July 2020.

ASSISTANT PROF RACHEL MELAMED, Department of Biological Sciences, presented "Drug-wide Association Studies of Cancer Using Real-world Health Data," AMIA Informatics Summit, March 2021.

PROF. HOLLY YANCO, Department of Computer Science, presented:

–"Going Cognitive: A Demonstration of the Utility of Task-general Cognitive Architecture for Adaptive Robotic Task Performance," 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems, October 2020.

–"Design of Human-Robot Interaction for Assistive Manipulation, Workshop on Robots for Health and Elderly Care: An Honest Discourse on the Gap Between Research and Practical Applications," IEEE/RSJ International Conference on Intelligent Robots and Systems, October 2020.

PROF. HOLLY YANCO AND ASST. PROF. REZA AHMADZADEH, Department of Computer Science, presented "Toward Mobile Multitask Manipulation in a Confined and Integrated Environment with Irregular Objects," Proceedings of the International Conference on Robotics and Automation, June 2020.

New Faculty

BIOLOGICAL SCIENCES
Asst. Prof. Teresa Lee
Asst. Prof. Rachel Melamed

COMPUTER SCIENCE
Asst. Prof. Hugo Alves Akitaya
Asst. Prof. Ruizhe Ma
Asst. Prof. Saeed Mehrabi
Asst. Teaching Prof. Mimi Tam

MATHEMATICAL SCIENCES
Assoc. Teaching Prof. Roser Gine
Asst. Prof. Paul Joris Roos

PHYSICS AND APPLIED PHYSICS
Asst. Prof. Erin Bertelsen

PARTING SHOT

Lab safety took on new meaning during the pandemic. Students and faculty in a microbiology lab observe COVID-19 and lab safety protocols.