UMASS BOSTON

UMB*Research*

INTRODUCTION

It is my distinct pleasure to introduce the inaugural issue of UMB*Research*, highlighting a few of the facets of UMass Boston's research profile. As Boston's public research university, we are committed to scholarship that embeds the creation of new knowledge within a larger mission of public good both locally and globally. The research and scholars profiled in this issue illustrate not just campus creativity but also some of the core institutional values such as diversity, environmental stewardship, sustainability, and urban engagement that embody this commitment and serve to motivate campus directions. The binding theme for this issue is the future, whether it is of emerging science and technologies, personalized medicine, the Boston harbor, or the demographic composition of the workforce and how campus research is both advancing knowledge and helping influence policy.

I am grateful for your interest and invite you to explore further on our website—**https://www.umb.edu/research**. Of course, if you happen to be in the neighborhood, feel free to stop in and engage the campus research community.

Sincerely,

Bala Sundaram, Ph.D.
Vice Provost for Research & Strategic Investments
Dean of Graduate Studies
Professor of Physics

ON THE COVER

Molecular, Cellular, and Organismal Biology (MCOB) PhD students Melissa Brown, Sayantanee Paul, and Heya Zhao are studying protein expression in Drosophila tissues using the Zeiss confocal microscope.

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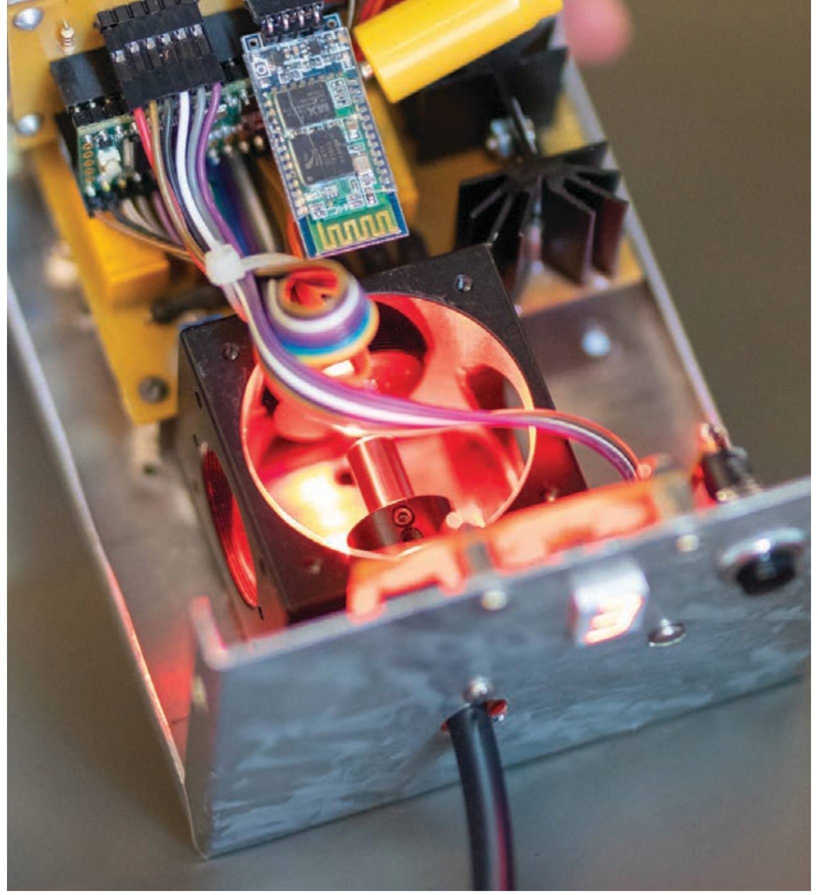
The Future of Cancer Research

BY LISA ALLEN

Red light is delivered through an optical fiber using a low-cost, portable device developed in the laboratories of Professor Celli and Professor Cuckov for photodynamic therapy treatment of oral cancer in resource-limited settings.

▶ Early prototype of battery-powered photodynamic therapy (PDT) device for oral cancer treatment



UMass Boston is shaping the future of cancer care at every stage, from prevention to detection to treatment. Cancer is the second-leading cause of death worldwide, causing 9.6 million deaths globally in 2018, according to World Health Organization estimates. Research groups across UMass Boston are committed to fighting cancer together, united in a culture of collaboration and focused on saving lives.

The research culture at UMass Boston thrives on interdisciplinary work. Scientists also extend their reach by leveraging a powerful network of partnerships with hospitals and academic research institutions around the world. Culture like this doesn't grow in a Petri dish. The following case studies show UMass Boston's research culture at work, from impact-driven project designs to interdisciplinary collaboration and wide-ranging partnerships that drive creativity, innovation, and results.

India has one of the highest rates of oral cancer in the world, largely due to the widespread popularity of chewable tobacco mixtures. The consequences are especially dire in rural areas far from medical facilities that provide surgery and radiation treatments. That health crisis motivated the Celli lab in the department of Physics and the Cuckov lab in the department of Engineering, both at UMass Boston, as well as Professor Tayyaba Hasan, co-pi at Massachusetts General Hospital (MGH), to work together on a low-cost device that would be portable and easy to use. The labs partnered to develop image-guided photodynamic therapy devices and technology to treat oral lesions, and ultimately developed an LED-based prototype that connects to a smartphone-based imaging-device for ease of use. The project originated with funding from the National Cancer Institute, and its current commercialization efforts receive funding from the UMass Office of Technology and Commercial Ventures. Alongside technology co-inventors at MGH, the labs recently filed a coversheet provisional patent application to protect their intellectual property while they work with an India-based commercial partner interested in licensing their technology. The prototype developed through this collaboration is being evaluated in an experimental clinical study at Aligarh Muslim University in India, which has treated about 23 oral cancer patients.

Professor Jill A. Macoska, director of the Center for Personalized Cancer Therapy (CPCT), and her lab are targeting a major obstacle to early diagnosis of the most common form of kidney cancer, renal cell carcinoma. The majority of small renal masses are malignant, and tumor metastasis is difficult to treat. However, there is currently no standard or specific method to detect or assess small renal masses. Macoska's lab is testing a non-invasive way to do just that: using urine to diagnose renal cell carcinoma. Her group's preliminary studies have identified an RNA signature in urine that distinguishes between cancerous and non-cancerous small renal masses, and also predicts which patients have the highest risk of developing metastatic cancer. This method could essentially diagnose patients without an invasive needle biopsy or exposure to harmful radiation-based imaging. The studies are in a validation phase using extensive urine samples obtained by physicians at the Dana-Farber Cancer Institute and Emory University.

Mutations in hereditary cancer genes BRCA1 and BRCA2 predispose women to a high risk of breast and ovarian cancer, while men with those mutations are predisposed to pancreatic and prostate cancer. Professor Shailja Pathania in the CPCT and her group are working to understand what early events drive normal cells in these mutation carriers to become tumor cells, and what factors allow tumors to resist chemotherapeutics. Pathania's group aims to design better preventive and therapeutic strategies using these insights. The group uses a variety of approaches including mouse models, cancer cells, and cells derived from breast tissue collected during prophylactic mastectomies to study BRCA1 and BRCA2, using resources including the CPCT Genomics Core facility at UMass Boston. The group is also collaborating with the Broad Institute of MIT on CRISPR and ORFeome-based whole genome screens to better understand the early changes that drive cancer.

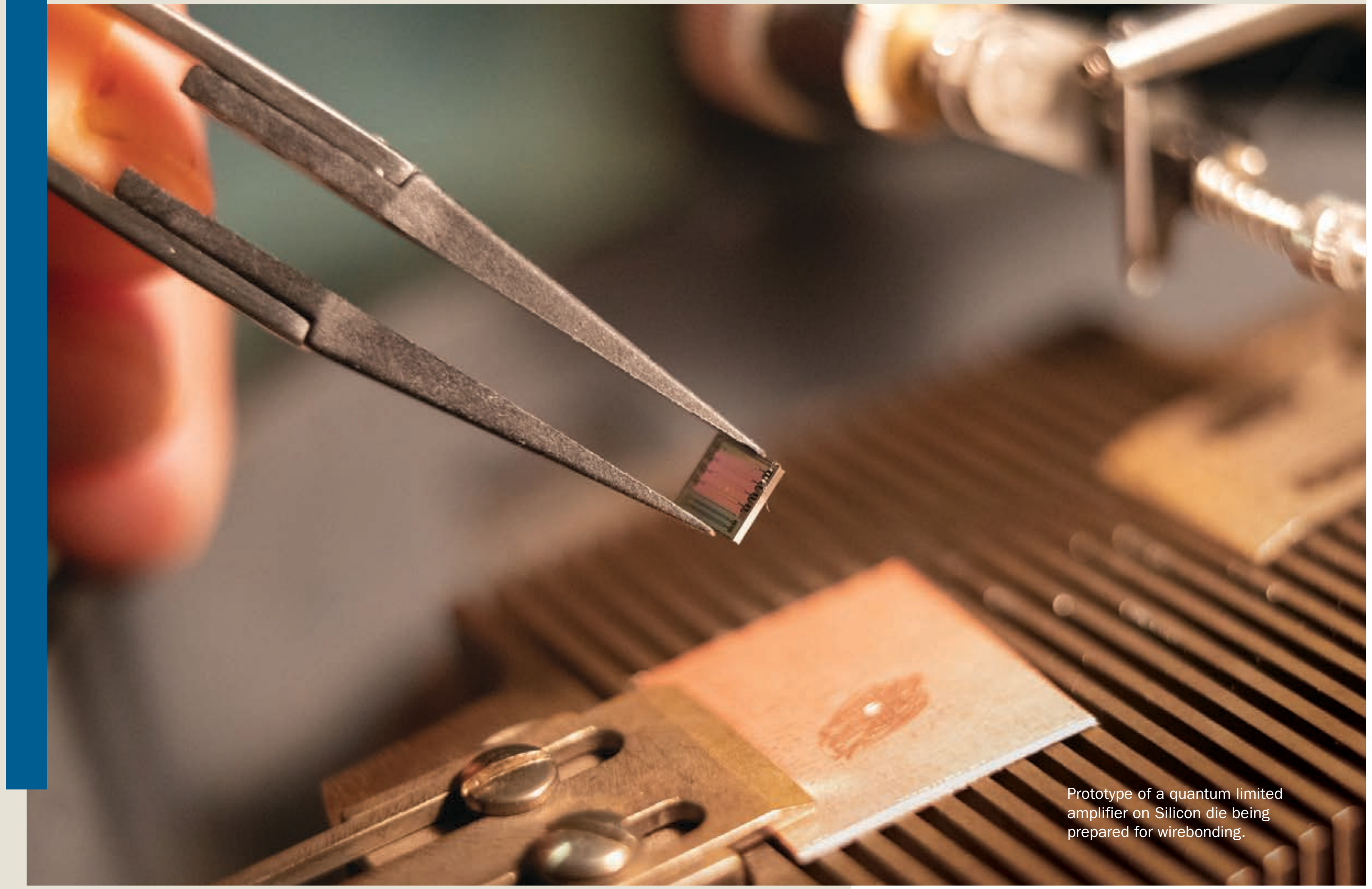
Prostate cancer is the second-leading cause of cancer-related death for American and European men, and UMass Boston is producing research breakthroughs with implications for prevention and treatment. Professor Changmeng Cai in the CPCT and his group are investigating the roles of androgen receptors in prostate cancer. His group conducted a paradigm-shifting study testing a variety of preclinical prostate cancer models and demonstrating that tumor growth can be effectively blocked using inhibitors of Lysine Specific Demethelase 1. That discovery promises to impact the development of novel treatments of advanced prostate cancer. Another project in his lab found a novel avenue of study that provided a solid mechanism to support the strategy of using high doses of testosterone to treat advanced prostate cancer. Cai's research has received funding from the U.S. Department of Defense and the National Cancer Institute. ■

◀ CPCT Postdoctoral fellow Mathilde Bonnemaison (right) and graduate student Alisa Zhilin-Roth (left) prepare kidney tumor cell protein for analysis.

▶ The Mexican Axolotl is used to study organ regeneration in Catherine McCusker's laboratory in the Biology department.

REGENERATIVE THERAPIES

Unlike most vertebrates, many salamanders can re-grow their arms and legs if they damage or lose their limbs. How do salamanders turn back time to make their cells behave like embryonic cells? Professor Catherine McCusker's research team in UMass Boston's biology department is studying an aquatic salamander species, the Mexican Axolotl, to answer that question. The team has observed major changes in the genetic landscape of the Mexican Axolotl's limb cells when those cells regenerate. One important discovery: regenerating cells unravel their DNA until it is "unpacked" and the genes are accessible to the cell. The McCusker team suspects that this process is essential to make the adult cells plastic and allow them to regenerate. The team is working to understand the molecular mechanisms that facilitate DNA unpacking, investigating specific types of marks on DNA and identifying the parts of the genome that are associated with those marks. These lessons from the Mexican Axolotl could be the key to new regenerative therapies for humans. ■



Prototype of a quantum limited amplifier on Silicon die being prepared for wirebonding.

Back to the Future:

Quantum Opinions

BY LISA ALLEN

Nearly a century old, quantum mechanics, a physical theory that describes the microscopic world, is experiencing a second youth. Physicists have long wondered whether the most counterintuitive predictions of quantum mechanics could actually be true. For example, quantum entanglement says that particles on opposite sides of the universe can be intrinsically linked to share information. Only in recent years has the technology necessary for answering such questions become accessible, enabling a string of experimental results showing that key predictions are indeed correct.

While theorists are still trying to interpret the meaning of quantum theory's mysteries—why the world is built in such a way that it can only be described by the strange rules of quantum mechanics—experimentalists are showing engineers how to exploit them. Earlier this year, the LIGO-Virgo network of gravitational wave detectors made what may be the first-ever observation of an apparent crash between a neutron star and a black hole. The network had just completed upgrades that improved the detectors' sensitivity using squeezed light—a true quantum effect that had eluded experimental demonstration until 1985.

"I think that is a good example of using quantum mechanics to increase what we can see in the universe," UMass Boston physics professor Christopher Fuchs (CF) said. Fuchs approaches quantum mechanics from the theoretical perspective, focusing on areas such as quantum information theory and QBism. When the theory of quantum mechanics was constructed in 1925, "you might say there was a turn where people said, 'Oh hell, what does this mean?' The attitude has changed from one of, 'Sober up and live with it' to 'What kinds of great things can we do?'" Fuchs said.

"This is an experimental science, which means there are things that we just need to accept without a reason, just to observe them," said Alioscia Hamma (AH), a professor in UMass Boston's physics department who studies quantum information and quantum entanglement theory. Fuchs and Hamma sat down on campus to discuss their vision of the quantum future, and how their work will shape it. The conversation is edited for length and clarity.

LA: What potential applications of quantum technologies excite you the most?

CF: What we do in the laboratory here, using quantum theory to design more accurate instruments, opens up a much bigger vision of the universe than we had previously. At the National Institute of

Professors Christopher Fuchs (left) and Alioscia Hamma (right), Physics department.

Standards and Technology and at some labs in Germany, people are working very, very hard to measure the exact wavelength of the colors of light that come from hydrogen. The theory predicts what the colors will be, that's not the issue. But can you build an instrument that checks the theory to the 18th digit or the 19th digit? You may think, if the theory has worked to calculate the first 17 digits, why do we really care to be able to check if it works for the 18th digit? Take the example of a faraway star with a little earth-sized planet going around it. Wherever the earth-sized planet is, it tugs the big star toward it. Consequently, there's something called a Doppler shift that makes that very precise wavelength of light go a little low, and then a little high, and then a little low, and a little high. You don't see it until about the 18th digit. If you can build instruments that are that accurate, you turn them up to the sky and look for little wobbles in stars, and every time you see a wobble, you say, "there's a planet there." The earth-based telescopes that are looking for stars use this method, that's really the future of it. By using these quantum technologies, you open a new window into the universe.

LA: Chris, you have created what's called QBism, a subjective interpretation of quantum mechanics, which removes the paradoxes that have plagued the field. What is it?

CF: QBism was initially an attempt to sharpen Niels Bohr's idea that quantum theory had more to do with information than had previously been appreciated. It's an understanding of probability along Bayesian lines, and it leans heavily on the results of quantum information theory to help us understand what quantum theory as a whole is about.

AH: If I may, I want to add something about this idea of information and quantum mechanics and why it is so important. In 1920, there was a very influential philosophy book by Alfred North Whitehead, The Concept of Nature. Whitehead maintains that theories of nature can always completely abstract from the fact →

that nature is in some relationship with an observer, so that you never need to make reference to the fact that someone is observing something. There is an idea that the observer in the act of observing is not a natural phenomenon by itself.

CF: Whitehead pointed out the normal way of thinking.

AH: Now the thing is, if there is one thing quantum mechanics tells us, it is that we cannot ignore the observer. We can only talk somehow about the relationship between the observer and whatever is being observed. The theory of nature is not just a theory of nature, but of this relationship.

CF: And I should have said that's what QBism is about. It's neither about nature all by itself, nor the observer all by himself, but the two of them together. That's what quantum theory is all about, the agent being immersed in nature.

LA: What kind of work is the UMass Boston QBism Group doing currently?

CF: For the most part, our effort goes into trying to find a different way of writing quantum mechanics that makes it absolutely clear that it's about probabilities. To get there requires some mathematical steps that no one knows how to do yet, so most of our work is really devoted to exploring that mathematical question.

LA: What is quantum theory telling us about nature and our place in it?

AH: Before quantum mechanics, the human being was completely inessential to nature. The most dramatic outcome of this view is that basically, it implies the complete collapse of the notion of value, morality, religion, meaning. In other words, if everything is made of atoms and molecules that just travel in space according to some given laws, and humans are just that, then there is no meaning to anything. It just is what it is. We're pieces of matter that travel in space. This has had dramatic cultural consequences. Either it brings about some form of nihilism or, which is the case because societies still exist, some sort of schizophrenia. How do we think about the human being in the quantum world? We have no idea. We actually do not have a vision of what a human being is, knowing that quantum mechanics is the best thing we can say about nature. I think this is huge, it's something that people should think about and talk about.

LA: What area of physics, in your opinion, is likely to spark the next revolution in quantum thinking?

CF: We actually think we are it. Look, Alioscia is saying that quantum physics has implications on how we understand what it means to be human. That's a very, very big thing.

AH: I think there is also another mission that we all do, even when we do not think of it as a mission. Here at UMass Boston, we teach quantum mechanics to our students, even when we don't teach it formally in a class. Because we are probably at the dawn of a new industrial revolution based on quantum technologies, we need people who have some idea about quantum mechanics even when they're not quantum physicists. If they have some way of thinking where quantum mechanics does play a role, they can imagine new applications. I think that being taught quantum mechanics in the right way, without metaphors that make it sound like a bad sci-fi movie, actually can be very useful for practitioners and entrepreneurs who will bring these technologies to their full ability.

▶ Professors Walter Buchwald (left) and Matthew Bell (right) of Engineering department are discussing new device designs for the exploitation of quantum phenomenon.

EXPERIMENTAL APPROACHES:

From Quantum Computing to Spectral Signatures

Beyond illuminating what is in the stars and what it means to be human, quantum theory has a tangible influence on the world around us. "All modern technology owes something to the quantum theory: computers, cell phones, lasers, communications," UMass Boston engineering professor Matthew Bell (MB) said. Leveraging these technological advances, Bell and his colleague Walter Buchwald (WB), also an engineering professor at UMass Boston, are conducting experiments to guide the quantum mechanical principles of the 1920s into the future. Their research has applications related to a powerful emerging technology: quantum computing. "Quantum computers are good at solving difficult problems which are out of the reach of classical methods of computation," Bell explained. A quantum computer is exponentially faster than a classical computer because it stores information in qubits, the quantum analogue to a bit. A bit in a classical computer stores information in a zero and one, as one piece of information. A quantum computer, on the other hand, stores quantum information, which is represented as a superposition that can be one and zero at the same time. That property massively increases processing power, since doing one operation on a quantum computer is like doing that operation to all of the possibilities at the same time. Buchwald specializes in quantum photonics, conducting non-classical experiments focused on single photons. "If you can generate a single photon and control the single photon, you can do quantum computing," Buchwald said.

Bell and Buchwald explained how their research fits into the quantum revolution, and where they think it's all going. The conversation is edited for length and clarity.

LA: What possible applications of quantum computing excite you the most?

WB: If you ask where it's going to go, probably where everything is going, which is into deep learning and artificial intelligence. That's the future. Quantum computing solves problems not by asking what will happen, but by asking what is the probability of a specific event happening.

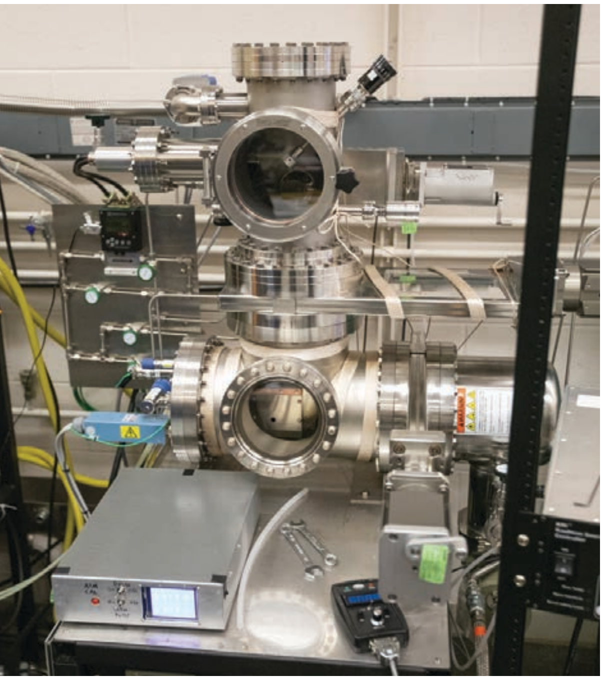
MB: Look at situations where you're processing large data sets, like the data Amazon collects about you, Google, Facebook. How to find patterns, how to find trends in this large amount of data? Even if you scale classical computers out ten to twenty years or beyond, the power of those computers is just not enough to solve these problems. That's where this quantum computer comes in.

LA: Matt, how will your qubit research help usher in the age of quantum computing?

MB: Qubits are very fragile. Anything can disturb them. Since they're so fragile, you have to probe them with very small signals and read out very small signals to not destroy the quantum state that's stored in them. When you store quantum information in the qubit, it can only stay in the qubit for so long. When you're doing operations on the qubit, trying to control it or read it out, it destroys the coherence of it. The type of qubits I work with have a protected state. Mainly, we're trying to get these qubits to work, to extend their coherence in the protected state, and then prove that we can actually store the qubits in the protected state, perform gate operations on them in the protected state, and then read them out.

LA: What experimental challenges do you face in your quantum mechanical research?

MB: Qubits are very fragile no matter what domain they live in. In my domain, you have to cool them down to very low temperatures like 20 millikelvins, almost near absolute zero. The experimental challenge for me is cooling to lower temperatures. In the past, to cool down these chips, you had to use liquid helium. It's very expensive, and helium is in short supply, it's somewhat dangerous, there are people that burn their hands with it. They've made refrigerators now where you don't need to cool with liquid helium. We have such a system here, so some of the challenges of cooling down have been →



▲Ultra-high vacuum deposition system used for quantum circuit fabrication.

removed. The advent of these new types of refrigerators that just run on electricity is advancing the field quite a bit.

WB: You have to understand, the refrigerator is as big as this room.

MB: It's still challenging compared to room temperature.

WB: It takes a day, two days to cool down, which makes experimental research difficult. The advent of present-day refrigerator technology fuels those qubit technologies that require ultra-cold temperatures; however, room temperature qubits are being investigated.

LA: Beyond quantum computing, what other applications do you see for your quantum research?

WB: I exploit quantum phenomena that do not require ultra-cold temperatures, such as single photon generation and detection. Single photons are required for ultra-secure communication networks, and are used to investigate a host of quantum mechanical concepts that have no classical analog. My research is also applied to a variety of techniques related to the non-linear generation, detection, and control of photons for use in remote sensing applications.

MB: I work on low-noise amplifiers that can also be used for astronomy applications, if people have very weak signals from distant galaxies that they have to measure.

LA: Walter, what applications are you working on in partnership with Solid State Scientific Corporation?

WB: They are funding me to build a machine that pairs frequency comb laser spectroscopy with a holographic image of a cell. This is done to train a cloud-based artificial intelligence to identify pathogenic, or "bad" cells, which can then be used for the remote identification of pathogens. The technologies that allow this work to take place are based on long-standing quantum mechanical principles to the point of becoming commonplace; however, it is in the ability to show correlations between such massive amounts of data through quantum-computer-based artificial intelligence that has the greatest quantum technological potential.

LA: How do you get undergrads involved with your research?

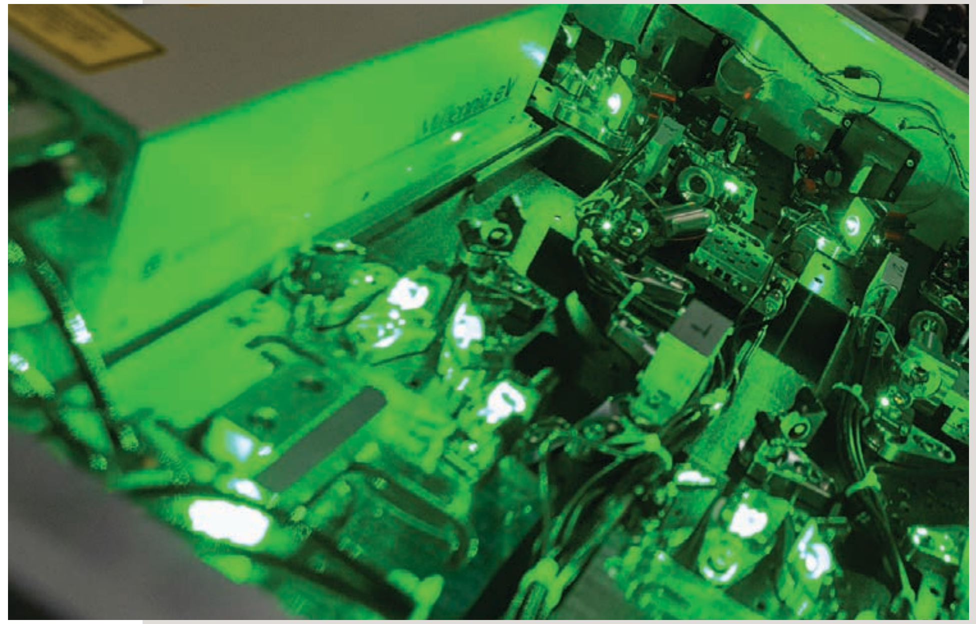
MB: At most universities, it's usually PhD students and postdocs working in this line of research, just because there's such a large learning curve to become proficient at it. Fortunately, on the experimental side, there are actually a lot of components that go in, it's not just quantum physics. For the undergrad students we work with, we get them making circuits for measurements, or learning how to do a fabrication recipe in our clean room, one piece of the bigger project. They do get hands-on exposure. There are companies out there that are not in quantum physics, but they're in the fabrication of coating to go on a window or something like that, and they use a lot of the similar processing that is used to make these chips. They like to see students with some experience, so it helps them get jobs.

LA: You have also done outreach with middle and high school students. How do you get students in that age group excited about quantum research?

MB: We have one project with National Science Foundation grants for mainly 9th–12th grade students. We do demonstrations, show them something that's very small with the atomic force microscope, and then show some quantum mechanical properties that happen at that scale. There aren't a whole lot of courses in this field for undergrads, and there isn't much of it in high school science classes, so how to get students involved with it and exposed to it? It's kind of like a chicken and egg problem. You've got to commit to this area for graduate school before you're even exposed to anything in the area. This grant and this project were born to expose students to nanotechnology and quantum technology at a younger age.

LA: Walter, you have worked on projects with space-related applications. Have you ever looked up into the sky and seen something you worked on?

WB: Actually, yes. I was responsible for the manufacturing of the power amplifier that went into the Iridium satellite system's main mission antenna. If you know where to look at night, you can see sunlight glinting off the satellite's antenna. ■



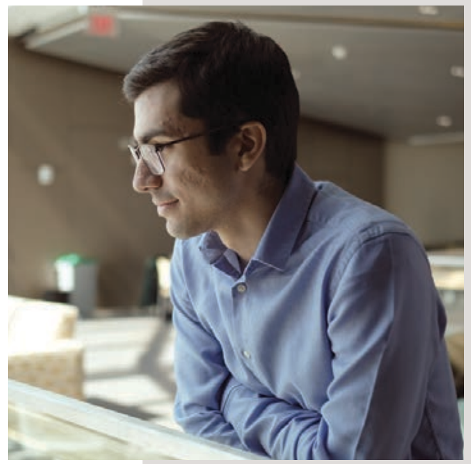
▲Ultra-short pulse, mode locked laser system used for laser spectroscopy to characterize and investigate quantum system.

LASER TAG

Greg Sun (GS), an experimental researcher and founding chair of the department of Engineering at UMass Boston, is focused on developing optoelectronic devices—devices using optical technology—that can be integrated with electronic devices. The goal is a so-called super chip that combines the best of both worlds for applications such as communications, thermal imaging, and environmental monitoring. Given the hype around lasers, I had to ask:

LA: Is working with lasers as cool as it sounds?

GS: Yes, indeed. Lasers were invented in 1960. At the beginning, they were ruby crystal and gas lasers that are bulky, heavy, and power hungry. Semiconductors changed all that. Laser diodes made of III-V compound semiconductors are compact, lightweight, and easy to operate, but they are not compatible with Si electronics, which makes them hard to be monolithically integrated with silicon chips. Silicon is a difficult material to work with for making lasers, but the payoff is huge. We are a part of a multi-university team funded by the Department of Defense to develop silicon-based optoelectronic devices including lasers. With some luck, we could be the first to demonstrate the first silicon-based laser diodes, and how cool is that? ■



▲ Photo of Joseph Farah is taken by Victor Ho, UMass Boston student.

STUDENT SPOTLIGHT:

JOSEPH FARAH

In his time as a physics major at UMass Boston, Joseph Farah has done everything from coding for quantum mechanical research to hunting black holes with the Event Horizon Telescope. UMass Boston physics professor Christopher Fuchs described meeting Farah as a "promising and always enthusiastic" student in his modern physics course and bringing him into the QBism Group, where he became a productive teammate. "He loves to code," Fuchs said, explaining Farah's work on a software suite designed to solve equations more efficiently in service of a difficult mathematical question. Farah is grateful to the UMass Boston professors who have helped him satisfy his fast-paced ambitions. "Working in an on-campus lab with one of the best research groups in the world has enabled me to learn about the research process quickly and productively," he said. Beyond his on-campus research, Farah is a Smithsonian Fellow at the Harvard-Smithsonian Center for Astrophysics. As the only undergraduate member of the Event Horizon Telescope Collaboration, Farah was part of the team that captured the first-ever image of a black hole. Going forward, he aspires to earn a doctorate in physics and pursue a career in academia. Farah made UMass Boston history this year as one of the first two students to win the Barry M. Goldwater Scholarship, one of the most prestigious awards for undergraduates in the sciences, mathematics, and engineering. See page 20 for a profile of UMass Boston's other winner, Sarah DuBois-Coyne. ■

Left to right: Professors Adán Colón-Carmona and Rachel Skvirsky (Biology department), Richard Fleming (department of Exercise and Health Sciences), S. Tiffany Donaldson (Psychology department and Honors College), Ling Shi (department of Nursing) and Megan Rokop (Honors College).

Careers for the Future

BY LISA ALLEN

UMass Boston offers exceptional opportunities for undergraduates to participate in scientific research. Hands-on experience can help students decide whether they want to pursue careers in science, and it provides a crucial edge when the time comes to apply for graduate programs or jobs. Case in point: UMass Boston student Sarah Mansour ('19), who is completing research on DNA-damage repair in BRCA1 and BRCA2 hereditary breast and ovarian cancers in Shailja Pathania's lab. Mansour will enter a PhD program in biochemistry, cell and developmental biology at Emory University in the fall.

Mansour's research experience was facilitated through a mentoring program called the Initiative for Maximizing Student Development (IMSD). The National Institutes of Health (NIH) founded IMSD in 2008 to prepare students from disadvantaged backgrounds or groups underrepresented in the sciences for PhDs and biomedical research careers. Last year, the NIH granted UMass Boston biology professors Rachel Skvirsky and Adán Colón-Carmona an additional $1.3 million five-year grant to continue implementing the program.

IMSD takes UMass Boston students beyond the realm of textbooks and in-class experiments to participate in the latest scientific inquiries. IMSD Junior Scholar Keith Ameyaw ('21) is investigating the regulation of zebrafish gonad development in Kellee Siegfried's lab, while Senior Scholar Shayla Newman-Toldeo ('21) is examining the regulation of meiosis in budding yeast in Linda Huang's lab.

Beyond these guided research experiences, IMSD fellows participate in training activities such as intensive mentoring, networking events with scientists from diverse backgrounds, and workshops on communication in science, ethical conduct of science, issues facing minorities and women in science, and other elements of research careers.

"As an immigrant, the mentorship, support, and guidance I have received through IMSD has helped me develop a sense of belonging and community in science that I had not found before," former IMSD fellow Leslie Torres said.

Another avenue for undergraduates to participate in research at UMass Boston is the Caregiver and Child Health (CatCH) Scholars Program. The NIH recently awarded a multidisciplinary team of scientists at UMass Boston—Megan Rokop, Honors College; S. Tiffany Donaldson, Psychology department and Honors College; Ling Shi, department of Nursing; and Richard Fleming, department of Exercise and Health Sciences—a $500,000 five-year grant for CatCH, which mentors undergraduates and trains them for careers in the science of caregiver, child, and family heath.

The team behind CatCH designed the program to address the severe disparities in heath behaviors, health care quality, and outcomes in African-American, Latinx, and American Indian/Alaska Native populations documented by Healthy People 2020, a federal initiative that tracks national health objectives. One strategy for closing those gaps is increasing the number of scientists and professionals from those populations.

CatCH runs intensive 10-week summer research programs that engage diverse cohorts of UMass Boston undergraduates in a core program that builds skills in areas such as statistics and data analysis, and in faculty mentors' research projects.

The 2019 program paired CatCH Scholars Kristine Guo and Tuyet Nguyen with Teri Aronowitz, a professor in the Department of Nursing who is interested in promoting health and preventing substance misuse among Native American youth. The CatCH scholars will help Aronowitz develop an addendum to a Centers for Disease Control and Prevention-approved substance abuse intervention. They will be involved in focus groups with elders of Native American communities, and they will also help the research team develop an intervention manual for Native American college-aged interventionists to use with middle-school-aged Native youth this fall.

Another pairing will allow CatCH Scholars Isabella Mia Antenucci and Yessica Guzman to work with Maria-Idalí Torres, a retired professor from the Department of Anthropology, as she researches Puerto Rican mothers' perspectives about the role of fathers in parent-child communication about sexual health.

The next generation of scientists is at UMass Boston, where CatCH, IMSD, and a variety of other programs prepare students for the realities of careers in research. ■

▲ **Left to right:** Undergraduate student Songi Kim and Clinical Psychology graduate students Lana Andoni and Looknoo Thammathorn, with professors Abbey Eisenhower and Alice Carter of the Psychology department.

BUILDING RESOURCES TO TEACH CHILDREN ON THE AUTISM SPECTRUM

ADDITIONAL REPORTING BY COLLEEN LOCKE

When their research found that many teachers feel underprepared to help students on the autism spectrum succeed in the classroom, a team of UMass Boston professors decided to take action. Abbey Eisenhower, Alice Carter, and Mel Collier-Meek, professors with expertise in psychology, and their collaborators received a $1.4 million grant last year from the Institute of Education Sciences to help improve outcomes for elementary school children with autism spectrum disorder. The team is working on a project called the Smooth Sailing Study alongside collaborators at the University of California – Riverside, including principal investigator Jan Blacher, focusing on general education classrooms. The end goal is to develop a training program that will help young students find a smooth transition to school by promoting close, low-conflict teacher-student relationships. The Smooth Sailing Study includes teachers as collaborators and consultants to make sure its recommendations are relevant to their day-to-day needs in the classroom. The rates of autism spectrum disorder diagnoses for children have increased over the past two decades—one in 59 children now meets the criteria for a diagnosis—making this project more important than ever. ■

Professors Ellen Douglas (left) and Paul Kirshen (right), School for the Environment, overlooking Dorchester Bay.

FUTURE OF US: Climate Change Resilience

BY LISA ALLEN

Boston is highly vulnerable to the effects of climate change, including coastal storms, rising sea levels, flooding, and extreme heat. By 2070, the ocean could rise as much as three feet from its year-2000 level, according to a 2016 report from City Hall's Climate Ready Boston initiative. That outcome could expose more than 88,000 Boston residents to flooding that has a 1 percent chance of occurring in any given year, and it could cause an estimated $1.39 billion in annualized losses from property damage, relocation costs, and other factors, the report projected.

UMass Boston researchers are integral to the city's climate change preparedness. For more than a decade, Ellen Douglas and Paul Kirshen, professors in the School for the Environment, have been working with the City of Boston and other coastal communities to address vulnerability to coastal flooding and to develop climate resilient strategies. Most recently, Douglas and Kirshen led the Boston Research Advisory Group (BRAG), which evaluated the climate change impacts specific to Boston. The BRAG report initiated and informed the city's Climate Ready Boston strategies. In addition, among other publications, they co-authored "Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options for the Central Artery" and "Preparing for the Rising Tide", highly influential reports. Douglas and Kirshen are currently expanding their research for a broader climate report encompassing the Greater Boston area, collaborating with UMass Boston's Urban Harbors Institute and the Metropolitan Area Planning Council.

Building infrastructure to protect against climate change can be speculative and expensive, and UMass Boston researchers have helped distinguish promising ideas from boondoggles. Harbor walls are gaining popularity worldwide as a way to mitigate storm surges and flooding. Kirshen led a study concluding last year that the billions of dollars and decades of construction required for a harbor barrier would not be practical for Boston.

In the News: Making the Call on the Harbor Wall

"Building a massive barrier wall in Boston Harbor to protect the city from the increasing risk of flooding isn't worth a price tag that could reach $11 billion, according to a new study for a City Hall-led commission. A research team at the University of Massachusetts Boston's Sustainable Solutions Lab said the city should instead focus on smaller, shore-based projects, estimating it would take at least 30 years to build a wall while the need for solutions is far more immediate."

-The Boston Globe, "The next Big Dig? UMass study warns Boston Harbor barrier not worth cost or effort," May 29, 2018

"Boston could revisit the barrier idea in a few decades, when the impacts of those cheaper alternatives could be measured and technological advances might make a harborwide barrier more feasible, Paul Kirshen, the UMass-Boston professor who led the project, said in an interview ahead of the report's release Wednesday."

-The Associated Press, "Report: Boston harbor barrier could take 30 years, cost $12B," May 30, 2018

"The city's shift away from a big sea wall was sparked in large part by research at the Sustainable Solutions Lab at the University of Massachusetts, Boston. The aptly named 'Feasibility of Harbor-wide Barrier Systems' report laid out the time and expense of a wall — along with a host of navigational and environmental issues.' We found that, dollar for dollar, we could have the same amount of protection for much less cost, and in doing so also invest in our neighborhoods and have more green space,' said Rebecca Herst, director of the lab."

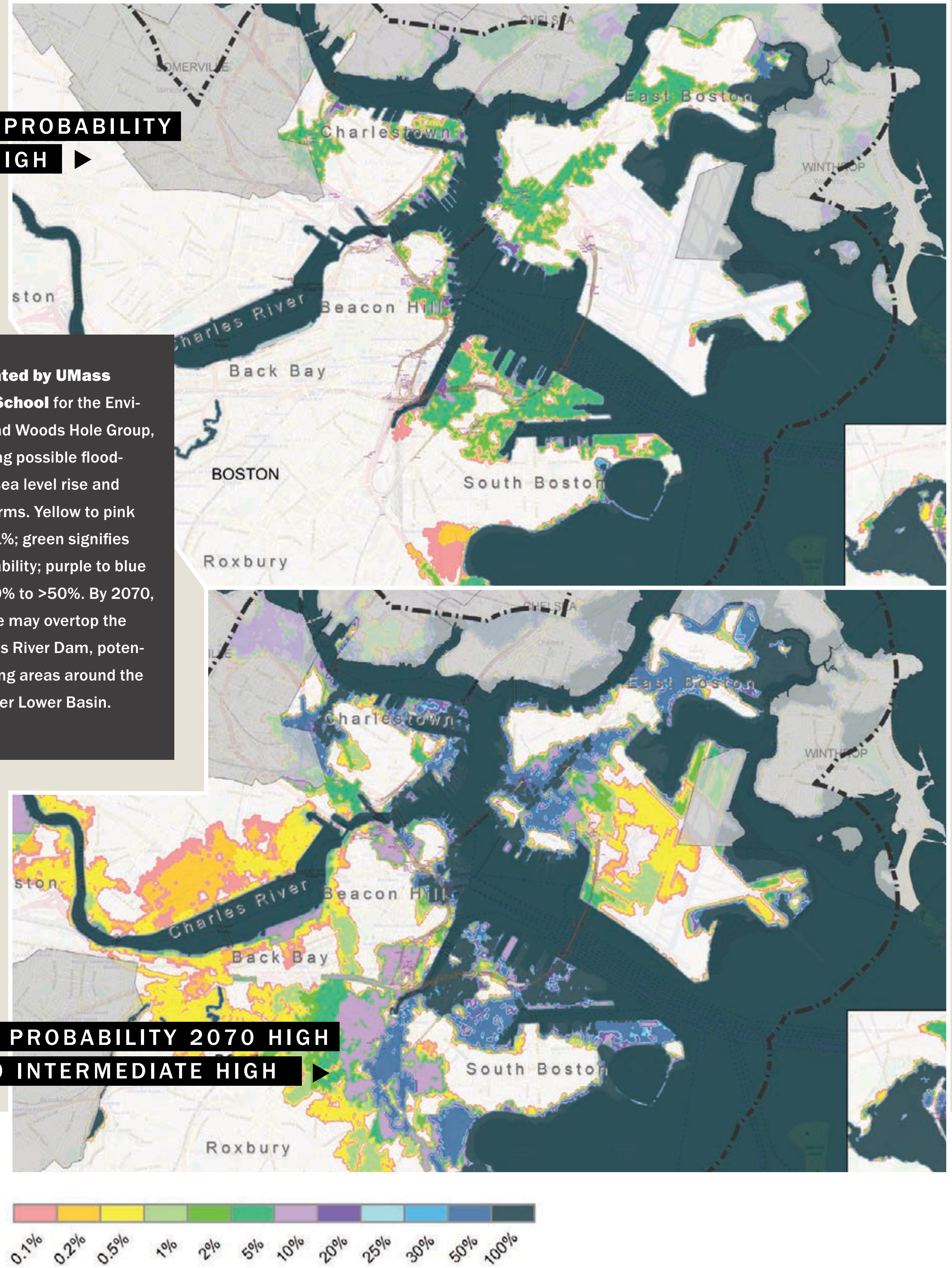
-The Huffington Post, "'Living with Water': Facing Climate Change, Cities Trade Sea Walls for Parks," Nov. 2, 2018

Sustainable Solutions Lab: Quick Facts

What is the Sustainable Solutions Lab?
The SSL is an interdisciplinary partnership between five schools and four institutes within UMass Boston. Its mission is to understand the disproportionate impacts of climate change on marginalized populations and work with them to develop sustainable and equitable solutions.

What does the Sustainable Solutions Lab do?
The SSL focuses on **three strategies:**
1) Research into the impact of climate change on vulnerable communities, which can provide a foundation for action
2) Convening diverse groups of stakeholders to build relationships and expertise, with a shared goal of addressing climate change and inequity
3) Thought leadership promoting the importance of climate adaptation and prioritizing the needs of vulnerable populations

What's next for the Sustainable Solutions Lab?
A $1 million grant from the Barr Foundation will provide additional resources for the SSL to pursue climate resilience work. Among the SSL's upcoming projects is a report on Greater Boston residents' views and experiences of climate change, which is expected to be released by the fall of 2020. Keep an eye out for events such as the quarterly Climate Adaptation Forum that the SSL organizes in partnership with the Environmental Business Council of New England. ■



Maps created by UMass Boston's School for the Environment and Woods Hole Group, Inc., showing possible flooding due to sea level rise and coastal storms. Yellow to pink signifies <1%; green signifies 2-5% probability; purple to blue signifies 10% to >50%. By 2070, storm surge may overtop the New Charles River Dam, potentially flooding areas around the Charles River Lower Basin.

▶ Photo of professors Jonathan Rochford (left) and Neil Reilly (right), Chemistry department, is taken by Colleen Locke, UMass Boston Office of Communications.

FUEL OF THE FUTURE

Harnessing sunlight to generate fuel looks so easy when plants do it. In reality, imitating the way photosynthesis transforms carbon dioxide and water into fuel remains a scientific holy grail. Jonathan Rochford's research tackles that challenge, with the goal of creating renewable fuels and energy-rich chemical feedstocks. Rochford, a professor in UMass Boston's Chemistry department, takes cues from nature's macromolecular enzymes, such as the nickel-iron carbon monoxide dehydrogenase enzyme, to develop molecular catalysts that can mimic photosynthesis. Successful studies in this area have often relied on expensive rare earth metals such as platinum. Rochford is innovating in a sustainable direction by using cheap and widely available metals such as manganese, iron, cobalt, and nickel instead as he works toward a green energy supply with minimal environmental impacts.

The negative effects of soot are far-ranging, encompassing everything from health problems such as asthma and heart attacks to impaired efficiency of combustion engines. In light of these public health and environmental impacts, the Environmental Protection Agency dramatically strengthened its restrictions on soot pollution in 2012. Neil Reilly, a professor in UMass Boston's Chemistry department, is going straight to the source, studying entities that play a key role in the formation of soot. Reilly's research deals with reactive intermediates, or species that are generated and rapidly consumed during chemical reactions. These intermediates are too reactive to be studied with typical instrumentation; they must be generated and isolated in vacuum chambers, cooled to extremely low temperatures, and interrogated with laser beams. Reilly aims to observe the intermediates' electronic spectra and, ultimately, determine their structures. He is focusing on resonance-stabilized radicals, which are critical to the formation of soot and large aromatic molecules. Reilly's objective is to provide spectroscopic data that will facilitate the unambiguous identification of these radicals and provide benchmarks for quantum chemical methodologies. ■

Hubs of Innovation

BY WILLIAM BRAH & LISA ALLEN

Samples are placed into the autosampler tray of the Orbitrap Fusion Lumos Tribrid Mass Spectrometer to identify and quantify the proteins in a cellular extract, professor Jason Evans's lab, Chemistry department.

▶ Molecular, Cellular, and Organismal Biology (MCOB) PhD student Melissa Brown is taking samples out of ultra-cold storage.

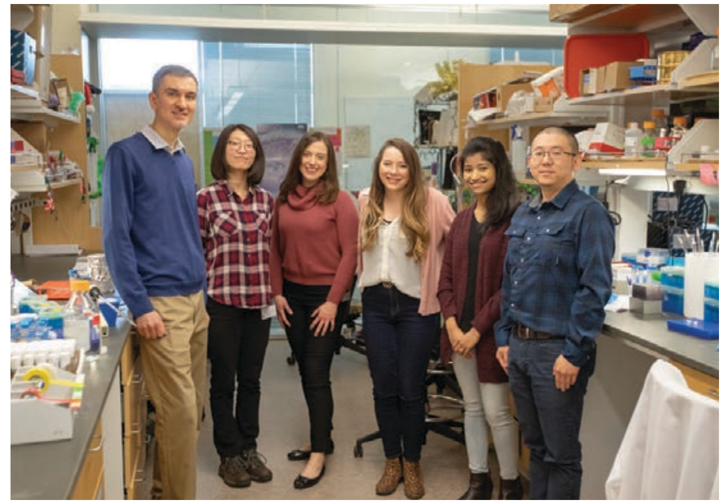
It takes a lot more than just scientists and equipment to translate research into practice. That's why UMass Boston draws entrepreneurial pioneers from many different universities and fields to its incubator, the Venture Development Center, which opened in 2009. With expert business guidance, these entrepreneurs are proving business opportunities in much the same way as proof of concept or prototype activities validate technologies. Many of them have also become educational and career resources for UMass Boston by offering internships and sponsoring capstone projects.

When eGenesis founder Dr. Luhan Yang arrived at the Venture Development Center from the George Church lab at Harvard Medical School, her first request was for talented and highly skilled interns. She brought on four biology undergrads who worked with her for a year and were listed as authors in a transformative publication in Science. Underlying these collaborations is a passion to deliver impact. UMass Boston is educating its students to prepare them to transform the world once they graduate, and equipping its researchers with specialized core facilities to conduct high-quality state-of-the-art translational research.

Collaboration between researchers from different disciplines is key to shepherding research along the translational path into practice. There are multiple hubs on campus where these collaborations occur. The newest are the research core facilities. In 2018, UMass Boston completed the multi-year purchase and installation of $8 million of equipment in the genomics, imaging, mass spectroscopy, fabrication, flow cytometry and the vivarium cores, as shown in Figure 1. Most are located in the 220,000 sq-ft. Integrated Sciences Complex, which opened in 2015.

These shared resources have drawn researchers both academic and non-academic:

- Dr. Jon Celli (Physics), who studies image-guided photodynamic cancer therapy, is working with Dr. Filip Cuckov (Engineering) to develop a low-cost battery-powered delivery platform, which is being tested at sites in India.



▲**Left to right:** Professor Alexey Veraksa (Biology department) with students Heya Zhao (graduate), Sarah DuBois-Coyne (undergraduate), Melissa Brown (graduate), Sayantanee Paul (graduate), and Fei Chai (graduate).

- The mass spectroscopy core is being used by Dr. Jon Celli (Physics), Dr. Chandra Yelleswarapu (Physics), Dr. Jason Evans (Chemistry) and Dr. Kimberly Hamad-Schifferli (Engineering) to explore the impact of specific proteases expressed by cancer cells on biomolecules that form around gold nanoparticles targeted at pancreatic tumors, a major factor in using the nanoparticles as drug carriers for cancer treatment.

→

•Scientists at Platelet Biogenesis, a resident company at UMass Boston's Venture Development Center, rely on the capabilities of the imaging and vivarium cores. The company is undertaking pre-clinical studies of their on-demand platelet product made from stem cells.

To further promote these types of collaborations, UMass announced an Innovation Voucher Program in 2018. Young, innovative technology companies headquartered in Massachusetts can use over 90 collections of advanced instruments across the five-campus UMass system on a discounted, fee-for-service basis.

UMass Boston's location in the heart of Massachusetts' top-ranked and world-class innovation economy is advantageous. Leading research institutes, teaching hospitals, and technology companies, large and small, abound. Researchers can readily build upon each other's work and tackle mutually relevant questions. The answers hold the potential to improve lives in meaningful ways. ■

▲Molecular, Cellular, and Organismal Biology (MCOB) PhD student Heya Zhao is observing Drosophila cells using the Zeiss confocal microscope.

Sarah Dubois – Coyne, UMass Boston undergraduate student.

STUDENT SPOTLIGHT:

SARAH DUBOIS-COYNE

UMass Boston biochemistry major Sarah DuBois-Coyne has exciting plans for her future in research. She has worked in biology professor Alexey Veraksa's lab since the fall of 2016, investigating cell signaling in development and disease. "Doing research in his lab has enabled me to work extensively on the Zeiss LSM 880 confocal microscope and gain enough skills so that I feel I am ready to apply directly to PhD programs," she explained. DuBois-Coyne is involved with a project that studies the protein neurofibromin 1, a collaborative effort with James Walker of Harvard Medical School. That protein has far-reaching significance since its main role is to inhibit another protein called Ras, which is estimated to cause 30% of human cancer in its overactive form. DuBois-Coyne plans to seek a PhD in biophysics or molecular neuroscience and focus her research on light-based technologies that could diagnose or treat cancer with neural origins. One day, she hopes to run her own neuro biomedical optics lab while working as a professor. She is already getting recognition for her work. DuBois-Coyne won the prestigious Barry M. Goldwater Scholarship this year, making UMass Boston history as one of the school's first winners alongside fellow honoree Joseph Farah (for more about his research, see page 11). The two students have been friends since meeting at a scholarship luncheon last year, and this outcome "felt like a double victory," DuBois-Coyne said. She was also selected this year for UMass Boston's Entrepreneur Scholarship, which provides a $2,500 award and two years of mentorship from Dan Phillips, the founding director of UMass Boston's Entrepreneurship Center and an advisor in the Venture Development Center. ■

FIGURE 01 ▼

CORE	FACULTY	EQUIPMENT	CAPABILITY
Genomics	Jill Macoska (Center for Personalized Cancer Therapy)	Illumina HiSeq 2500 Illumina MiSeq Qubit 2.0 Agilent Bioanalyzer NanoString nCounter QuantStudio™ 12K Flex Real-Time PCR System	Traditional capillary sequencing, high-throughput next-generation sequencing, library preparation, and various data analyses
Proteomics	Jason Evans (Chemistry)	Nanoflow HPLC-high resolution mass spectrometer system with Thermo- Forma EASY- nLC 1200 System, Orbitrap Fusion Lumos Tribrid Mass Spectrometer (LC-MS), UltiMate™ NCP3500RS HPLC system	High pH reversed phase fractionation of protein digest to support 2D-LC-MS-MS applications
Vivarium		Perkin Elmer IVIS Lumina XRMS Series III	Visualization of tumor growth, response to chemotherapeutic agents, and assessment of tumor biomarkers in vivo and in real time without the need to sacrifice the host animal
Imaging	Alexey Veraksa (Biology)	Zeiss LSM 880 Confocal Microscope, and Olympus BX53 upright and IX73 inverted fluorescence microscopes	High-resolution 3D imaging of biological specimens
Advanced Digital Design and Fabrication	Filip Cuckov (Engineering)	GCC LaserPro Spirit LS, Object30 3D Printer, Roland MDX-540SA CNC Mill, Ultimaker 2 Formlabs Form 2 3D printer, Markforged Mark 2	Printing of objects from biocompatible materials
Flow Cytometry	Catherine McCusker (Biology)	Becton Dickinson FACS Aria III	Live cell sorting and cell counting
Broad Spectrum Molecular Imaging	Walter Buchwald (Engineering) and Matthew Bell (Engineering)	Bruker SENTERRA II micro-FTIR/micro-Raman spectrometer, femtosecond ASOPS system, and cryogen-free refrigeration system	Spectral assessment of a wide variety of biological materials ranging from tissues to complex mixtures in the very far IR, near IR, visible and UV spectral ranges.

Professor Banu Özkazanç-Pan, College of Management.

Understanding the Venture Capital Decision-Making Process

BY LISA ALLEN

Banu Özkazanç-Pan is working on an ambitious model that simulates venture capitalists' interactions with entrepreneurs. The UMass Boston management professor believes HBO's hit comedy Silicon Valley—which brought VCs into the mainstream—nails the cultural issues but risks misleading viewers. "What they get wrong is that not everyone has access to funding opportunities via VCs. The networks are rather small and closed-off, and while diversity is valued, it is not necessarily funded," she explained. The prominence of Silicon Valley's female VCs raises another question about realism. "Women managing partners are few and far between, and watching the show might give some the sense there's equal opportunity when there really isn't," Özkazanç-Pan said.

The numbers are bleak. A 2018 study of nearly 1,500 VC investors revealed a demographic breakdown that skewed 82% male and 70% white, and found that a stunning 40% of the investors went to one of two schools—Harvard or Stanford, according to figures compiled by Richard Kerby, a partner at VC firm Equal Ventures, who published his results on Medium.

Özkazanç-Pan's model incorporates interviews, surveys, and observations into computer simulations to approximate VCs' behavior in choosing which entrepreneurs to fund. The model focuses on the influence of networks and decision-making in the deal sourcing process, and the role of entrepreneurs' identity features. "This approach allows us to combine different methods but focus on the same phenomenon—why do we keep seeing the same pattern of funding in the VC world," she said, noting that the pattern favors young white men. The next step, pending additional funding, would be to add geography to the model and see how that factor influences networks and deal flows.

To make progress on diversity, data is crucial. That is one area where organizations such as UMass Boston's Venture Development Center (VDC) can provide support. "Keeping track of firms, their outcomes, and their management teams is really important and necessary work—and the VDC does this well," she said.

Workplaces with gender-neutral philosophies tend to neglect that kind of data collection. Özkazanç-Pan defines gender-neutral thinking as the idea that an organization's practices benefit everyone equally, and that making changes will "upset the presumed meritocracy." She contrasts that mindset with gender-aware policy-making, "a proactive way organizations can self-assess their approaches and really question whether their existing ways are meritocratic if they only benefit certain groups of people over others." Gender-aware policies can map where organizations stand, so they can determine how to move forward. ■

VC DIVERSITY STRATEGIES

"There is always recognition of the problem of diversity, but not as much urgency to address the issue," Özkazanç-Pan noted. Getting it right can be complicated. One increasingly popular strategy, creating funds specifically for female-led or owned ventures, is under scrutiny for its potential to silo women from resources and funding in the greater startup ecosystem. Based on her research and her work with organizations such as the City of Boston's Women Entrepreneurs Boston initiative, which supports women-owned businesses, Özkazanç-Pan has identified three strategies as a starting point for VC firms to improve their diversity practices:

- Review the internal organization of the firm, noting who is a partner and who has investment decision capacity. Making sure there is gender equity among the partners is a start.
- Source deals from a diverse network, rather than the firm's own small network.
- Work on unconscious bias issues and assumptions about risk, growth, and capability in relation to women- and minority-owned ventures. ■

FY2019 by the Numbers

RESEARCH

"FY19 continued an impressive showing of winning external support for our research," says Matthew Meyer, Associate Vice Provost for Research and Director of the Office of Research and Sponsored Programs. "Among all our successes, our Centers and Institutes, and the College of Sciences and Mathematics, College of Liberal Arts, and McCormack Graduate School continued to build and grow." ■

TOP SPONSORS (>$1M)

- **$8.2M** US Department of Education
- **$5.7M** National Institutes of Health
- **$4.5M** Education Sales & Service
- **$4.4M** US Department of Health & Human Services
- **$2.7M** National Science Foundation
- **$1.5M** Various Sponsors
- **$1.4M** MA Department of Developmental Services
- **$1.3M** University of Massachusetts Foundation

TOP 10 FUNDING RECIPIENTS (>$1M)

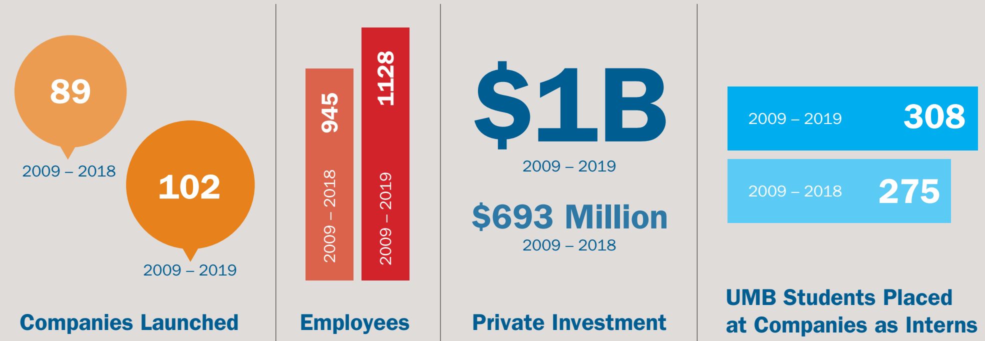
- **$13.7M** | Institute for Community Inclusion
- **$4.0M** | Biology Department
- **$2.8M** | Collins Center for Public Management
- **$2.6M** | School for the Environment
- **$2.3M** | Psychology Department
- **$2.1M** | Gerontology Institute
- **$2.0M** | College of Science & Mathematics
- **$1.5M** | Center for Survey Research
- **$1.4M** | Department of Curriculum & Instruction
- **$1.1M** | Center for Personalized Cancer Therapy

	AWARDS WITHIN ALL UNITS	PROPOSALS SUBMITTED
Academic Affairs	$ 17,992,225	82
College of Science & Mathematics	$ 9,414,540	78
McCormack Graduate School of Policy & Global Studies	$ 6,353,484	61
College of Liberal Arts	$ 4,000,572	31
Academic Support Services	$ 3,890,819	3
College of Education & Human Development	$ 3,276,781	39
School for the Environment	$ 3,232,580	23
College of Management	$ 496,989	
Office of Global Programs	$ 493,735	1
College of Nursing & Health Sciences	$ 480,772	25
Center of Science & Mathematics in Context (COSMIC)	$ 354,308	2
Division of Government Relations and Public Affairs	$ 191,356	
Student Affairs	$ 148,341	1
Other		9

TOTAL AWARDS **$50M**

TOTAL PROPOSALS **355**

ECONOMIC DEVELOPMENT



In FY19, the tech companies incubated in the on-campus Venture Development Center hit over $1B in funding and 1,000 employees, including over 300 UMass Boston students. "Many more companies will be engaging with UMass Boston with the development of the 20-acre site of the old Bayside Expo Center near the JFK/UMass "T"," said William Brah, Assistant Vice Provost for Research and Director of the Venture Development Center. ■

Office of the Vice Provost for Research and Strategic Initiatives

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