



MICHIGAN STATE UNIVERSITY
**INNOVATION
CENTER**
2022
ANNUAL REPORT



REFLECTING ON A YEAR OF INNOVATION

WITH ASSISTANT VICE PRESIDENT FOR INNOVATION AND ECONOMIC DEVELOPMENT, CHARLES A. HASEMANN

Dear friends and partners of the MSU Innovation Center,

2022 has truly been an interesting year. Like many others, we are now “fully hybrid,” with people working entirely at home, entirely in the office, and everything in between. This new flexibility is good for us, and if well managed, will yield dividends both in our productivity and in our overall well-being. We embrace this new working atmosphere and whatever new changes are yet to come.

Going hybrid was not our only change in 2022. Anne Di Sante accepted the role of Executive Director of MSU Technologies (MSUT), filling the position vacated by Rich Chylla in January. Anne was the clear choice to succeed Rich, with a distinguished career in tech transfer at three prior universities, and an appetite for the challenge this leadership position brings with it. Anne immediately launched a search for her replacement as Associate Director, with Brian Wright (Auburn

University) joining us in January 2023. We also implemented some modest growth in the team, with Julia Miller joining as a new Technology Manager in MSUT, Leon Ma joining as an Assistant Director for Corporate Relations in Business Connect, and Audrey Sebolt joining MSUT to grow our support for the large volume of material transfer and confidentiality agreements for MSU. These new hires are key to keeping pace with MSU’s current and planned growth in research funding, as well as with the innovation and corporate engagement that comes with that expanding volume of research.

You will find in the “By the Numbers” section of this report that we are bouncing back from the low levels of productivity that COVID-19 caused in almost every metric. 2022 brought a 25% increase in Corporate Support for research (\$25M vs. \$20M), and a 30% increase in Invention Disclosures (157 vs 130). Not surprisingly, new startup corporations, a lagging indicator of ecosystem productivity, have not yet rebounded, with 2 new starts in 2022.

Throughout 2022, we had a strong focus on several areas of strength and growth at MSU:

Electrified and Autonomous Mobility was a very active area of partnership, with our ongoing partnership on last-mile micro-mobility with SPIN, an autonomous bus shuttling students on campus, and a host of research partnerships to improve autonomy, batteries, user experience, and other key factors for the future of this revolution in how we get around.

Drug Discovery and Development was another area of growth and success, with both home-grown projects that yielded startup companies (see Portera story), as well as collaborations with corporations driving change in how we do drug discovery (see Atomwise story). Furthermore, two MSU faculty members, Karen Liby and Rob Abramovitch, received prestigious Catalyst Awards from the Dr. Ralph and Marian Falk Medical Research Trust, supporting their pursuit of life-changing drugs. Both Liby and Abramovitch are “frequent fliers” in the Innovation Center: they have many patents to their names, and both are founders of a startup company.

Nuclear Physics and the Facility for Rare Isotope Beams (FRIB) were also a focus of new activity, with FRIB opening its doors in May 2022 as a National User Facility. With the opening, we experienced a new opportunity for corporate engagement, with several major corporations who manufacture or rely on devices that operate in outer space eager to use the facility. Together with the MSU Space

Electronics Center, the companies will use the FRIB radiation beam to simulate the harsh interstellar radiation found in outer space— aiming to improve the “space hardness” of devices that spend extended periods exposed to interstellar radiation.

Finally, 2022 saw the continued development of Grand Rapids as a hub for MSU medical research activity and opportunities for corporate and economic development partnerships. MSU opened the Doug Meijer Medical Innovation building, with BAMF Health as a key innovation partner and anchor tenant in the building. MSU also welcomed Perrigo, which relocated its North American corporate headquarters to the Grand Rapids Innovation Campus. Furthermore, the MSU Research Foundation subsidiary Spartan Innovations grew its Grand Rapids staff and reported strong engagement and growth of support for the GR Innovation Ecosystem through their operations as a Grand Rapids Regional Smart Zone grant recipient.

Thank you for taking time to view the 2022 MSU Innovation Center Annual Report. I hope you enjoy reading the stories as much as we love sharing them.

Stay well, and please stay in touch.

CHARLES A. HASEMANN, PHD
Assistant Vice President for Innovation and Economic Development

MORE THAN THE SUM OF ITS PARTS



MSU Innovation Center collaborated closely with Portera Therapeutics, a venture capital-funded biotech startup.

This is the story of how a fledgling biotech company with its origins in the Michigan State University (MSU) Department of Chemistry leveraged nearly every facet of the MSU Innovation Center ecosystem to move from the barest beginnings of drug discovery to a venture capital-funded startup. Business Connect, MSU Technologies, Spartan Innovations, and Red Cedar Ventures have all had a role to play in the pursuit of this promising new opportunity.

Foundations in Science

The launch story of Portera Therapeutics begins in a lab at MSU with the drug discovery work of Professor of Chemistry Jetze Tepe, Ph.D. Tepe's work seeks to identify innovative therapeutics for treating cancer and neurogenerative diseases. Specifically, he and his graduate students have been studying how to prevent the accumulation of toxic, dysregulated, and disordered proteins with small molecules in cells. The team developed a novel approach to degrade disordered proteins that build up in cells that can cause cancer or create plaque, for example, in the brains of Alzheimer's or Parkinson's patients.

The idea is still in the very early stages of research. "We discovered a completely new approach that prevents previously undruggable proteins from accumulating and driving disease progression with the small activator molecules," explained Tepe.

The MSU Innovation Center assisted in moving Prof. Tepe's initial research forward, with \$34,949 in funding, which helped generate data with the assistance of MSU's Drug Discovery Center. "The

Drug Discovery Center was absolutely vital to getting the data we needed to secure outside grants to continue our research," said Tepe. That data was crucial in securing three grants from the National Institute of Health (NIH), totaling an additional \$2.4 million.

Interest from an investor

MSU Technologies (MSUT) would become key in forming a company around the professor's technology. MSUT collaborates with inventors like Prof. Tepe to analyze and make decisions about the best ways to transfer technology so that its benefits reach the public. "We are the stewards of technology that is developed during the course of research at MSU," said MSUT Executive Director Anne Di Sante.

Di Sante agreed that a start-up company was the way to go. "Jetze's invention was too early-stage for an established company to pick up, but as a startup, it could become something that could develop and grow," she said.



Jetze Tepe, Ph.D., Professor of Chemistry, MSU and Founder of Portera Therapeutics, works with a colleague to identify innovative therapeutics for neurogenerative diseases and cancer.

A competition to win seed funding

AbbVie Ventures focuses its investments in early-stage opportunities in immunology, oncology, and neuroscience. In approaching Prof. Tepe about funding a startup, AbbVie Ventures suggested entering their newly established AbbVie Innovation Midwest (AIM) Award competition. The award is an incubator program designed to support emerging scientists, researchers, and biotech entrepreneurs working on novel science with potential for transformational therapies.

With its goal to stimulate the biotech ecosystem in the Midwest, the AIM Award is an opportunity to receive seed funding from AbbVie Ventures. It is awarded to up to two early-stage biotech companies annually.

To form a new business and gain the best shot at that funding, MSUT sought

to leverage other partners in MSU's Innovation Ecosystem. The MSU Research Foundation often partners with the Innovation Center to encourage innovation and facilitate economic development through commercialization, new venture creation, and innovation partnerships. To that end, a cross-functional team that included MSUT, Spartan Innovations (SI), and Red Cedar Ventures (RCV) set about the work with Prof. Tepe to create Portera Therapeutics.

A winning business formation

RCV makes early-stage investments in technology startups commercializing intellectual property created at MSU. However, RCV does more than provide funding. "We're a turnkey solution to innovation at MSU," said Executive Director Jeff Wesley. "We offer consulting, mentorship, and strategy as well for business formation."

RCV Venture Associate Matt Okenoski and SI's Director of Venture Creation Frank Urban were highly involved not only in Portera's formation but also in prepping for the AIM Award competition.

"We're privileged with where we sit in proximity to the university and with the tools that we have available to us through Red Cedar Ventures and Spartan Innovations," said Okenoski. "These advantages allow us to nurture some of the most promising ideas coming out of the university."



Dr. Tepe was named the 2022 Innovator of the Year by the MSU Innovation Center for his work leading to Portera's founding.

He added, "There's a lot of preparation involved in presenting to a world-class company like AbbVie that's beyond the science."

For example, Urban, with his background in life sciences, worked with Prof. Tepe on product positioning and early product development milestones that a therapeutic startup company must complete. "That was key in laying out the path forward from a business and development perspective," Urban said.

In October 2021, Prof. Tepe delivered Portera's presentation for review at the AIM Award competition in Chicago. "Afterward, Jetze didn't think we'd won,"

said Di Sante. "And I told him, it's ok. We'll still move forward with Portera. But then, they announced we'd won," she said. "We were so excited."

The win meant seed funding for Portera Therapeutics, an investment that will be crucial to advancing the company. "The pre-seed investment will be used to push the technology forward to the point where we'll be able to attract much greater funding," Tepe said.

"Ultimately, we hope that the technology can address some human health issues," said Tepe. "That's been our goal, and now, we have a path to that goal."

Next steps to sealing the deal

With the promise of venture capital at hand, the new company, with support from SI, began recruiting others to come on board. With Tepe as Portera's founder and board chair, biotech consultant Jeff Brinza was hired as executive chair of the board. He is the point person on the business side. He said, "I came on board to get the company up and running; to manage everything administrative in nature so Jetze can focus on the science."

"It's very unusual for a professor to be approached by somebody on the outside to start up a company around something he has discovered," Brinza went on. "So, it's amazing for Jetze to have this opportunity. We are confident in the science, and we think we can really make something happen here."

While investment conversations were happening, MSU's Di Sante worked on the option agreement to transfer Tepe's technology to Portera. "An option

"AS A STARTUP, PORTERA DOESN'T HAVE ITS OWN LABORATORY OR EMPLOYEES. SINCE JETZE'S TEAM DEVELOPED THE CHEMISTRY, THEY ARE BEST SUITED TO DO THE EARLY EXPERIMENTS, AND MSU OFFERS THE EXPLORATORY CHEMISTRY CAPABILITY THAT ENABLES THE RESEARCH. SO, WE PUT A CONTRACT IN PLACE BETWEEN THE UNIVERSITY AND PORTERA TO USE THE COMPANY'S INVESTMENT FUNDS TO CONTRACT BACK INTO THE UNIVERSITY TO SPONSOR THE RESEARCH BEING DONE IN JETZE'S LAB."

Charles Hasemann, Associate Vice President for Innovation & Economic Development

agreement officially puts the technology into the hands of the company so they can evaluate it," she said.

RCV also invested in Portera. "We always look forward to supporting innovation like this," said Wesley. "It's exciting to see the momentum coming out of the university and being able to back it."

At the same time, MSU Business Connect negotiated a sponsored research agreement with Portera. Business Connect coordinates contractual negotiations and other business agreements between the university and partner organizations.

Associate VP for Innovation & Economic Development Charles Hasemann explained, "As a startup, Portera doesn't have its own laboratory or employees. Since Jetze's team developed the chemistry, they are best suited to do the early experiments, and MSU offers the exploratory chemistry capability that enables the research. So, we put a contract in place between the university and Portera to use the company's investment funds to contract back into the university to sponsor the research being done in Jetze's lab."

The sponsored research agreement enables Portera to continue doing the work it was formed to do.

"This is a great story of how all parts of the Innovation Center came together to support the right commercial outcome to get this technology into use out in the real world," Hasemann continued. "Early on, the drug discovery process enabled Jetze to move forward by providing data. Then, MSU Technologies assisted with the AIM Award competition and negotiated the option agreement. Spartan Innovations further helped with the company formation. Portera won the competition and got funding, then Red Cedar Ventures co-invested to further fund them and to help seal the deal. Finally, Business Connect put in place a sponsored research contract to make it all work.

"None of this happens without all of those parts," he said. Yet the outcome is bigger than what any part of the Innovation Center does separately.

Di Sante put it even more succinctly, "All the agreements are signed, research is continuing, there's an option in place, there is additional internal investment, and we have a startup that is unique having venture capital funding right out of the gate."

"All of which is pretty great," she said.

HUMAN-CENTERED TRACTOR CABIN DESIGN



MSU Partners with CNH Industrial
to Develop a Human-Centered
Tractor Cabin Design.

Michigan State University (MSU) has long enjoyed an esteemed reputation for its Agriculture and Engineering programs. So, when CNH Industrial, a global leader in agriculture and construction equipment, was looking for partners to help gather intel on the user experience and design of the CIH Magnum tractor line, MSU was high on their list of potential collaborators.

MSU Partners with CNH Industrial to Develop a Human-Centered Tractor Cabin Design

Michigan State University (MSU) has long enjoyed a positive reputation for its Agriculture and Engineering programs. So, when CNH Industrial, a global leader in agriculture and construction equipment, was looking for partners to help gather intel on the user experience and design of the CIH Magnum tractor line, MSU was high on their list of potential collaborators. Citing MSU's historical experience in agriculture as a Land Grant University as well as its ties to the automotive industry, David Sachtleban, CNH Industrial Customer Experience for AG/CE Seating & Controls said, "MSU has proven itself as an esteemed partner who can provide unmatched commentary and insight that can give CNH Industrial the upper hand in providing the best possible customer journey."

A history of agricultural and engineering research excellence

Director of Corporate Partnerships at MSU's Innovation Center Brice Nelson discussed the genesis of the partnership between CNH Industrial and MSU faculty members Dr. Tamara Bush and Dr. Sarah Swierenga. Nelson explained that CNH Industrial's interest in MSU stems from the university's substantial overlap in agriculture and mobility engineering work, stating, "Our faculty value corporate partners and projects that impact real-world applications. We have a long history of work in agriculture and engineering as well as a broad faculty base that has a lot to offer."

Nelson's primary focus is to create connections between MSU researchers and corporations to establish mutually beneficial collaborations that advance innovation at the university. Nelson expressed that this project is an excellent example of MSU's strength as a corporate research partner because of the cross-disciplinary opportunities for collaboration. This unique project combines efforts from numerous fields of study on campus, including the MSU farming and agriculture community, MSU College of Engineering, and MSU College of Communication Arts and Sciences.

A cross-discipline partnership

MSU Faculty members, Dr. Tamara Bush and Dr. Sarah Swierenga, exemplify the strengths of a cross-disciplinary approach to problem solving. Dr. Bush's background in biomedical engineering and work with seat design brings a unique aspect to the table when engaging in this study. As a professor of Mechanical Engineering, Dr. Bush has focused on how devices interface with people and how to use human-centered data to influence design specifications. Dr. Sarah Swierenga, an MSU Professor of Practice in User Experience, is teaming up with Dr. Bush. Dr. Swierenga has started

a Master of Science in User Experience program in the Department of Media and Information, and has worked with numerous companies on User Experience (UX) design challenges. She brings her extensive expertise and a critical eye for user-focused design research to the project.

Designing for the next generation of tractor owners

As part of the initial research, Dr. Bush and Dr. Swierenga are conducting intensive hour-long interviews with twelve farmers to better understand how they navigate the

One area of focus will be how driver's interface with the many screens and displays inside the tractor cab.





The average farmer can spend 15+ hours in a tractor cab each day.

current Case IH (CIH) tractor cabin interiors. Additional work with MSU agriculture students allows Dr. Bush and Dr. Swierenga to receive feedback from the next generation of farmers. The younger consumers and interviewees add an exciting aspect to this study. Understanding the needs of the next generation of farmers can help create an innovative interior cabin design. Dr. Swierenga stated, “We are very interested in getting a broader audience of users to participate in these interviews.” Swierenga added, “We want to understand how they’re currently using the tractors, current experiences in the cab, context of use, and how these fit into their ecosystem.”

Why tractor interiors? As Dr. Bush explained, the average farmer can spend 15+ extended

hours in a tractor cabin each day, and we want to create features within the cabin’s design that will improve the farmers’ overall user experience. CNH aims to provide a world-class buyer experience, and with the generational nature of their products, is always looking for ways to improve the process. An unmatched user experience is a benchmark in creating their newest line of tractors.

A human-centered tractor cabin design

After the first round of interviews, Dr. Bush and Dr. Swierenga will identify common themes from the feedback that will influence future design decisions. Based on their

initial findings and their experiences in human-centered design, they will then work together to design a model or prototype to present to CNH Industrial. Bush and Swierenga’s goals are to take a critical look at current tractor cabin configurations and find ways to improve the interiors to better address the needs of future users. One such area of focus will be how drivers interface with the many screens and displays in current CIH Magnum Tractor cabs and how they can be made more user-friendly. Likewise, seat design and ergonomics research can also be applied to the cabin where drivers spend many hours working; a comfortable driver’s seat and an intuitive cabin layout could also be incorporated into the next-generation prototype.

After creating a new model, they will go back for the second round of interviews to assess customer satisfaction with the new design. With data from these second-round interviews, the team will continue to evaluate and edit the model.

A bright future for a continued partnership

Receiving customer feedback allows CNH Industrial to not only improve its products but also improve customer loyalty to the brand. As CNH Industrial looks ahead to the future of farming and the comfort of future farmers, getting feedback to create a tractor cabin interior designed around the needs of future farmers is vital. Dr. Swierenga expressed how in-depth user experience data can give CNH Industrial that competitive edge they are looking for.

Excited about the project’s future, Sachtleben expressed, “The partnership with MSU and efforts of Dr. Swierenga, Dr. Bush, and the student project team show just how focused CNH Industrial is

on putting the customer first and creating a world-class operator experience. By breaking new ground together, we can solve real-world problems and provide additional value to those who feed the world.”

These same methodologies can be applied to the cabin of any vehicle. As society embarks on its mobility revolution, expect to hear of more great work from this team on a variety of vehicle usability design projects.

“OUR FACULTY VALUE CORPORATE PARTNERS AND PROJECTS THAT IMPACT REAL-WORLD APPLICATIONS. WE HAVE A LONG HISTORY OF WORK IN AGRICULTURE AND ENGINEERING AS WELL AS A BROAD FACULTY BASE THAT HAVE A LOT TO OFFER.”

Brice Nelson, Director of Corporate Partnerships at MSU’s Innovation Center



Finding ways to improve current cab designs requires a critical analysis based on user feedback.

**A HISTORY OF
ENTREPRENEURSHIP,
AN IDEA, AND A
COMMUNITY OF
RESOURCES.**



From student start-up to
global company.

Entrepreneurship seemed to be in the cards for Brendan Wang. Wang started his first business as a senior in high school. Boka Bands sold goal-oriented bracelets that kept short-term and long-term goals tucked into pockets within the bracelet, keeping them close to the wearer. Joining Michigan State University (MSU) as a first-year student, Wang was immediately impressed with the entrepreneurial ecosystem available at MSU. “I have this entire community before me, with access to interns for help, receive funding, along with competition opportunities and exposure, especially with introductions to our alumni network, which has been quite helpful,” said Wang.



Attending his first start-up event, Wang recalled, “I was aware of the Hatch and aware of the entrepreneurial resources, but it was really my first Burgess New Venture Challenge that I attended as a freshman, where I saw all of these young founders with their new products, their ideas, their banners ... and I just felt so incredibly inspired.”

In April 2022, Wang was also among the student exhibitors at the MSU Innovation Center’s Innovation Celebration. As a result, he could network and showcase his product to the MSU community and industry leaders. “It was really meaningful to be in a space with people who have created such impactful technologies and innovations,” he said.

Inspiration based on personal experience combats a global problem

Wang was inspired by his personal experience as a former vape user. He recounted, “At 14, I began vaping and was addicted for over five years. I’ve lived it, I’ve breathed it, and I’ve seen it time and time again across my own communities.” Wang wanted to create a product to help people beat their nicotine addictions and lead healthier lives. According to the World Health Organization (WHO), there are 1.3 billion tobacco users across the globe. In addition, the WHO estimates that more than 7 million tobacco users die yearly due to the consequences of tobacco use.

Wang’s idea was innovative and had a potentially global impact. After several venture pitches and 3D-printed prototypes, he went on to ‘create’ a patent-pending, flavored, pressurized air inhaler that mimics a traditional vape pen, but with zero smoke, zero nicotine, and zero charge: the CAPNOS Zero.

With assistance and resources at the MSU Innovation Center and the Burgess Institute for Entrepreneurship and Innovation, CAPNOS Zero is now being sold to users globally, both online and in stores.

From MSU startup to a global company

In 2021, when asked about his hopes for the future of CAPNOS, Wang said, “The primary vision that I have for CAPNOS is to see that we can become a global company. Seeing CAPNOS in obscure places in Europe or Asia, building more products, building our service line to combine tech with the physical aspect are all the major initiatives that I would like to see for CAPNOS over the next five years.”

Now, in 2022, Wang is seeing his vision as a reality. “We have seen our number of people using CAPNOS products across the world increase month over month. Right now, we’ve delivered 19,000 products this year to people all over”, Wang stated.

To meet the increasing demand of a global customer base, CAPNOS has continued to grow its employees. “We have three full-time and fifteen contractors across Nigeria, in Bosnia, as well as folks in Florida. We have an entire team in Bangladesh and the Philippines,” said Wang.

While CAPNOS focused on its direct-to-consumer sales, it partnered with other smoking cessation programs worldwide. For example, in May 2022, CAPNOS partnered with Wellness Aids Services of Flint to support clients trying to quit vaping. In addition, they intend to establish further partnerships with national and global tobacco quitting programs and advocacy groups to help people manage their behavioral cravings to quit successfully.

The future of CAPNOS

“So, we’ve recognized that, for one, smoking cessation is a market that’s valued at over \$58 billion in 2025. The tobacco smoking market is valued at over \$1 trillion just on its own,” Wang said. With a growing level of support through receiving endorsements from quit therapists, doctors, and clinicians, Wang prepares to, in his words, “invite an open conversation into improving an industry in need of innovation by tackling one of the leading causes of death through a behavioral approach.”

Many CAPNOS consumers have reached out about their success with the CAPNOS Zero product.

“We have hundreds of customers who have written letters or shared DMs, talking about how they’ve gone weeks and months without relapsing,” Wang said. “There are people who have gone decades smoking and vaping, but finally, after trying everything out there, they found success with CAPNOS... which is so rewarding to hear.”

In a market that appears ripe for innovation, Wang is optimistic about the future of CAPNOS. “For us to become a brand leader in the space and helping the 1 billion smokers in the world, we’ve got to stay focused. We’re definitely very focused on a cessation-first approach, and we’re just excited to continue innovating.”

“I WAS AWARE OF THE HATCH AND AWARE OF THE ENTREPRENEURIAL RESOURCES, BUT IT WAS REALLY MY FIRST BURGESS NEW VENTURE CHALLENGE THAT I ATTENDED...WHERE I SAW ALL OF THESE YOUNG FOUNDERS WITH THEIR NEW PRODUCTS, THEIR IDEAS, THEIR BANNERS...AND I JUST FELT SO INCREDIBLY INSPIRED.”



**MSU RESEARCHER
AND PROFESSOR
COLLABORATES WITH
ATOMWISE TO CREATE
NEW CANCER DRUGS**

Blazing new paths in medical drug
research using artificial intelligence.

The process of creating new pharmaceuticals is time-consuming and expensive. Discovering a new drug and bringing it to market can take 10-15 years and costs upwards of \$2.5 billion, making traditional drug discovery an area primed for innovation. Dr. Jeff MacKeigan, Assistant Dean for Research in the College of Human Medicine and Professor in the Department of Pediatrics & Human Development, is hoping his collaboration with technology-enabled pharmaceutical company, Atomwise Inc., will improve the science behind the initial stages of oncological drug discovery.

The crossroads of medicine and AI

The process of creating new pharmaceuticals is time-consuming and expensive. Discovering a new drug and bringing it to market can take 10-15 years and costs upwards of \$2.5 billion, making traditional drug discovery an area primed for innovation. Dr. Jeff MacKeigan, Assistant Dean for Research in the College of Human Medicine and Professor in the Department of Pediatrics & Human Development, is hoping his collaboration with technology-enabled pharmaceutical company Atomwise Inc. will improve the science behind the initial stages of oncological drug discovery.

MacKeigan's lab works in the earliest stages of the drug discovery process, which aims to identify target proteins within cancer cells and then identify small molecule inhibitors that match the target's structure. "Historically, the pharmaceutical industry would identify a lead target and then screen millions of compounds biochemically, one at a time," MacKeigan said. However, in collaboration with Atomwise's AtomNet® technology, MacKeigan's lab can now virtually screen millions of compounds and narrow down the numbers to assess experimentally in the lab.

Founded in 2012, Atomwise invented the first applied convolutional neural net (CNN) technology for drug discovery, the



Dr. Jeff MacKeigan, Assistant Dean for Research in the College of Human Medicine and Professor in the Department of Pediatrics & Human Development investigating the cell signaling networks that encompass autophagy, the mTOR pathway, and cancer metabolism.

"IN A LAB, YOU IDENTIFY A LEAD TARGET AND THEN SCREEN MILLIONS OF COMPOUNDS BIOCHEMICALLY"...THOSE COMPOUNDS ARE THEN FED INTO ATOMWISE'S ALGORITHM. PRIOR TO COLLABORATING WITH ATOMWISE, PROCESSING AND SCREENING COMPOUNDS COULD TAKE YEARS.

Dr. Jeff MacKeigan, Assistant Dean for Research, College of Human Medicine, Professor, Department of Obstetrics, Gynecology and Reproductive Biology and Pediatrics & Human Development

AtomNet® platform. CNN technology is a type of artificial intelligence (AI) featuring deep learning algorithms that are well-suited for image classification and object detection. CNN technology is often used in computer vision applications such as facial recognition as well as in self-driving cars. An additional benefit of utilizing CNN is that the algorithm continues to improve with use. Thus, with each new test, the AI can improve its capability to identify more accurate matches and provide better results. The more the algorithm is tested, the closer researchers get to identifying

binders to targets.

MacKeigan's lab discovers novel drug targets in cancer cells required for cancer cell growth and survival, explores the drug target's molecular structure in detail, and then provides 3D conformational structures of high-priority targets that are fed into Atomwise's AtomNet® model. AtomNet's CNN then proceeds to screen billions of compounds virtually in a matter of hours. The lead molecules identified by AtomNet, whose structure could potentially bind to the target structure,



“WHERE WE’VE SEEN OUR TECHNOLOGY EXCEL IS TO CHALLENGE SOME OF THAT DOMAIN EXPERTISE OF ANTIBODIES, TO LOOK AT AREAS THAT NORMALLY WOULDN’T BE CONSIDERED APPROPRIATE FOR A SMALL MOLECULE, AND WE’VE HAD SUCCESS DOING THAT.”

Terrence O’Brien, Associate Director at Atomwise

are then sent back to MacKeigan’s lab for further validation and clinical development. “Atomwise sends us those lead small molecules that potentially bind in the 3D pocket. Then we test them in the lab, both biochemically and in mutant cancer cells,” MacKeigan said. The AI then optimizes and learns about molecules with optimal drug docking poses across numerous previous projects, effectively improving future results.

However, the goal of Atomwise’s academic collaborations is not just to discover drugs, but to also expand our understanding of the fundamental biology of their protein targets. “We want to get at the underlying mechanism causing our targets to behave the way that they do, so we can find binders to those targets,” said Dr. Stephanie Hare, Computational Chemist at Atomwise. The collaboration between MacKeigan and Atomwise aims to further explore drug chemical space and optimize around those high-priority 3D structures. MacKeigan and his lab eventually hope to find one or more compounds that are inhibitors of the drug target, which could potentially lead to new cancer treatments.

Atomwise has collaborated with over 400 academic researchers through the Artificial Intelligence Molecular Screen (AIMS)

program, which was first launched in 2017 to broaden the pool of scientists involved in drug discovery through access to Atomwise’s AI-enabled discovery engine. MacKeigan has received three AIMS awards from Atomwise for his research in cancer drug discovery. His work continues to impress the company, and a solid partnership has been established.

“It is extremely important for the AIMS program’s success to be working with partners that are rigorous in terms of their science and good partners on a scientific project,” said Hare. “It speaks volumes that we have multiple projects with Jeff because there are very few [researchers] for which we continue those partnerships.”

It is still uncertain when or if MacKeigan’s work will lead to new therapeutics to combat cancer. “It is not clear yet if the compounds identified are interesting tool compounds that we can help understand the disease better or if they really have the ability to advance forward,” said Associate Director at Atomwise, Terrence is clear, however, is that the collaboration between Dr. MacKeigan and Atomwise is revolutionizing the earliest stages of the drug discovery process and may lead to new therapies in the future.

MAKING LARGE-SCALE QUANTUM COMPUTING A REALITY



Trapped electron technology offers promising benefits.

For decades, a large-scale quantum computer has only been a theoretical possibility. Yet, the wide range of potential applications of quantum computing has led to numerous universities and corporations dedicating significant resources to unlocking its potential. Quantum computing promises to solve computational problems that are too complex for even the most advanced classical computer.

Unlocking quantum computing's potential

EeroQ, a Chicago-based startup, was founded to make large-scale quantum computing a reality. EeroQ hopes its approach to quantum computing will lead to it being used to address a wide array of computational challenges, including computational problems in cryptography, cybersecurity, optimization, and drug development, to name a few. "Those are big, exciting computational problems that quantum computers could have a big impact on. I get excited about the drug discovery stuff; I think that it's really cool, and it would be taking, what has been up to this point, physics research and using it to do something powerful, like developing new materials," exclaimed EeroQ co-founder and current Chief Science Officer Johannes Pollanen.

Pollanen, an Associate Professor, and Jerry Cowen, Chair of Physics in the Department of Physics and Astronomy at Michigan State University (MSU), are experts in quantum systems. Since joining MSU's faculty in 2016, Pollanen's research group has focused their research in combining quantum systems having fundamentally distinct, but interacting, degrees of freedom to create hybrid systems that exhibit altogether new phenomena or capabilities.

Pollanen also serves as the Principal Investigator of the Laboratory for Hybrid Quantum Systems, as Associate Director of the MSU Center for Quantum Computing Science and Engineering, and is a co-founder and board member of the Midwest Quantum Collaboratory.

Nick Farina, co-founder and CEO of EeroQ, is also excited about the drug discovery application of quantum computing technology, claiming, "a quantum computer can be the cornerstone of a revolution in the development of new medicines, and that is really exciting." Farina also cites the application of a large-scale quantum computer in developing next-generation batteries, some possibly powerful enough to power an electric airplane, which he suggests "would have a tremendous impact on the climate."

Farina has known Pollanen for a long time and was fascinated when Pollanen introduced him to the possibility of a new method to create a large-scale quantum computing device. "When he told me that he thought he knew a better way to build a quantum computer, once I realized what the implications for the world would be if there were to be a successful one, I was immediately captivated, and it was like nothing that I had ever done before," exclaimed Farina, adding, "I realized that this was an opportunity to really reinvent



Johannes Pollanen, Associate Professor of Physics and Astronomy at MSU and co-founder of EeroQ, conferring with a colleague at the MSU Center for Quantum Computing Science and Engineering.

computing. The chance to be part of that ground floor is really exciting."

Farina and Pollanen, together with David Rees, founded EeroQ, a quantum hardware startup dedicated to building a large-scale quantum computer using a trapped-electron, spin-based technique initially developed at MSU. "The base technology for EeroQ is based on a joint invention between MSU and EeroQ. Pollanen and his post-doc student Niyaz Beysengulov collaborated with David Rees from EeroQ and invented a new concept for a qubit," explained Raymond DeVito, Technology Manager at MSU Technologies (MSUT). DeVito went on to explain, "EeroQ started with access to this invention since it was a joint invention. Once EeroQ gained momentum as a business, they requested license to MSU's rights and now have all the rights to this patent with an exclusive license from MSU to MSU's share of the rights."

Although many companies are pursuing the development of a large-scale quantum computer, EeroQ's approach differs from that of many of its would-be competitors.

"We are using trapped electrons that we place in a vacuum, and we use the magnetism of that electron as the fundamental building block for that quantum computer," explained Pollanen. "We like this system because ultimately, these electrons can be packed in quite tightly. So you can get many of the basic elements, like the qubits you need for building the quantum computer, into a tight space. Then you can ultimately do logic operations due to computation quite fast."

This trapped electron approach was first proposed at MSU in 1999 by Mark Dykman, a professor in the Department of Physics and Astronomy. When Pollanen first came to MSU, he made it his goal to expand on Dykman's theory and bring the idea to fruition, precisely what he is doing at EeroQ. "I was inspired by Mark's original theory because of how he clearly identified that electron qubits floating above superfluid helium would be shielded from sources of noise and decoherence by the nearly perfect superfluid substrate. In fact, even before Mark's theory, electrons on helium

were known to be the purest, most defect-free, low-dimensional electron system in condensed matter. The field of quantum computing is always looking for better, more noise-free hardware, and it seemed to me that electrons on helium were a great foundation from which to try and build a new technology,” said Pollanen.

Although EeroQ’s qubit technology is at an earlier stage of engineering than some other qubits, as it is brought to maturity, it will offer some key advantages over competing platforms. These include exceptionally long coherence times, high qubit connectivity, CMOS compatibility, fast gates, and the ability to fit millions of electrons on a single chip, eliminating the need for modular designs.

Qubits, short for quantum bits, are the fundamental bits of information needed to create a quantum computing device.

While qubits can be made from trapped atoms, or in other cases, circuits made of superconducting materials, for EeroQ, the qubit is based on trapped electrons floating on helium. “It is not clear which of these is best yet for making a large-scale quantum computer, but ultimately, we think it’s going to be the trapped electrons for a number of reasons,” said Pollanen.

EeroQ is banking on its unique trapped electron technology setting it apart from many other startups with the same goal. “We’ve kind of cornered the market on the trapped electron approach,” explained Pollanen. “Our technical team has a lot of expertise in this system; it’s technically niche and also very challenging. There aren’t many folks that know how to do it, and essentially, we have nearly all of them at EeroQ. “

When asked about the progress EeroQ has made, Farina said they could have a device ready for commercial use within 3-4 years. “We are getting much closer. The progress in quantum computing has been linear in almost all the different types of quantum computing, and we think the rate of speed that we can build this once it starts to work can be exponential,” Farina claimed. Due to the unique approach EeroQ is taking, it will be able to be produced in completely standard chip manufacturing facilities. “What’s exciting about this technology and what makes it practical and easier to understand is that what we are doing is we are just designing a computer chip that looks and feels identical to what people have in their computers at home,” explained Farina. “The only difference, which is obviously a big difference, is that we then add a layer of superfluid helium on top of that computer chip, and then we control these single electrons on top of that helium.”

Whether it be optimization, cryptography, drug discovery, or data decryption, the work EeroQ is making promises to potentially revolutionize many industries. “EeroQ’s goal over time is to build something that is useful for any company,” said Farina. “The potential of quantum computing has been known for a while, and now, we’re working to make them come true.”

“THOSE ARE BIG, EXCITING COMPUTATIONAL PROBLEMS THAT QUANTUM COMPUTERS COULD HAVE A BIG IMPACT ON. I GET EXCITED ABOUT THE DRUG DISCOVERY STUFF; I THINK THAT IT’S REALLY COOL, AND IT WOULD BE TAKING PHYSICS AND USING IT TO DO SOMETHING POWERFUL, LIKE DEVELOPING NEW MATERIALS.”

Johannes Pollanen
EeroQ co-founder and current Chief Science Officer and Assistant Professor and Principal Investigator leading the Laboratory for Hybrid Quantum Systems at MSU

BY THE NUMBERS

\$25,114,620
CORPORATE SUPPORT FOR
MSU PROJECTS IN 2022

29
EXECUTED
LICENSE/
OPTION
AGREEMENTS

2
STARTUPS
(1 based in Michigan)

52
US PATENTS
ISSUED

55
NEW PATENT
APPLICATIONS

157
INVENTION
DISCLOSURES

\$4,032,058
ROYALTIES RECEIVED

*Translational Grants Investing in
MSU Intellectual Property:*

ADVANCE **2** TSGTD **3** MTRAC **19**



IAN GRAY SCHOLARSHIP RECIPIENT

Madison Marsh, author of *The Cut Cookbook*, was named the 2022 Ian Gray Scholar in Entrepreneurial Studies.

Madison Marsh knows that the best ingredients for every meal are passion and joy. As the author of *The Cut Cookbook*, Marsh, an MSU senior within the College of Agriculture and Natural Resources, is the 2022 recipient of the Ian Gray Scholarship in Entrepreneurial Studies.

Today, Marsh's cutting-edge recipes aim to serve her community, taking strides to make her customers' cooking experiences easy, fun, and delicious.

Inspired to share her love of cooking, Marsh wrote *The Cut Cookbook*, focusing on easy-to-make recipes with delicious, organic ingredients. The book also showcases Marsh's photography throughout, placing

the spotlight on the beauty surrounding her home in Northern Michigan. Marsh aims to spread her passion for healthy and organic food while honoring the many wonders Michigan has to offer.

With busy daily schedules and complicated recipes, cooking often becomes a chore for many. Recognizing the power of a good meal, Marsh knows food brings people

together and nurtures the body and soul. *The Cut Cookbook* is designed to encourage adventurousness in the kitchen and inspire cooks of all skill levels.

"Cooking should not be a stressful experience," Marsh explained. "With *The Cut Cookbook*, we are creating the mind, plus body, plus food connection to help our consumers restore their relationship with food and find joy in cooking."

Each year, the Ian Gray Scholarship is awarded to an MSU student exhibiting exceptional entrepreneurial qualities. Named after Ian Gray, who spearheaded the creation of the Innovation Center and served as Vice President for Research and Graduate Studies at MSU for nearly a decade, this scholarship honors Marsh's determination as a young, motivated innovator.

The recipient of the Ian Gray Scholarship receives \$2,000 per semester to help cover tuition or student expenses. With her tuition supported, Marsh plans to invest more into her venture, expanding *The Cut Cookbook's* reach while creating new products under The Cut brand to serve her customers.

"After launching *The Cut Cookbook*, we had tremendous feedback from our customers saying how much they loved the quick, easy, and healthy recipes," Marsh expressed. "This sparked an idea for me to create The Cut Vegan sauces, a versatile line of delicious, shelf-stable sauces that can be used to elevate your cooking experience."

Marsh's involvement within the Burgess Institute for Entrepreneurship and Innovation has helped provide resources, support, and experience opportunities to feed her curiosity and passions. In April, she found herself competing against

People's Choice Award in the 2022 Burgess New Venture Challenge. Most recently, Marsh traveled to Chicago to compete in DePaul University's Fifth Annual University Pitch Madness Competition, using the experience to network with student innovators from across the Midwest, and make connections with inspiring community members.

Marsh also serves as President of MSU's Women in Entrepreneurship student organization, leading a team of motivated student innovators with the experience she's gained through her opportunities.

Her goal is to grow her business and pursue her entrepreneurial passion full-time after graduation. Marsh says, "I will be graduating after this year, and I hope that throughout my senior year, I can help inspire other young aspiring entrepreneurs at MSU because it has been a fantastic learning experience and a place to grow."

EACH YEAR, THE IAN GRAY SCHOLARSHIP IS AWARDED TO AN MSU STUDENT EXHIBITING EXCEPTIONAL QUALITIES. NAMED AFTER IAN GRAY, WHO SPEARHEADED THE CREATION OF THE INNOVATION CENTER AND SERVED AS VICE PRESIDENT FOR RESEARCH AND GRADUATE STUDIES AT MSU FOR NEARLY A DECADE, THIS SCHOLARSHIP HONORS MARSH'S DETERMINATION AS A YOUNG, MOTIVATED INNOVATOR.



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