



**ANNUAL
REPORT**

FY22



OUR MISSION

We pair solution-oriented research with real-world needs for the enrichment of society through the protection, acceleration, and commercialization of Northeastern innovation.

A Message From The Executive Director	01
Protecting Our Innovations	02
By the Numbers & Highlights	03
A Year of Impact: Faculty Granted Patents	04
Faculty Spotlight: Barbara Waszczak	05
Accelerating Our Impact	07
Faculty Spotlight: Dr. Sunny Zhou	09
Spark Fund Awardees	11
Showcasing Our Transformational Technologies	12
By the Numbers	13
Spinouts Network	14
Staff Spotlight: Katie Hemphill	15
New Initiatives	16



A MESSAGE FROM THE EXECUTIVE DIRECTOR

At the Center for Research Innovation (CRI), we are creating a nexus of inspiration and innovation. We have the honor of working with the Northeastern research community to move research discoveries from the lab to the market for maximum societal impact. Our team has a unique opportunity and important responsibility to get these innovations into the world.

This year's annual report highlights the impacts of our commercialization accomplishments. CRI worked with our global community of researchers on 111 invention disclosures and filed a total of 290 patent applications. Northeastern had a record-breaking 77 patents issued and was ranked in the National Academy of Inventors' Top 100 Worldwide Universities Granted U.S. Utility Patents for the 7th consecutive year.

Last year alone, 9 technology-based ventures were spun out of research labs as a result of Northeastern's innovative capacity and entrepreneurial spirit. University startups raised over \$157 million in non-dilutive capital, investments, and acquisitions. Two companies had successful exits this year bringing the total to 6 acquisitions in the last 5 years; risQ, a company deploying sophisticated, data-driven technologies for managing climate change risk, to Intercontinental Exchange, Inc. (ICE), and VocaliD, the founder of proprietary voice matching and blending technology focused on personalization and customization.

The fiscal year 2022 also resulted in the continuation of many dynamic programs such as the Spark Fund, providing gap funding to further develop six cutting-edge technologies, and the launch of many new catalytic programs. Programs include the Commercialization Specialist program, which actively promotes and accelerates CRI commercialization efforts while creating experiential education opportunities for students. We're proud to welcome our first cohort from the College of Science and look forward to expanding the program in future years.

The CRI team is dedicated to creating a legacy of successful technology commercialization. Moving forward we look to amplify commercialization impact by working with our external partners, and internal research, innovation and entrepreneurship collaborators across the university system. Our momentum over the past several years combined with a robust and growing patent portfolio, strengthened industry alliances, and a strong culture of entrepreneurship position Northeastern to become a true global leader in improving society through innovation and entrepreneurship.



Jennifer Boyle-Lynch

Jennifer Boyle-Lynch | Executive Director

Northeastern University, Center for Research Innovation

**ANNUAL REPORT
FY22**

Protecting Our Innovations





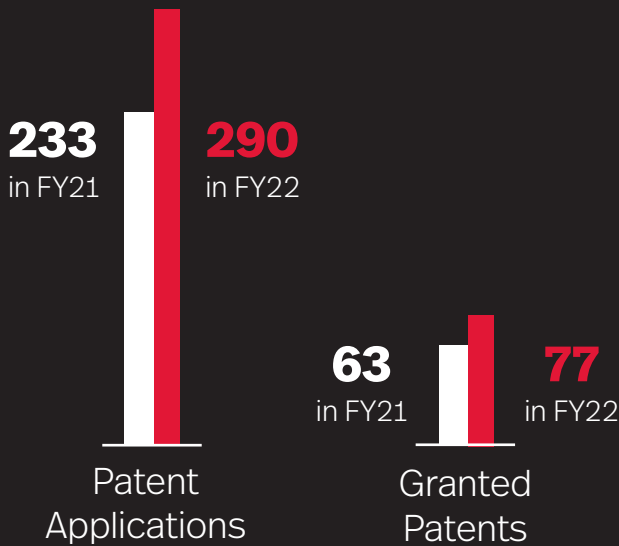
BY THE NUMBERS

111

Invention Disclosures

144

New Inventors



HIGHLIGHTS



NAI Top 100 for the seventh consecutive year

Northeastern University has secured its place as a center for innovation and entrepreneurship, making its 7th consecutive appearance on the Top 100 Universities in the world that have granted patents.



Invented Here!

Northeastern innovators Sanjeev Mukerjee, Michael Bates, Shraboni Ghoshal, and Huong Thi Thanh Doan were honored by The Boston Patent Law Association.

A YEAR OF IMPACT

Faculty Granted Patents

Bouvé College of Health Sciences

Tania Konry
Abhijit Kulkarni
Ganeshsingh Thakur
Raymond Booth

College of Engineering

Vincent Harris
Nian-Xiang Sun
Ahmed Busnaina
Yung Joon Jung
Sivasubramanian Somu
Cihan Yilmaz
Srinivas Sridhar
Qianqian Fang
Jeffrey Ruberti
Edgar Goluch
Adam Hatch
Abigail Koppes
Ryan Koppes
Shashi Murthy
Elizabeth Podlaha-Murphy
Thaddaeus Webster
Thomas Webster
Ali Abur

Cristian Cassella
Yajie Chen
Kaushik Chowdhury
Emrecan Demirors
Salvatore D'Oro
Hui Fang
Tommaso Melodia
Sarah Ostadabbas
Vageeswar Rajaram
Francesco Restuccia
Matteo Rinaldi
Aatmesh Shrivastava
Edmund Yeh
Parisa Andalib
Efstratios (Stratis) Ioannidis
Randall Erb
Joshua Martin
Jeffrey Paten

College of Science

Slava Epstein
Jonathan Tilly
Dori Woods
Neel Joshi
George O'Doherty
Ke Zhang
Zhaohui Zhou
Mohammadamin Alibakhshi
Arun Bansil
Swastik Kar
Rajiv Kumar
Joseph Larkin
Fangze Liu
Pradeep Waduge
Meni Wanunu
Ozgun Yavuzcetin
Amissi Sadiki
Alexandros Makriyannis
Yury Petro

FACULTY SPOTLIGHT

A Novel Gene Therapy Approach for Combating Opioid Use Disorder

Barbara Waszczak is a Professor of Pharmacology at Northeastern University. Waszczak is currently leading research on a project that aims to treat opioid use disorder via a novel gene therapy. The National Institute on Drug Abuse (NIDA) recently awarded a joint grant worth \$14.7 million to Northeastern and Copernicus Therapeutics, Inc., a biotech company whose cDNA nanoparticles are being used in the project. The project revolves around the use of glial cell-derived neurotrophic factor, or GDNF, which has the ability to promote the recovery of dopamine neurons in the brain (a.k.a. the pleasure center). By placing the cDNA for GDNF within nanoparticles from Copernicus, the GDNF could be sent directly to those neurons in a non-invasive way – specifically, via intranasal delivery. This novel approach using intranasal GDNF nanoparticles could potentially make recovery for opioid users a more streamlined process, with no need for surgery or injections.

Prior to her work on opioid use disorder, Waszczak first began working with intranasal GDNF to treat Parkinson’s disease. The work done had shown that intranasal GDNF protected dopamine neurons from damage in a rat model of Parkinson’s disease, suggesting it might help slow the progression of the disease in humans. However, this method of applying GDNF wasn’t efficient, as the GDNF would rapidly break down soon after being administered. In response to this, Waszczak developed the method of intranasal delivery of DNA nanoparticles for GDNF that made the overall process much easier. Her partnership with Copernicus allowed her to use their cDNA nanoparticles, which were able to carry the gene for GDNF directly into the brain through the intranasal pathway from nose to brain. “These nanoparticles get into the brain and increase the production of GDNF, rather than just delivering GDNF itself and watching it degrade very quickly,” she notes. Unfortunately, industry interest in



GDNF for Parkinson's began to wane. While Waszczak was working on her novel approach to the issue, others in the field were having less success with surgical infusions of GDNF in Parkinson's patients. This led to grant funding for GDNF and Parkinson's research being greatly reduced. This wasn't the end of Waszczak's work however, and she took a different direction. She made the connection that GDNF could potentially be used to treat similar disorders that affect brain dopamine neurons – notably, opioid use disorder.

Currently, there are a number of existing methods to help those suffering from opioid use disorder, one of which is Medication-Assisted Therapy (MAT). MAT works by giving patients specific drugs (that are often a type of opioid themselves) that essentially work as a substitute to help them stay off of dangerous opioids. While MAT can be effective at weaning patients off dangerous drugs, it doesn't fully curtail the issue. "There are really no drugs that can stop patients from wanting to return to these opioids – they're still very likely to relapse," Waszczak says. Opioid drugs work by triggering the dopamine neurons in the reward circuit of the user's brain, and chronic overuse eventually leads to dopamine-deficiency. This will, in turn, lead the user to crave more of the drug. This is where Waszczak's work comes into play; by using the GDNF gene therapy, the dopamine neurons will be able to recover from the deficit. "The hypothesis of our study is if they stop having a dopamine deficit, they will have less craving and thus less tendency to relapse."

Moving from hypothesis to testing can be an arduous process not only due to the work involved, but also due to the challenges involved in securing funding for a project. Luckily, Waszczak was able to find the support she needed

to kickstart her project. Shortly after describing her work at a RISE event at Northeastern, she began working with Northeastern's Center for Research Innovation (CRI) to file a patent application on intranasal delivery of Copernicus's cDNA nanoparticles for brain disorders. "It was very generous of them to support this patent and pay for the cost of filing," she says. In November of 2016, the patent was issued jointly to Northeastern and Copernicus.

With the technology secured, it became a matter of finding funding. Following the backing of an early grant from the Brain Research Foundation, Waszczak's preliminary tests on rats were a success; rats that associated a certain place with the rewarding effects of opioids would no longer return to that place once treated with the intranasal GDNF DNA nanoparticles. These early tests gained Waszczak's work more recognition in the field of addiction science.

Soon after, she found a second sponsor in the Tufts Clinical Translational Science Institute. With the awards from these two foundations, Waszczak was able to gather the preliminary data on rats that attracted the attention of NIDA, resulting in the recent \$14.7 million grant she received. Thanks to that funding, and the support of the CRI, she has been able to continue to accelerate her innovation.

For Waszczak, this support ultimately provides the means to test a novel treatment for an important brain disease. The opioid epidemic is extensive, ruining an extraordinary number of lives. "This is a moment in history where we need new kinds of treatments, and if this could be of any benefit to patients with opioid use disorder, I would be delighted," Waszczak explained. Interestingly, just as her initial work with GDNF and Parkinson's led her to this project, success here could result in many other avenues to explore. Other addictive substances work in a similar way to opioids in that they stimulate the dopamine reward neurons in the brain; in theory, a similar intranasal GDNF gene therapy could be feasible for reducing relapse with other drugs, such as alcohol, cocaine, amphetamines or nicotine. Waszczak could even go full circle and return to her initial work on Parkinson's, this time with more data demonstrating the feasibility of an intranasal GDNF gene therapy for brain disorders. She commented on her experience in shifting projects, "in science, a good idea never dies; if it doesn't succeed one way, you might try and see if there's another way it can still be beneficial." For now, she plans on tackling these issues one at a time, but the future for this project is bright with opportunity.





**ANNUAL REPORT
FY22**

**Accelerating
Our Impact**

Six Northeastern Spinout Companies Selected as Eddies Finalists for Their Groundbreaking Innovations

Every year, the Massachusetts Innovation Network hosts its signature innovation competition, The Eddies. The Eddies (formerly known as NE Innovation Awards) is the oldest and longest running innovation competition in New England.

DeepCharge was selected as winner.



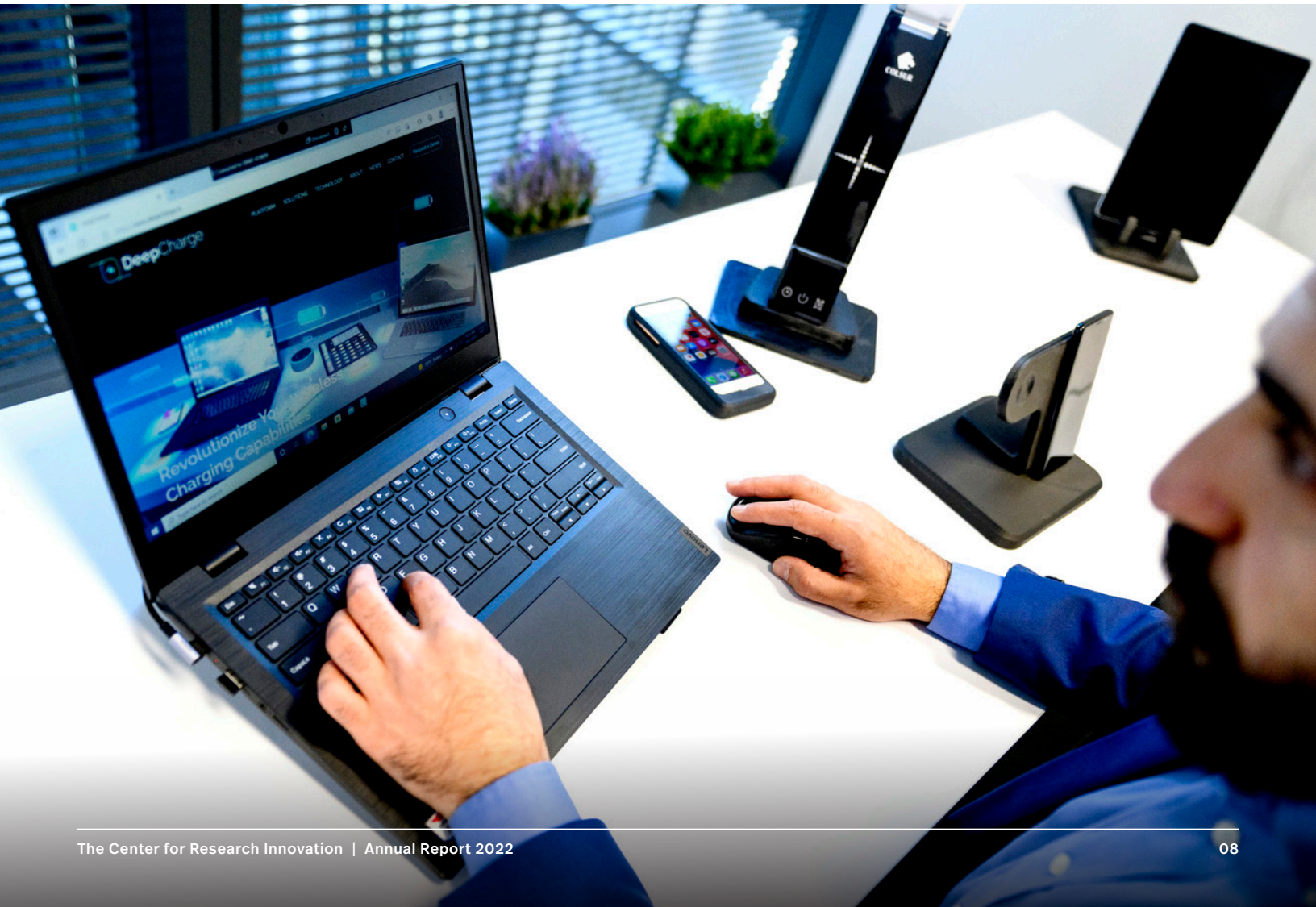
17

Non-disclosure agreements

SPINOUT AND RESEARCH FUNDRAISING

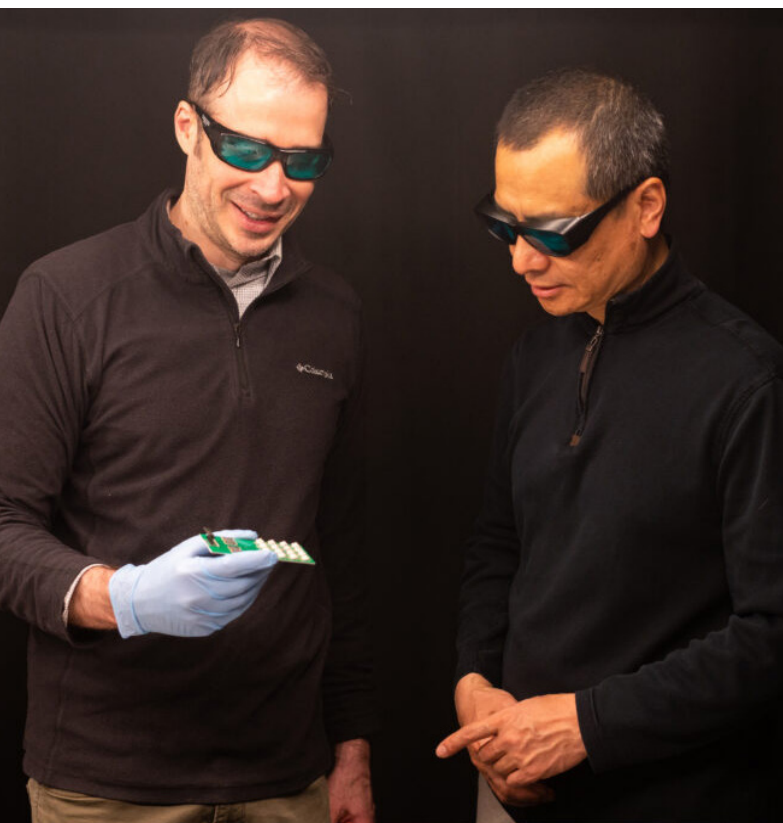
\$135,649,067

Venture Capital and SBIR Funding



FACULTY SPOTLIGHT

Using the Power of Light to Revolutionize Drug Efficacy and Safety – with Spark Fund awardee Dr. Sunny Zhou



Some of the best, world-changing ideas have been ideated in the most unlikely of places – such was the case one February morning, when Northeastern researcher Sunny Zhou thought of a revolutionary new way to make drug delivery more specific, efficacious, and safe, as he made his way to campus on the Orange line.

Dr. Zhou's idea addresses one of the biggest challenges that drug developers face – ensuring that a new drug is both effective and safe for human use. This is such a tricky problem because biology is often not as specific as researchers hope for. This means that drugs can have unintentional interactions in different places in the body, leading to serious side effects and toxicity. This is often referred to as off-target effects or off-target toxicity.

However, Zhou's idea was that photomedicine – an exciting field that combines physics, chemistry, and biology – could enhance temporal and spatial control over drug administration. It can help decrease off-target effects and therefore has the potential to treat many diseases that currently have no treatment due to specificity issues.

So, Northeastern researchers Dr. Sunny Zhou and Professor Bryan Spring, along with their team of about a dozen students and collaborators, have invented a photomedicine platform that enables highly specific drug administration.

Using Photomedicine to Make Drug Administration Highly Specific

Zhou’s invention and approach are to mask or “cage” peptides and proteins in a drug, rendering the therapeutic molecules inactive until they are administered to a specific site in the patient. After administration to the patients, the mask is removed with exposure to light (or other stimuli), which creates the active form of the drug. This enables the therapy to be delivered with precise spatial and temporal control, so it only treats the area of interest and minimizes or eliminates any off-target effects.

Zhou’s initial area of focus is Uveal Melanoma, a deadly and hard-to-treat type of eye cancer that can also lead to loss of vision.

“Ophthalmology is ideal for photomedicine because it is easy to administer light to the eye,” says Zhou. “Generally speaking, oncology has the most unmet needs that our technology can address, so that is where we are starting our focus, but many other diseases and conditions can also be treated with photomedicine, such as dermatology and pain management.”

In several years, Dr. Zhou envisions their lead candidates entering clinical studies and being approved for clinical applications.

Commercialization with the CRI Spark Fund

Zhou notes that commercialization can be challenging for an academician, because having a good invention with strong supporting research is typically not enough to succeed. Instead, successful commercialization primarily requires innovation that creates something that sells. While there are countless unmet needs that researchers could hope to address, it can be challenging to demonstrate viable solutions that can sell and are better than all other competing approaches.

For this reason, he notes that working with the Spark Fund was a very educational and informative process. “The best parts were going through self-evaluation and receiving feedback from the Spark Fund judging panel,” Zhou says. “Of course, the funding is a great help, but the continued feedback and support from CRI are equally valuable.”

“Commercialization is a long and trying process that requires a full team effort,” says Zhou. “This award is crucial for further development of our research and the CRI’s support, guidance and network have been essential for our success. Moreover, the people at CRI have been wonderful to work with over the years.”

Written by Elizabeth Creason



SPARK FUND AWARDEES

The Spark Fund helps Northeastern researchers bridge the gap between promising lab results and demonstrating a commercially viable prototype. Our grants and programs catalyze state-of-the-art technologies, advancing Northeastern inventions through prototyping, validation, and industry input. Representing multiple colleges and disciplines, this cohort of Spark Fund awardees presented diverse and exciting projects to the Center for Research Innovation. **Read more about the awardees here.**



RANDALL ERB AND JASON BICE
New Advanced Manufacturing Platforms

Certain types of ceramics known as phononic crystals exhibit the remarkable combination of thermal conductivity and electrical insulation. Randy and Jason are developing knowledge around new advanced manufacturing platforms that can process these all-ceramics into intricate parts at high rates of production.



JEFF RUBERTI
CRISPR Cas9 Acceleration of Human Active Collagen Production

To construct therapeutics that deliver active collagen to injuries, the EMERL lab has been working to enhance the production of this very important molecule using the CRISPR Cas-9 promotional system, focusing on developing and optimizing methods to induce human fibroblasts to produce large amounts of type I collagen.



AATMESH SHRIVASTAVA
“Ultra-low Power Wake-up” with Analog Computing for Always on Connectivity

Focusing on reducing the power consumption of radios by over 6-orders of magnitude, we aim to develop <20 nano-watts, wake-up radio circuits that can achieve a sensitivity greater than -90 dBm, to realize approximately 100-foot connectivity. The radio architecture is based on the energy detection of the incoming radio signal implemented using high sensitivity passive energy detection circuits to realize ultra-low power operation.



BEN WOOLSTON
A Co-Culture Method for Enhanced Biofuel & Biochemical Production from Untreated Waste Gases

The Woolston lab is developing a symbiotic co-culture to enable the high-yield conversion of carbon-rich waste gases to high-value fuels and chemicals. The use of multiple microbes with specialized metabolic capabilities enables the generation a wider portfolio of products and more stable operation than is possible with a single microbe.



YI ZHENG
Recyclable, Scalable and Self-cleaning Passive Cooling Paper for Building Roofs

Compressor-based cooling systems, providing comfortable interior environments for infrastructure, account for about 20% of total worldwide electricity consumption. The resultant greenhouse gas emissions intensify global warming and accelerate climate change. As such, an carbon-neutral, eco-friendly cooling approach is vital. Emerging passive cooling technologies are the perfect solution to this problem, without any energy consumption.



SUNNY ZHOU
Spatial and Temporal Activation of Protein Therapeutics by Light

A fundamental impediment in drug development is the limited therapeutic index, due to the on-target/off-tumor toxicity. Sunny's work masks (or cages) peptides and proteins, rendering them inactive. The invention and platform enable both the chemo-enzymatic site-specific conjugation and the engineered chemistry tailored for the controlled re-activation (unmasking or uncaging).



**ANNUAL REPORT
FY22**

**Showcasing Our
Transformational
Technologies**

BY THE NUMBERS

8

Licenses
& Options

\$689,561

Licensing Revenue

10

Spinouts
Formed

ACQUIRED

Intercontinental Exchange, Inc. Acquires Northeastern Spinout risQ

Intercontinental Exchange, Inc. (NYSE: ICE), a leading global provider of data, technology and market infrastructure announced the acquisitions of risQ and Level 11 Analytics, which deploy sophisticated, data-driven technologies for managing climate change risk and expanding our alternative data capabilities in U.S. fixed income, municipal and mortgage-backed securities markets.

Since the two companies were founded in 2016 and 2019 respectively, risQ and Level 11 Analytics have leveraged a variety of advanced geospatial mapping systems and have provided extensive expertise in analyzing and joining vast amounts of disparate public, corporate and third-party data sources. This data is integrated together and mapped to financial securities to provide high quality climate risk analytics and investment decision-making tools for the industries the companies serve. Initial offerings have included climate risk and ESG data for the U.S. municipal bond, mortgage-backed securities and real estate markets.

“Understanding and measuring climate risk, and its impact on investment decisions, continues to be a growing area of focus for our customers,” said Lynn Martin, President of Fixed Income and Data Services at ICE. “risQ and Level 11 Analytics provide unique data sets and platforms, and their strong analytical background and focus on ESG factors, real estate and the mortgage markets, serve as fertile ground for creating innovative products that offer more insights for our customers.”



ADA Tech LLC

Biosus Corporation

Boston NanoEnergy, Inc.

BrilliantStrings
Therapeutics, Inc.

Feromics

Fourier Technical
Ceramics

Mirlo Systems, Inc.

ParetoFront

PerZeption, Inc.

zTouch Networks, Inc.



SPINOUTS NETWORK

Each conference focused on connecting early-stage startups with prospective strategic partners and investors, offering access to their exclusive networks.

Digital RESI JPM – Redefining Early-Stage Investments

RESI connects start-ups and early-stage investors and strategic channel partners. These sessions maximize fundraising companies' efforts to find partners who are a fit for their technology and stage of development. RESI is uniquely cross-border and cross-domain, connecting start-ups with 10 categories of global investors across the silos of drugs, devices, diagnostics and digital health.

LSX

LSX gathered North America's leading Biotech, Medtech and HealthTech CEOs for a 2-day executive conference, 1-2-1 in-person partnering and showcase opportunities.

6 VENTURES PARTICIPATED:

- Ainnovation
- BrilliantStrings
- Imaginostics
- Interstellar Therapeutics
- Perzeption
- Syncell Biotechnology

STAFF SPOTLIGHT

CRI Welcomes Katie Hemphill

Exciting times await the Center for Research Innovation as Katie Hemphill joins us as the Director of Technology Ventures and Talent Network. She speaks about what she looks forward to and her work thus far, as she leaves her role as Associate Director of the McCarthy(s) Venture Mentoring Network (VMN) at Northeastern's Center for Entrepreneurship Education at D'Amore-McKim School of Business.

When asked if she is thrilled for her next step working with ventures and spinouts in their early stages she exclaims enthusiastically, "Of course, I am!" Expanding on the nature of benefit the role holds for her, she says, "Joining the CRI provides me with fantastic opportunity to expand my relationships inside and outside of Northeastern's entrepreneurial ecosystem." Her acumen in industry gives CRI a strong edge. Katie states, "We do that by increasing scalable support for spinouts and championing innovative inventions." In conclusion, she emphasizes, "I really look forward to further enabling entrepreneurial impact."

Katie's proven track record and impressive credentials make her a valuable asset to CRI. She spent the last 6 years at VMN where she worked as the Associate Director for the latter half. Katie's strategic vision at VMN resulted in her successfully forging dynamic partnerships between entrepreneurs and intrapreneurs tailored to specific business challenges.

Jennifer Boyle-Lynch, Director of CRI, adduces: "She is a dynamic problem solver who understands the value of a powerful network." Continuing, Jennifer confidently states, "Katie has experience in developing programs to support the venture community here at Northeastern. Her energy and passion for entrepreneurship are palpable." With the addition of Katie, Jennifer is poised to continue leading CRI into uncharted success for years ahead. "Among other inspiring programs, Katie will build and oversee a team of executive talent which will advance university spinouts – a gamechanger for CRI, and I look forward to working with her," she finishes with determination.

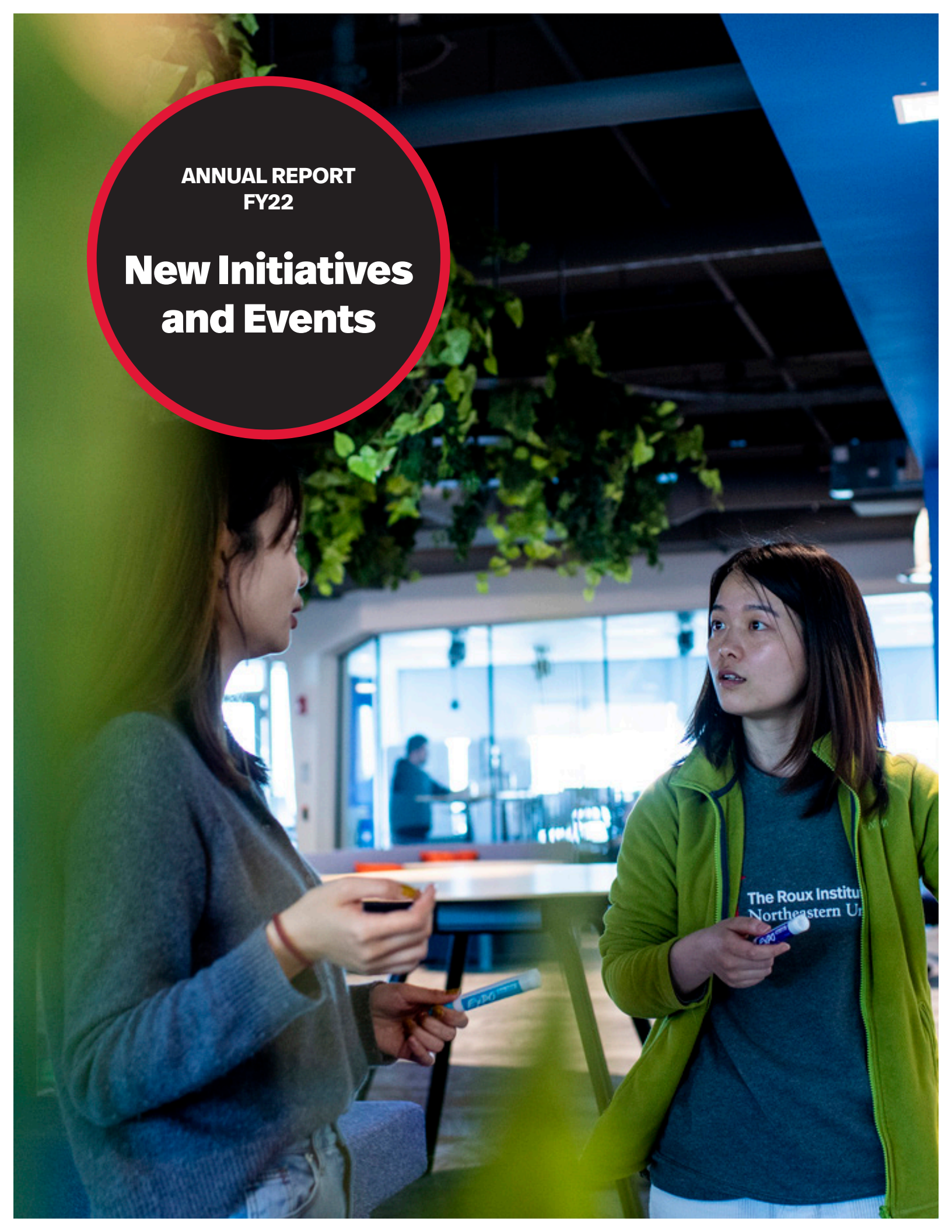


As denoted in her title, Katie's arrival at CRI behooves additional responsibility from that left by the former Director of Technology Ventures, Joel Bresler. A Husky herself, with a master's degree in project management from Northeastern University, Katie will be working in a familiar environment. She is well positioned to take on and succeed in the management of existing funding programs and building a robust talent network of enterprising inventors and executive talent.

Written by Vijay Harisudan Sivasekar

**ANNUAL REPORT
FY22**

New Initiatives and Events



New Initiatives



FedTech

Through accelerators and corporate venture programs, FedTech provides entrepreneurs a viable path to transition breakthrough technologies to real-world impact.

Master the Fundamentals

This premier program prepares entrepreneurs across all disciplines to translate technical work and research into value as a new venture in a commercial setting. The course walks participants step-by-step through the real-world entrepreneurial process to develop and launch a successful startup.

In a series of ten sessions, entrepreneurs learn Silicon Valley's tested startup methods and tactics that can help convert research and inventions into an investable company.

Entrepreneurs in Residence

The EIR is designed to enable use-inspired research with global impact through company creation and launch as well as increase awareness of companies launching out of Northeastern.

The EIR will work directly with CRI and its portfolio companies to mentor and enable business/product development as well as helping expand companies' networks with investors and corporations who have a strategic interest in early-stage innovations.

New Initiatives

(Continued)



Professional Discovery Network Commercialization Specialists

As part of the Professional Discovery Network, designed to enhance commercialization while advancing Northeastern's student opportunities for education and skill building, as the Commercialization Specialists, by actively marketing technologies in Northeastern's portfolio to industry. This creates the best possible opportunity for these technologies to become commercially available for the benefit of local communities and those around the world. The pilot program began with the College of Science, and given its success, it is now expanding to Bouvé.

Venture Specialists

Through the work of the specialist, spinouts in Northeastern's portfolio will be actively marketed to industry and investors, creating opportunity for these spinouts to launch and their technologies to become commercially available for the benefit of all.

Discovery Sessions

The CRI's Invention Discovery Program aims to provide a platform for Northeastern inventors to engage with specialized legal professionals for the purpose of discovering inventions and beginning the patenting process early. These personalized sessions provide inventors with tailored feedback and insights for intellectual property related issues or questions, and help educate inventors about the importance of, and the process for, protecting intellectual property.



NORTHEASTERN
UNIVERSITY

N Northeastern University
Center for Research Innovation

1.617.373.8810 | cri@northeastern.edu | 101 Belvidere St., 1st Floor, Boston, MA 02115