

2020 | 2021

SCHOLARSHIP REPORT

CHEMICAL

ENGINEERING

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With over 195 tenured/tenure-track faculty, 17 multidisciplinary research centers and institutes, and funding by eight federal agencies, the College of Engineering is a leader in experiential education and interdisciplinary research, with a focus on discovering solutions to global challenges to benefit society.

Northeastern University

Founded in 1898, Northeastern is a global research university and the recognized leader in experience-powered lifelong learning. Our world-renowned experiential approach empowers our students, faculty, alumni, and partners to create impact far beyond the confines of discipline, degree, and campus.

Our locations—in Boston; the Massachusetts communities of Burlington and Nahant; Charlotte, North Carolina; London; Portland, Maine; San Francisco; Seattle; Silicon Valley; Toronto; and Vancouver—are nodes in our growing global university system. Through this network, we expand opportunities for flexible, student-centered learning and collaborative, solutions-focused research.

Northeastern's comprehensive array of undergraduate and graduate programs—in on-campus, online, and hybrid formats—lead to degrees through the doctorate in nine colleges and schools. Among these, we offer more than 140 multidisciplinary majors and degrees designed to prepare students for purposeful lives and careers.



**We are a leader
in experiential
education and
interdisciplinary
research, focused
on Engineering
for Society**

DEAR COLLEAGUES, FRIENDS, AND STUDENTS,

At the Northeastern University Department of Chemical Engineering, 2020-2021 was not a 'normal' year. However, has it been for anyone? The department continues to reach new heights of achievement and we met change both in the classroom and in our research. Many of our faculty have dedicated their effort and expertise in the fight against COVID-19. In addition, we remind our students to become leaders in engineering to address challenges for our evolving world.

Our department is comprised of over 40 primary and affiliated faculty and we continue to grow. In the upcoming academic year, we welcome three new faculty members, with expertise in theoretical biology, computational catalysis, and designing of photocatalysts. Chemical Engineering had two NSF CAREER grant winners this past year, along with a number of awards to our faculty for their scholarship and service. Our highly accomplished, diverse faculty are leaders in their fields and continue to display excellence in their expertise. The department is supported by multiple areas of research: biomolecular & biomedical systems, complex & computational systems, energy & sustainability, engineering education & pedagogy, and materials & nanotechnology. These research areas provide a wealth of opportunity for students to have an impact on the environment, healthcare, and technology.

Northeastern's top-rated (and one of the nation's largest) cooperative education (co-op) program plays an important role in our success. Chemical engineering co-op positions span the areas of consumer products, plastics, biotechnology, nanotechnology, alternative energy, and petrochemicals, with students placed in positions both domestically and internationally. Through a combination of rigorous academics, research excellence, and professional experience, recent graduate students have taken industry and research positions at leading organizations such as Pfizer, Harvard University, Takeda, Sanofi, Lockheed Martin, and Intel, to name just a few.

I invite you to explore highlights of the many aspects of our Department of Chemical Engineering and research of our faculty through this Scholarship Report.

For more details, visit our website at
CHE.NORTHEASTERN.EDU.

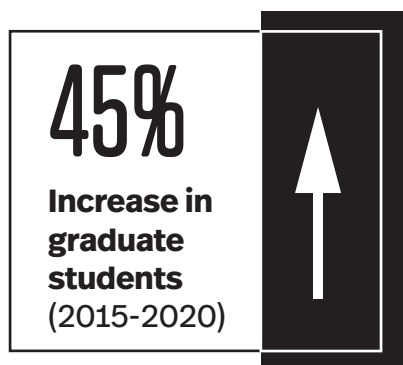


Sincerely,

Rebecca Kuntz Willits, PhD
Professor and
Department Chair
Chemical Engineering
r.willits@northeastern.edu

QUICK FACTS CHEMICAL ENGINEERING

583 Students
45% are Women



23 Young Investigator
Awards,
including **10**
National Science
Foundation
CAREER Awards

34 **TENURED/
TENURE-TRACK**
Faculty, including
Affiliated

Promotion
Abigail Koppes,
Associate Professor



National Academy Member
Arthur Coury, University
Distinguished Professor



13
Professional
Society Fellowships

54
Visiting Scholars
(2017-2020)

2021 NSF CAREER Award Recipients
Abigail Koppes, Associate Professor
Joshua Gallaway, DiPietro Assistant Professor

QUICK FACTS COLLEGE OF ENGINEERING

With **200** tenured/tenure-track faculty and **17** multidisciplinary research centers and institutes with funding by eight federal agencies, the College of Engineering is a leader in experiential education and interdisciplinary research, with a focus on discovering solutions to global challenges to benefit society.

5 **Engineering
Departments**

104 **YOUNG
INVESTIGATOR
Awards**

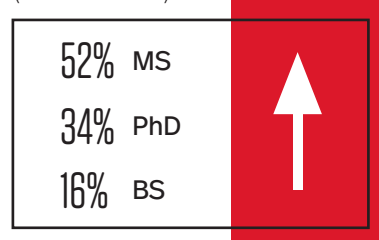
Including **58** NSF CAREER Awards, and **18** DOD Young Investigator Awards

84 **Professional
Society
Fellowships**

949 **Graduate Students**
Placed on Co-op
(2020-2021)

TOTAL ENROLLMENT (Fall 2020)
7873 49.8% Graduate
50.2% Undergraduate

Enrollment Growth
(2015 to 2020)



RECENT FACULTY HIRES



SRIRUPA CHAKRABORTY

Assistant Professor, Chemical Engineering

PhD, University of Buffalo, 2017

Scholarship focus: Theoretical biology and biophysics



BENJAMIN WOOLSTON

Assistant Professor, Chemical Engineering

PhD, Massachusetts Institute of Technology, 2017

Scholarship focus: Metabolic engineering and synthetic biology for sustainable biochemical production and human health



HANNAH SAYRE

Assistant Professor, Chemical Engineering, jointly appointed in College of Science

PhD, The Ohio State University, 2018

Scholarship focus: Design photocatalysts to improve efficiency and reactivity. Understand light-activated chemical reactions with time-resolved spectroscopy



QING ZHAO

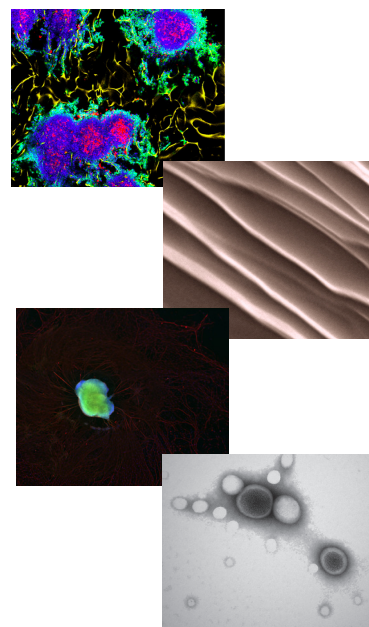
Assistant Professor, Chemical Engineering

PhD, Massachusetts Institute of Technology, 2019

Scholarship focus: Computational catalyst and material design for sustainable energy applications

RESEARCH LABS

- Bioresponsive Drug Delivery and Tissue Engineering Lab
- Laboratory for Advanced and Multiscale Polymeric Biomaterials (LAMP)
- Advance Drug Delivery Research (ADDRES) Lab
- Mechanobiology Lab
- Advanced Biomaterials & Tissue Engineering Lab
- Analysis of Complex Electrochemical Systems (ACES) Lab
- Sensors and Engineered Microbial Systems (SEMS)
- Complex Fluids & Soft Materials
- Molecular Modeling and Computer Simulation Lab
- Advanced Biomaterials for NeuroEngineering Laboratory (ABNEL)
- Laboratory for Neuromodulation and Neuromuscular Repair (LNNR)
- Cellular & Metabolic Lab
- Nanomagnetism Lab
- Translational Nanomedicine Lab
- Computational Modeling Lab (CoMoChEng)
- Materials for Tissue Engineering Lab (MTE)
- Metabolic Engineering & Synthetic Biology Lab
- Supramolecular Nanomaterials Laboratory



\$14M External
Research
Awards
(2019-2021)

FACULTY BY RESEARCH AREAS

Biomolecular & Biomedical Systems

Mansoor Amiji	Sara Hashmi
Debra Auguste	Abigail Koppes
Sidi A. Bencherif	Ryan Koppes
Rebecca L. Carrier	Carolyn Lee-Parsons
Arthur Coury	Steve Lustig
Eno Ebong	Ming Su
Adam Ekenseair	Rebecca Willits
Edgar Goluch	Benjamin Woolston

Complex & Computational Systems

Rebecca L. Carrier
Francisco Hung
Steve Lustig
Richard West

Energy & Sustainability

Hicham Fenniri	Laura Lewis
Joshua Gallaway	Steve Lustig
Edgar Goluch	Courtney Pfluger
Sara Hashmi	Ming Su
Francisco Hung	Richard West
Carolyn Lee-Parsons	Benjamin Woolston

Engineering Education & Pedagogy

Adam Ekenseair
Edgar Goluch
Lucas Landherr
Courtney Pfluger
Behrooz Satvat
Rebecca Willits

Materials & Nanotechnology

Debra Auguste	Sara Hashmi
Sidi A. Bencherif	Francisco Hung
Rebecca L. Carrier	Ryan Koppes
Arthur Coury	Laura Lewis
Eno Ebong	Steve Lustig
Adam Ekenseair	Ming Su
Hicham Fenniri	Ronald Willey
Joshua Gallaway	Rebecca Willits



Pioneering a Human-Centric Artificial Intelligence Research and Applications Hub

Northeastern University has allocated \$50 million to the new Institute for Experiential AI, a pioneering research hub that places human skills and intelligence at the forefront of artificial intelligence applications. Leading experts in computer science, engineering, ethics, humanities, law, public policy, health, security, and sustainability will collaborate to develop applied human-centric AI solutions that tackle the world's toughest challenges.

The Institute for Experiential AI is university-wide, based out of the Roux Institute at Northeastern—a graduate education and research campus in Portland, Maine, born from a \$100 million investment in the university by David and Barbara Roux. Designed

to educate generations of talent in the digital and life sciences sectors, the Roux Institute also acts as a driving force for sustained economic growth in Portland, the state of Maine, and northern New England.

“Northeastern has committed to building the top research institute in the world focused on Experiential AI,” says founding Executive Director **Usama Fayyad**. “No one has claimed this space yet and I’m excited for our chance to lead this field.”

To accelerate research and advance practical applications of AI in several domains, the Institute for Experiential AI is recruiting 30 new research and teaching faculty, data scientists, and postdoctoral fellows. In addition, faculty from colleges within the university such as the College of Engineering and Khoury College of Computer Sciences will conduct and collaborate on multidisciplinary research as part of the institute.

The Institute for Experiential AI will partner with industry, government, and academia to educate the next generation of AI professionals and lead efforts to create ethical and responsible human-centric AI. The institute also plans to be a prominent contributor to the global AI ecosystem and a key driver of experiential AI in New England through targeted activities in the region.



Photo by Matthew Modono

Joshua Gallaway, DiPietro assistant professor, chemical engineering

NSF CAREER Award to Make Batteries Safe and Inexpensive for the Electrical Grid

Joshua Gallaway, DiPietro assistant professor, chemical engineering, received a \$400K National Science Foundation CAREER Award for “Engineering Electrochemical Reversibility in Disordered Materials for High Energy Density Batteries.” The award will address the challenge of rechargeability of a battery material, manganese dioxide (MnO_2), that could speed the development of large, low cost, non-flammable batteries capable of powering the electrical grid, leading to widespread adoption of renewable energy.

“We’ve learned that you can make this material, MnO_2 , rechargeable by doping it with other atoms,” Gallaway explains. “If you use bismuth—a high molecular weight atom—to dope the MnO_2 material, it becomes rechargeable. Then you can conceivably make batteries for the electrical grid that are inexpensive and safe.”

The project is also researching why bismuth makes MnO_2 rechargeable. Gallaway and his research team are making MnO_2 that has several different forms of bismuth doped into it. “The large part is synthesis work with different amounts of

bismuth incorporated in different ways,” he says. “We are going to characterize that material, where it is and how much of it is there. We’ll cycle the material in different ways to see what happens to it and study the relationship between bismuth and the rest of the atoms.”

Aiding the team in watching materials while they’re doing electrochemistry is a synchrotron, a type of particle accelerator called NSLS-II and located on Long Island in New York. “These facilities make very high-quality X-rays that are also very bright and very high energy,” explains Gallaway. “We use powerful X-rays from the synchrotron to focus on bismuth during charging and discharging of the battery to see what the bismuth is doing.”

Additionally, Gallaway is researching a unique characteristic of the MnO_2 /bismuth pairing: While cycling in a battery, the MnO_2 material is initially ordered, showing general regularity, but it becomes disordered, and thus more difficult to characterize. “In the past, we looked at materials from an ordered perspective,” he says. “Now we look at these materials from the point of view of disorder, using different X-ray techniques...The point is knowing what bismuth is doing. Then we can engineer it to do better.”



Photo by Adam Glanzman

Abigail Koppes, associate professor, chemical engineering

NSF CAREER Award to Understand How the Nervous System Regulates the Gut

There's a growing awareness of the connection between the human brain and the intestinal tract, but many questions remain. Why do human neurological disorders, such as anxiety, often manifest themselves with irritable bowel syndrome and other conditions? Why do Crohn's disease and other intestinal disorders have broad implications for the nervous system?

Associate Professor **Abigail Koppes**, chemical engineering, received a National Science Foundation CAREER Award, titled "Defining the Regulators of Enteric Plasticity in Engineered Microfluidic Environments," to further her research in this area.

"The human body is incredibly complex, with a nervous system that acts as an 'information highway,' sending signals and triggering reactions," Koppes notes. "Because we don't understand the invisible mechanisms at work, we are unable to intervene in a helpful way. If we can figure out why the brain triggers a certain response in the gut—and vice versa—we can develop better treatments and improve patient outcomes significantly."

Koppes' research focuses on developing new, non-invasive methods of exploring human cellular responses to biological signals in her Advanced Biosystems for Neuroengineering Laboratory. As part of the CAREER Award research, she and her team will engineer and apply microphysiological systems to better understand how the nervous system regulates the gut in response to inflammation. Plastic, disposable handheld devices will be developed that expose engineered tissue to a range of signals, then measures its response. These models have wide applications to other organs in the body and will advance knowledge in neurobiology and engineering for human health discovery.

"This new platform will enable researchers to discover ways of turning pathologies 'on and off' via different kinds of biosignals," explains Koppes. "It's a cost- and time-effective means of testing tissue behavior, without risking the health of human or animal subjects. We can easily study reactions at the benchtop, then apply those findings in a clinical setting."

Koppes's lab is partnering with doctors at Massachusetts General Hospital and Boston Children's Hospital, as well as Northeastern chemical engineering, bioengineering, and biology faculty.

Faculty Highlights

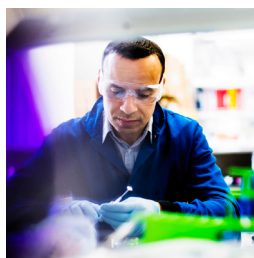


Abigail Koppes, associate professor, chemical engineering, received the **2020 Cellular and Molecular Bioengineering (CMBE) Young Innovator Award**, in which CMBE publishes the most innovative and impactful bioengineering studies carried out by junior faculty in the field.



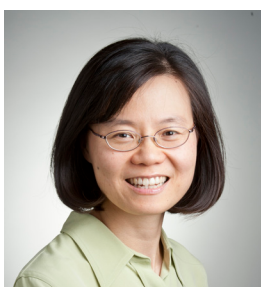
Assistant Professor **Benjamin Woolston**, chemical engineering, is the **2020 recipient of the Jay Bailey Young Investigator Award in Metabolic Engineering within the International Metabolic Engineering Society**. The award recognizes outstanding

research accomplishments in the field of metabolic engineering by a young investigator who has advanced the frontiers of metabolic engineering through originality and creativity of experimental or computational concept application. He also received the **2021 Daniel I.C. Wang Award** sponsored by Biotechnology & Bioengineering which honors a younger member of their dynamic community.

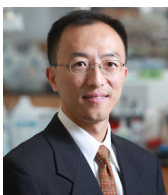


Assistant Professor **Sidi A. Bencherif**, chemical engineering, was selected as one of the **2021 Young Investigators by the American Chemical Society's Division of Polymeric Materials: Science and Engineering**

(ACS PMSE). ACS PMSE Young Investigators are early-career scientists and engineers from academia, national labs, and industry within seven years of beginning their independent careers. He was also named one of the **2021 Rising Stars by the Cellular and Molecular Bioengineering (CMBE) Special Interest Group (SIG)** within the Biomedical Engineering Society (BMES). Additionally, Bencherif received a **R01 \$2 million grant from the National Institutes of Health** for "Overcoming Vaccine-Associated Hypoxia with Advanced Biomaterials to Enhance Cancer Immunotherapy." This project is focused on the development of biomaterial-based vaccines against prostate cancer. The research will integrate advanced injectable hydrogels, hypoxia-fighting nanoparticles, tumor-specific antigens, and immunostimulatory factors. The proposed biomaterials can overcome hypoxia-driven immunosuppression in cancer vaccines and improve therapeutic efficacy. He was a **2021 Biomaterials Science Emerging Investigator** and his research was featured on the front cover of the *Biomaterials Science Emerging Investigator Issue* 2021.



Associate Professor **Carolyn Lee-Parsons**, chemical engineering, jointly appointed in chemistry and chemical biology, and Erin Cram, bioengineering affiliated faculty, were awarded an **\$800K National Science Foundation grant** for creating "A Novel CRISPR SynBio Tool for Investigating and Reprogramming the Regulation of Alkaloid Biosynthesis in *Catharanthus roseus*." This research project seeks to understand how plants rapidly and efficiently control the production of defense-related compounds and to build tools that will be used to engineer their increased production. Through this research, the investigators seek to increase the production of the critical anti-cancer compounds, vinblastine and vincristine, from the *C. roseus* plant.



Associate Professor **Guohao Dai** (PI), bioengineering, Assistant Professor **Ryan Koppes** (PI), chemical engineering, and Associate Professor **Abigail Koppes** (co-PI), chemical engineering, were awarded a **\$430K National**

Institutes of Health grant from the National Institute of Neurological Disorders and Stroke for "Bioengineer a Humanized Autonomic Neurovascular Innervation on a Chip" to improve clinical outcomes of vein grafts. The incomplete adaptation of vein grafts to arterial hemodynamics may be the primary reason of vein graft failure. One of the missing links in the vein graft is the lack of innervation, whereas arteries are closely associated with the sympathetic/parasympathetic nerves. A recent study in embryonic development suggested that sympathetic innervation is critical for the proper development of arteries through releasing sympathetic neurotransmitters, raising the possibility that providing innervation to the vein graft may facilitate the better switch of vein to artery, thus potentially leading to better clinical outcomes. To explore this possibility, the research will examine autonomic neural derived signals on the arterialization of vascular endothelial cells (ECs) and their impact on smooth muscle cells (SMC) phenotypes, by establishing a novel humanized vascular innervation model on a microphysiological chip.



Distinguished University and Cabot Professor **Laura Lewis**, chemical engineering, jointly appointed in mechanical and industrial engineering, in collaboration with the University of Warwick, UK, was awarded a **\$900K National Science Foundation - EPSRC grant** for "Multi-Driver Furnace Processing of Magneto-Functional Materials." This U.S. - U.K. collaborative project investigates new ideas and approaches to streamline the manufacture of advanced magnetic materials, while also minimizing the use of critical elements. This work is funded under the NSF-EPSRC "Manufacturing the Future" theme and features the development of a bilateral cohort of

under-represented minority students who have an interest in conducting research at the intersection of manufacturing, energy and environment.



Learn more about our accomplished faculty

Student Highlights

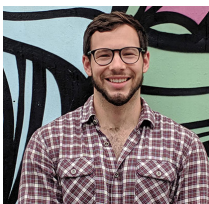


James Sinoimeri, E'21, ME'21, chemical engineering, was selected for the **Future Leaders in Chemical Engineering Symposium** organized by North Carolina State University. Sinoimeri was invited to present his research on the use of Hypoxia-Inducing Cryogels for Preclinical Anticancer Drug Screening, which was performed under the supervision and guidance of Assistant Professor **Sidi A. Bencherif**. Also, while on co-op, Sinoimeri

worked in mRNA process development at **Moderna**, which developed a COVID-19 vaccine. His primary responsibilities related to the scale-up, characterization, and optimization of the manufacturing process for mRNA-1273. He also worked on similar projects for the company's variant booster shot and seasonal flu vaccine. He joined Moderna after graduating as a process development engineer to continue his work.



Cameron Young, E'22, chemical engineering and biochemistry, was awarded the **Barry Goldwater Scholarship**—the United States' premier award to encourage and foster outstanding students to pursue research careers in the fields of the natural sciences, engineering, and mathematics.



Zach Rogers, PhD'23, chemical engineering, in the Bencherif Lab, was awarded his **third Alpha Fund Prototype Grant** for his proposal, "Oxygen-Controlling Cell Culture (OCC) Systems." The Alpha Fund, which is sponsored by both Northeastern's venture accelerator, IDEA, and the Center for Research Innovation aims to help early-stage innovations to test their concept and gain market feedback.

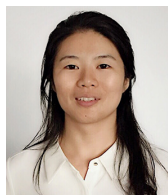


Anthony Stohr, E'21, chemical engineering, received a **National Defense Science and Engineering Graduate Fellowship** to support his doctoral work in chemical and biomolecular engineering. The fellowship is awarded to students who have demonstrated ability and special aptitude for advanced training in science and engineering.



Sagi Ravid, E'21, chemical engineering, received a **Fulbright U.S. student award**. He will pursue cancer treatment research in Spain. The Fulbright U.S. Student Program is America's premier international exchange fellowship, with a mission to promote mutual understanding between the people of the United States and the people of other countries.

Chemical engineering students and alumni **Sydney Morris**, E'21, **Nicholas O'Hare**, PhD'24, **Rachel Shapiro**, E'17, and **Evan Toth**, E'21, received **National Science Foundation Graduate Research Fellowships**. The NSFGRF program recognizes and supports outstanding graduate students who are pursuing full-time research-based master's and doctoral degrees in science, technology, engineering, and mathematics (STEM) or in STEM education.



Li Jiao, PhD'21, chemical engineering, currently working in affiliated faculty **Sanjeev Mukerjee's** research group, was **published in Nature Materials** for "Chemical Vapour Deposition of Fe-N-C Oxygen Reduction Catalysts with Full Utilization of Dense Fe-N₄ sites," developing a model catalyst with scientific breakthroughs and practical significance.



David R. Dias Vera, PhD'20

CHEMICAL ENGINEERING

Advised by Abigail Koppes, Associate Professor of Chemical Engineering

After receiving his bachelor's degree in chemical engineering from the Universidad Autonoma de Santo Domingo in 2013, David R. Dias Vera worked at Falconbridge Dominicana for almost two years before joining Northeastern University. As a PhD student in the Department of Chemical Engineering, his research focused on neural regeneration strategies and tissue engineering. His work included gene therapy with viral targeting and photostimulation of the peripheral nervous system for which loss of function causes significant socioeconomical costs and lower quality of life due to lack of functional recovery with conventional methods. Using in vitro models of neurons involved in sensory and motor function, Dias Vera has studied the nervous system's responses to a genetic manipulation and stimulation with light, a less invasive and more targeted approach than electrical stimulation. Importantly, he found that photo stimulation alone can manipulate how neurons grow and behave, which is important for defining boundaries of clinical applications. He also contributed to works focused on using other non-invasive neuromodulation techniques such as ultrasound and optogenetics to target and control nerve regrowth for improved injury recovery. This work was featured in the *Journal of Neuroscience Research, Women in Neuroscience* special issue in 2021. Overall, Dias Vera contributed to multiple manuscripts and peer reviewed conference presentations during his time at Northeastern. He also took advantage of the competitive graduate co-op program, working at Momenta Pharmaceuticals in Cambridge, Massachusetts, in platform development for protein glycosylation and enzymatic manipulation assays. He was also an outstanding teaching assistant for the Unit Operations Laboratory and Biology Laboratory where students enjoyed his hands-on approach to learning and depth of knowledge. Upon graduation, Dias Vera joined Sanofi Pharmaceuticals in Waltham, Massachusetts, as a scientist in the Genomic Medicine Unit in the Chemistry, Manufacturing and Control group.

DEPARTMENT OF CHEMICAL ENGINEERING

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COVER IMAGE

Joshua Gallaway, DiPietro assistant professor, chemical engineering, checks on an alkaline battery cycling test. He was recently awarded a CAREER Award from the National Science Foundation for "Engineering Electrochemical Reversibility in Disordered Materials for High Energy Density Batteries."

