Molecular Engineering & Sciences Institute

UNIVERSITY of WASHINGTON

Annual Report

2019-2020

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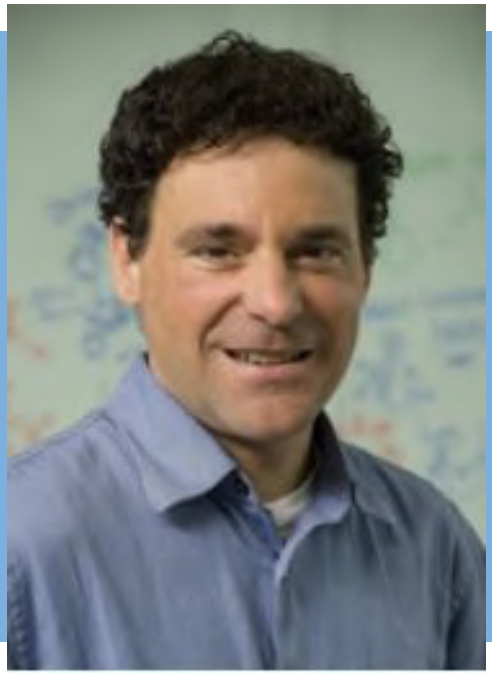
LETTER FROM THE MOLES DIRECTOR



In the face of a global pandemic and the increasingly destructive effects of climate change, we need engineers and scientists to come together now more than ever to develop innovative biotech and cleantech solutions to address humanity's greatest challenges. This is in part the mission on which the Molecular Engineering & Sciences (MolES) institute was founded. As you will see in this report, MolES faculty and students have been working to improve diagnostic testing and design targeted treatment strategies for SARS-CoV-2, and developing new materials for sustainable energy harvesting and storage.

Despite the pandemic, seven students successfully finished their Ph.Ds. in molecular engineering during the 2019-2020 academic year. When we launched our Ph.D. program in 2014, we knew that designing a new program around an emerging, interdisciplinary field would be challenging, but believed that training experts in this area was necessary to developing the materials, devices, and technologies for a healthy and sustainable future. We are thrilled to see our graduates embark on careers in academia and industry, working on everything from the development of novel therapeutics to energy-efficient manufacturing processes.

As worldwide calls for racial equity and justice emerged following the murder of George Floyd, we organized a virtual conference, in collaboration with institutions across the country, to highlight Black experiences in STEM. The response to this event was overwhelmingly positive, with over 3,500 registrants, demonstrating the great desire for many academics to engage in these conversations. We have since partnered with the Gladstone Institutes to keep the conversation going through a series of webinars examining racism in STEM. There is a lot of work to be done, but we are committed to making STEM – and in particular the field of molecular engineering – a more diverse, equitable, and inclusive space.

Sincerely,

Patrick Stayton, Ph.D.
Director, Molecular Engineering & Sciences Institute
Distinguished Career Professor of Bioengineering

INSTITUTE SNAPSHOT

MEMBER FACULTY
From over 20 different departments

118

CURRENT STUDENTS
& 11 graduated alumni

69

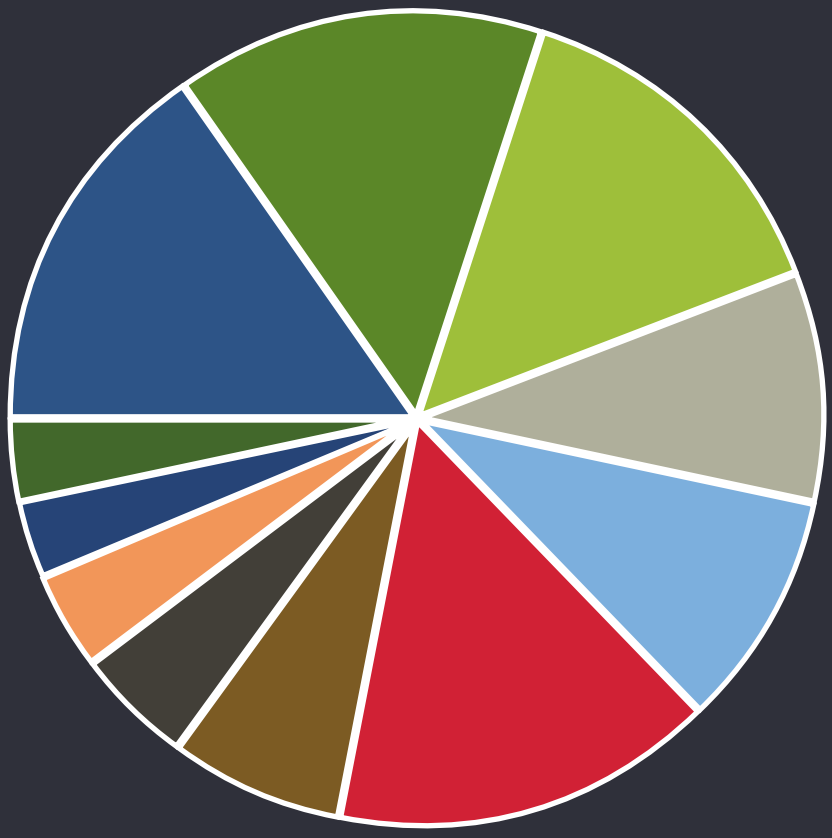
27

STARTUPS
created by MolES faculty from 2015 – 2019

271

PATENTS
granted to MolES faculty from 2015 – 2019

Faculty Member Disciplines/ Departments



- Chemistry
- Chemical Engineering
- BioEngineering
- Materials Science & Engineering
- Mechanical Engineering
- Other UW Departments*
- Electrical & Computer Enineering
- Physics
- Partner Institutes
- Biochemistry
- Physiology & Biophysics

*Astronomy, Biological Structure, Biology, Civil & Environmental Engineering, Environmental & Occupational Health Sciences, Genome Sciences, Medicinal Chemistry, Microbiology, Pathology, Pediatrics, Pharmacology, Pharmacy

ADDRESSING RACISM IN STEM

On July 14 and 15, 2020 faculty, students, and staff from academic institutions across the country came together to share their perspectives on the current barriers facing Black scholars in STEM fields, and to inspire participants to take action to address racial inequity in STEM. The event, "Experiences of Black STEM in the Ivory: A Call to Disruptive Action," was organized by MolES in collaboration with the Pritzker School of Molecular Engineering at the University of Chicago, Georgia Tech, the University of Texas at Austin, and Boston University. Roughly 3,500 individuals from over 300 institutions registered to attend and recordings of the event have collectively received over 10,000 views on YouTube.

MolES and other organizers of the two-day virtual conference subsequently partnered in fall 2020 with the Gladstone Institutes to host "Amplified: Race and Reality in STEM," a seminar series that gives speakers a national platform to have candid conversations around race and diversity in STEM fields. Topics of discussion included gaslighting, the cost of being one of the only or the few, and the intersections of racism, culture and health.

BOSTON UNIVERSITY

Georgia Tech

GLADSTONE INSTITUTES

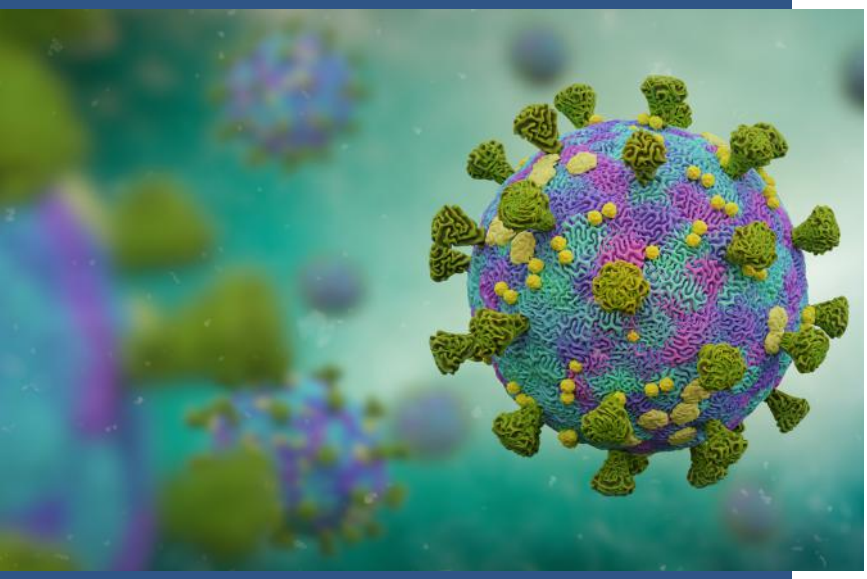
PRITZKER SCHOOL OF MOLECULAR ENGINEERING
THE UNIVERSITY OF CHICAGO

TEXAS
The University of Texas at Austin

RESEARCH HIGHLIGHTS

COVID-19

In response to the COVID-19 pandemic, MolES researchers applied molecular engineering approaches and tools to develop new diagnostic tools, targeted treatment strategies, and a better understanding of the virus.



Designing targeted treatments

A team of researchers at the UW Institute for Protein Design, including molecular engineering Ph.D. student Brian Coventry, designed over two million proteins capable of binding either the spike proteins present on the SARS-Cov-2 virus or ACE2, the human receptor used by the virus to get inside the cell. The team tested over 20,000 of the most promising candidates and identified several minibinders that can neutralize live virus at a level similar to antibodies. This work was published in Science Magazine. Researchers are now moving several minibinder candidates into clinical testing to investigate their viability as therapeutics.

Testing for COVID-19

UW chemical engineering professor James Carothers and chemistry professor Jesse Zalatan were awarded a National Science Foundation grant to develop a new type of SARS-Cov-2 antibody test. Reliable and widely-available SARS-CoV-2 antibody testing is critical for researchers to better understand the level of antibodies needed for protection, how long SARS-CoV-2 antibodies last, and the viral loads needed to generate antibody responses. The team aims to create an inexpensive, highly-accurate platform that can rapidly detect SARS-CoV-2-specific antibodies in patient samples, helping public health officials track the spread of COVID-19, respond to outbreaks and support the development of diagnostics, treatments, and vaccines.

Understanding SARS-Cov-2

As a molecular engineering graduate student in Jens Gundlach's lab, recent graduate Ian Nova developed a new high-resolution technique to visualize individual proteins processing DNA in real-time. Using this technique, the Gundlach lab is studying the SARS-Cov-2 helicase and RNA polymerase enzymes in order to better understand how the virus works and inform the design of new therapeutics. Inhibitors to the SARS-Cov-2 RNA polymerase are already being developed as potential therapeutics for COVID-19. High-resolution visualizations of this polymerase in action could help to tease out the mechanism of inhibition.

BIOTECH

Researchers at MolES are harnessing cellular and molecular processes to develop technologies that will help improve our quality of life and the health of our planet.

First-of-its-kind hydrogel platform enables on-demandproduction of medicines and chemicals

Researchers in the lab of chemistry professor Alshakim Nelson – along with collaborators at the University of Texas – unveiled a new way to produce medicines and chemicals and preserve them using portable "biofactories" that are embedded in water-based gels known as hydrogels. The approach could help people in remote villages or on military missions, where the absence of pharmacies, doctor's offices or even basic refrigeration makes it hard to access critical medicines and other small-molecule compounds.

CLEANTECH

MolES researchers are developing new materials for energy harvesting and storage that provide superior performance at lower costs, while reducing negative ecological impacts and promoting the responsible use of natural resources.

New technique lets researchers map strain in next-gen solar cells

A team led by chemistry professor David Ginger has developed a way to map strain in lead halide perovskite solar cells. Their approach shows that misorientation between microscopic perovskite crystals is the primary contributor to the buildup of strain within the solar cell, which creates small-scale defects in the grain structure, interrupts the transport of electrons within the solar cell, and ultimately leads to heat loss through a process known as non-radiative recombination.

FACULTY AWARDS

Dr. David Baker was awarded the Breakthrough Prize in Life Sciences for developing technology to design of proteins never seen before in nature, including novel proteins that have the potential for therapeutic intervention in human diseases.

Drs. David Castner, Buddy Ratner and Lara Gamble received the Technology Innovation and Development Award from the Society for Biomaterials for their leadership of the UW-based National ESCA and Surface Analysis Center for Biomedical Problems. Dr. Cole DeForest received the Young Investigators Award.

Dr. Corrie Cobb received a 2019 Young Faculty Award from the U.S. Defense Advanced Research Projects Agency to advance her research on new battery electrode architectures and packaging integration.

Dr. Lih Lin was selected as 2020 Optical Society Fellow in recognition of her significant technical achievements and contributions to the field of photonics.

Dr. Christine Luscombe was elected to Washington State Academy of Sciences in recognition of her considerable research contributions, including the development of controlled polymerization reactions for conjugated polymers for organic electronics applications.

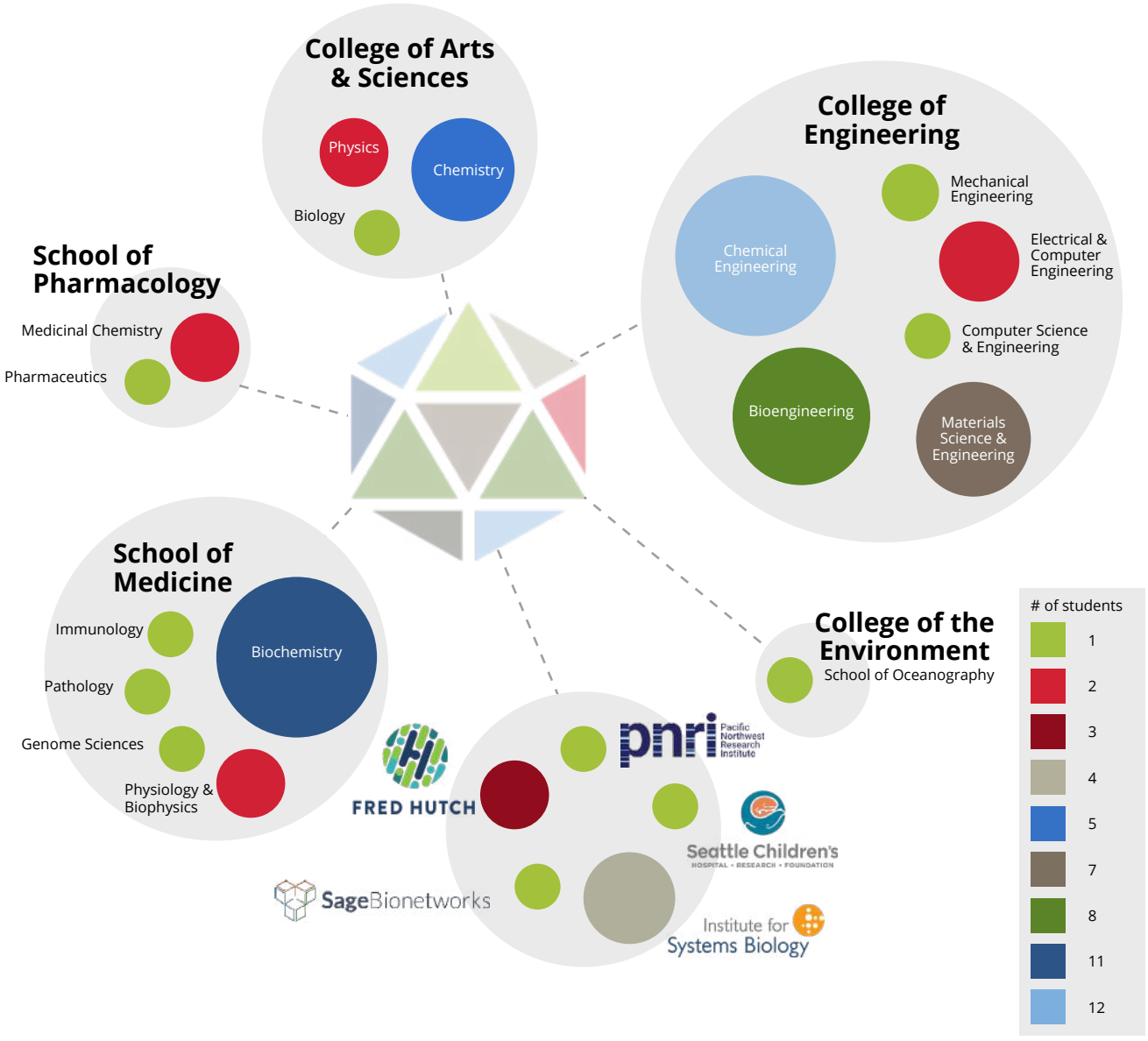
Dr. Elizabeth Nance received a 2019 Presidential Early Career Award for Scientists and Engineers for her research on nanotechnology-based treatments for brain diseases and injuries.

The UW College of Engineering presented Dr. Miqin Zhang with the 2020 faculty award in research and Dr. Cole DeForest with the junior faculty award.

EDUCATING THE NEXT GENERATION OF INTERDISCIPLINARY RESEARCHERS & INNOVATORS

The Molecular Engineering (MolE) Ph.D. program – now in its seventh year – currently supports 69 trainees. MolE students work on everything from developing better battery materials for a clean energy future, to designing de novo proteins that selectively bind targets to treat or prevent disease. Our students carry out their doctoral research in one of the over 130 MolES affiliated laboratories located at the University of Washington, Fred Hutch, Institute for Systems Biology, Pacific Northwest Research Institute, and Seattle Children's.

MolES PhD Research labs



Alshakim Nelson Named MolES Director of Education

Alshakim Nelson, UW associate professor of chemistry, has been named MolES Director of Education. Nelson replaces Christine Luscombe, professor of chemistry and materials science & engineering, who served in the role prior to her recent appointment as interim chair of the Materials Science & Engineering Department. Nelson will lead the MolE Ph.D. Program and oversee a faculty committee responsible for its curriculum, admissions, and oversight of students.

Student Awards

The College of Engineering awarded the Dean's Fellowship – a graduate fellowship presented to approximately 10 outstanding incoming doctoral students per year – to MolE students Nate Bennett, Nick Bohmann and Marti Tooley.

The UW Clean Energy Institute's Graduate Fellowship Program funds students from departments across UW to explore new research in solar energy, energy storage, and energy systems. MolE students Theodore Cohen, Amy Stegmann and Liwen Xing were selected as 2019-2020 CEI Graduate Fellows.

Recent MolE Ph.D. alum, Dr. Dan Lee was awarded the 2020 Distinguished Dissertation Award in mathematics, physical sciences and engineering from the UW Graduate School for his dissertation, "Synthesis of novel backbone functional polymers."

New Data Science Option

In spring 2019, MolE added a new data science option for Ph.D. students to introduce them to the foundations of data science and provide them with techniques and tools that they can apply to their own research. This option, supported by the UW eScience Institute, enables students with little or no background in data science, computer science, or coding, to become proficient users of data science tools.

2019 – 2020 MolE Ph.D. Graduates

Justin Davis

Characterization of combustion generated particulates produced in an inverted gravity flame reactor

As a graduate student in the lab of mechanical engineering professor Igor Novosselov, Justin analyzed the formation and evolution of particulate nanostructures generated by combustion, which are a major component of air pollution with known health risks and adverse environmental impacts. Justin is now a junior data engineer at Allstate in Bothell where he is working with Allstate agents across the country on their data infrastructure.

Jason Fontana

CRISPR-Cas activation for regulating multi-gene expression in bacteria

As a graduate student in the labs of chemical engineering professor James Carothers and chemistry professor Jesse Zalatan, Jason developed tools to genetically engineer bacteria for the production of valuable biosynthetic products. Jason is currently in the process of patenting some of his research findings.

Dion Hubble

From Solvate to Cell: A Molecular Engineering Approach to the Lithium-Sulfur Battery

As a graduate student in the lab of materials science and engineering professor Alex Jen, Dion designed and tested new types of electrolyte materials for lithium-sulfur (Li-S) batteries that could be used in applications where low weight is critical, such as electric vehicles. Dion is now a postdoctoral scholar with Gao Liu's Applied Energy Materials group at Lawrence Berkeley National Laboratory focusing on the synthesis and processing of energy materials.

Dan Lee

Synthesis of novel backbone functional polymers

As a graduate student in bioengineering professor Suzie Pun's lab, Dan developed easily synthesized, biocompatible hydrogels that can conduct electricity and could be used to engineer cardiac or neural tissues among other applications. Dan is now a postdoc in Professor Yan Xia's lab at Stanford developing novel molecular structures and organic materials with tailored conformations, nanostructures, properties, and functions.

Ian Nova

High Resolution Single-molecule Analysis of RNA Polymerase Transcription and Pausing using Nanopore Tweezers

As a graduate student in Jens Gundlach's lab, Ian developed a new high-resolution technique to visualize individual proteins processing DNA in real-time. Ian is continuing this work as a postdoc in the Gundlach lab, using this technique to study the SARS-Cov-2 helicase and RNA polymerase enzymes in order to better understand how the virus works and inform the design of new therapeutics.

Ivan Vulovic

Software Algorithms for Design of Symmetric Protein Complexes Applied to Cryo-Electron Microscopy Scaffolds & Antibody Nanoparticles

As a graduate student in David Baker's lab at the Institute for Protein Design, Ivan developed new computational methods and strategies to design protein assemblies that were used to create a new vaccine technology in which viral antigens are integrated into designed nanoparticles. Ivan now works as an independent software developer in the protein design field.

Grant Williamson

Synthesis & Electrochemical Cycling Characteristics of Nanostructured Antimony Alloying Electrodes for Energy Storage Applications

As a graduate student in the lab of chemical engineering professor Vince Holmberg, Grant developed new materials for high-capacity lithium-ion and sodium-ion batteries that can charge faster and last longer. Grant is now a product engineer at ABV Technology, a startup in St Paul, Minnesota that has developed a way to transform alcoholic beverages into non-alcoholic beverages without altering their intended flavor and taste.

MOLECULAR ANALYSIS FACILITY

The Molecular Analysis Facility (MAF) at the University of Washington (UW) – an open-access instrumentation facility located in the Molecular Engineering & Science Building – offers microscopy, spectroscopy and surface science tools for the characterization and development of novel materials, advanced biomedical devices, drug delivery systems, solar cells, photonic sensors, thin films and more.

Note from the MAF Director

The MAF strives to meet the material characterization needs of our users, whether they are looking to conduct a routine experiment or undertake more specialized analyses. The pandemic has forced us to adapt the way we work – developing new processes for coming into the lab, enabling remote access of instruments and creating online training videos. Ultimately, our goal remains the same – ensure that all users have access to a safe environment in which they can generate the data they need to advance their research.

Earlier this year, the National Science Foundation re-upped its commitment to nanotechnology infrastructure at the UW, awarding the UW and Oregon State University $5 million over the next five years to advance nanoscale science, engineering, and technology research in the Pacific Northwest. This support is critical to maintaining and expanding the equipment and expertise we offer our users. We look forward to working with users near and far on characterizing novel materials for use in many applications including next-generation biomedical and energy devices.

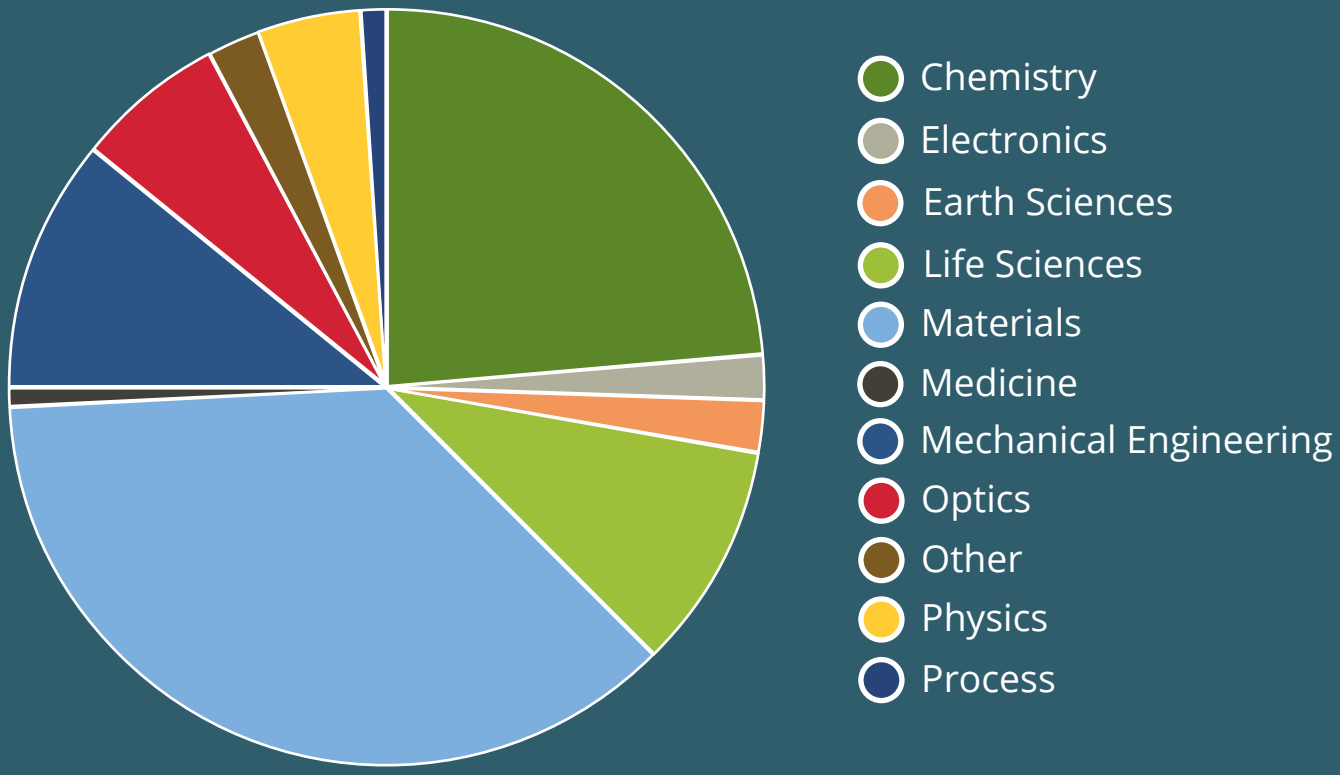
Sincerely,

Lara Gamble, Ph.D.
Director, Molecular Analysis Facility
Research Associate Professor of Bioengineering

MAF USERS

The MAF is a critical resource for researchers, both inside and outside the UW, studying or developing materials for a variety of applications.

MAF Users by Discipline



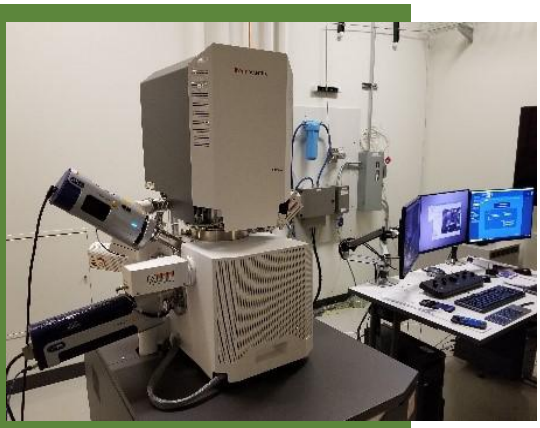
"I use multiple MAF tools several times weekly, and I can safely say that my research would grind to a halt if not for the instrumentation available to us there. The staff is always willing to help us figure out techniques to help us answer even very complicated research questions, and they're always looking to expand the techniques that are available to users on existing and new instruments."
- UW Chemistry graduate student

"The ability to access and work with the incredibly helpful staff at the MAF allows me to do cutting-edge nanomaterials research at a small liberal arts university."
- Associate Professor of Chemistry at Pacific Lutheran University

Tool Highlight

The MAF's high-performance Apreo Scanning Electron Microscope (SEM) is capable of imaging a wide variety of materials with one nanometer resolution.

This SEM image is of a packing of tensegrity triplex stacks, a structure that obtains its structural integrity from tension, it was made using two-photon lithography. This structure represents the first in a new investigation into highly flexible, tunable and recoverable tensegrity-based mechanical metamaterials.



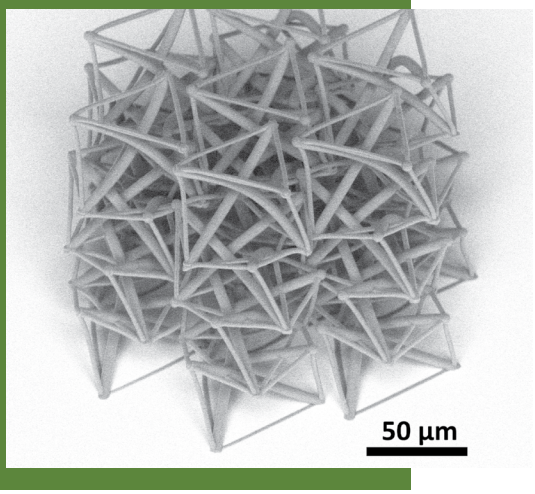


Image credit: Caelan Wisont, Lucas Meza - Meza Research Group

Research Highlight

Pacific oysters in the Salish Sea may not contain as many microplastics as previously thought

Using advanced instrumentation in the Molecular Analysis Facility, researchers in the lab of chemistry and materials science & engineering professor Christine Luscombe investigated the extent of microplastic contamination in Salish Sea oysters.

Molecular Engineering & Sciences Institute

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