VOLUME 1, ISSUE 3 - 2017

INFORMER

Molecular Engineering & Sciences Institute
UNIVERSITY of WASHINGTON

NEWS FROM THE UNIVERSITY OF WASHINGTON MOLECULAR ENGINEERING & SCIENCES INSTITUTE

MOLECULAR INTERACTIONS

Integrating the Analytical Biopharmacy Core adds new analytical expertise in state-of-the-art biophysical methods to the Molecular Analysis Facility

In partnership with the University of Washington School of Pharmacy, the Molecular Engineering & Sciences Institute is pleased to announce the integration of the Analytical Biopharmacy Core (ABC) into the Molecular Analysis Facility. Established in 2009 with funding from the Washington state Life Sciences Discovery Fund (LSDF), the ABC has long served as a resource to research communities at the UW, the Fred Hutchinson Cancer Research Center, and regional biotechnology companies. The facility offers consulting services and a suite of instrumentation for analytical ultracentrifugation, surface plasmon resonance, differential scanning calorimetry, and isothermal titration calorimetry.

▶ *CONTINUED: See "Molecular Interactions" page 4*

MAF Senior Research Scientist John Sumida runs samples on the facility's Isothermal Titration Calorimetry

Learn more about the new instruments at www.MolES.washington.edu/MAF

Governor Jay Inslee cuts the ribbon, officially opening the Washington Clean Energy Testbeds on February 16, 2017

NEW FACILITY ACCELERATES TESTING OF CLEANTECH INNOVATIONS AND LAUNCHING OF COMPANIES

Cleantech businesses and academic researchers can prototype and test clean energy devices, software and systems at the Washington Clean Energy Testbeds.

A new facility for accelerating the clean energy innovation cycle opened in Seattle Feb. 16. The Clean Energy Institute, a research unit at the University of Washington, created the Washington Clean Energy Testbeds to increase the rate at which breakthrough science and engineering discoveries turn into market-adopted clean energy technologies. The state-of-the-art user facility has labs for manufacturing prototypes, testing devices, and integrating systems. CEI unveiled the Testbeds at a celebration with Washington Gov. Jay Inslee, cleantech leaders and clean energy researchers.

"The process of taking a clean energy research discovery and making a prototype, then rigorously testing and refining it for market readiness, requires equipment and expertise that is expensive to acquire, and rarely available when and where you need it," said CEI director and UW professor Daniel Schwartz. "As a result, too many start-ups have great ideas, but fail before fully demonstrating their technology. Amazingly, lack of easy access to facilities and expertise is often a barrier for big companies, too. The Washington Clean Energy Testbeds centralize these resources to help shorten the time between clean energy idea to prototype, while reducing the capital and providing the expertise a company needs to get a viable product in the hands of customers."

▶ *CONTINUED: See "New Clean Energy Facility" page 6*

MESSAGE FROM THE DIRECTOR

Pat Stayton

We are continuing to build collaborations, make our facility available for interdisciplinary work, and educate an elite class of students, but it's a season of change here at the Molecular Engineering & Sciences Institute.

MolES recently welcomed Mechanical Engineering Professor Corie Cobb, who came to the UW from Palo Alto Research Center (PARC), Inc., to pursue novel manufacturing and design methods for energy devices and materials. We are also looking forward to the completion of the building adjacent to MolES, which will be home to researchers working in nano-engineered systems. Additionally, I am happy to announce, in partnership with the UW School of Pharmacy, the integration of the Analytical Biopharmacy Core to the Molecular Analysis Facility. The added biophysical instrumentation and expert staff will allow users to characterize interactions of biotherapeutic molecules and their receptors, metabolites, delivery vehicles, or any relevant biological components.

I'm always pleased to share the accomplishments of our faculty and students, who continue to publish cutting-edge research and make contributions that are recognized locally and nationally. In this issue, you will hear about how Grant Williamson—one of our second-year Ph.D. candidates—has taken a role as a liaison between the Washington State Legislature and the UW to help Washington state make more informed decisions about clean energy. Also, Giles Eperon, a member of Chemistry Professor David Ginger's laboratory, has been recognized on Forbes's 30-under-30 in Energy list for his work on solar cells, joining a distinguished group of high-profile inventors and entrepreneurs.

Start-ups in cleantech can now utilize the Washington Clean Energy testbeds, operated by our partners in the Clean Energy Institute, thanks to an eight-million-dollar capital fund provided by the state of Washington. The instrumentation in these testbeds will focus on creating low-cost solar cells and batteries. With the testbeds, companies and start-ups will be able to utilize instrumentation that they otherwise would not be able to access and receive troubleshooting assistance for their work.

We hope you enjoy this window into MolES activities. We encourage you to reach out to us to explore opportunities for collaboration with our outstanding interdisciplinary researchers or to learn more about becoming a user of the Molecular Analysis Facility.

Pat Stayton

Patrick Stayton
Director, Molecular Engineering & Sciences Institute

MolE Ph.D. Stude

Recognized for his dedication to responsible engineering and clean energy research, Grant Williamson is being honored as one of the 2017 Husky 100, a group of outstanding students who are making the most of their time at the University of Washington

"Without a broad ethical awareness, scientific and engineering technological advances can cause more harm than good."

This belief strongly motivates the life and research of Grant Williamson, a second year Ph.D. candidate in Molecular Engineering whose commitment to service and policy work outside the lab recently landed him a competitive spot on the Husky 100 list. Williamson is focusing on improving science communication with policy makers to help them make more informed clean energy legislation for the State of Washington. The UW's Husky 100 program awards, now in their second year, are a recognition given to UW students that show not only academic excellence, but also a commitment to strengthening their communities outside the classroom as well.

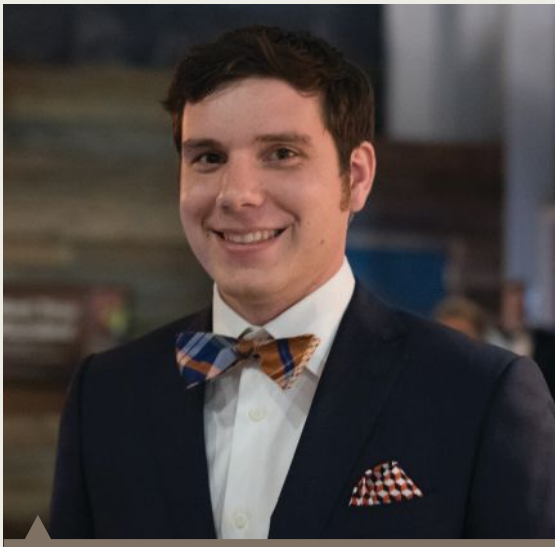
After graduating from the UW with a B.S. in Chemical Engineering, he entered the workforce as an engineer, but found himself wanting to make a greater change in how corporations and local government approached climate change. This desire led him to return to the university to further pursue the concept of ethical awareness in engineering. He joined the lab of MolES professor Vince Holmberg's lab in 2015, and, drawing on mentoring relationships with MolES faculty members, is now pursuing research and policy work in clean energy.

Next-gen battery materials can help compensate for the inte power. Williamson's research in the Holmberg Lab is helping think about powering our devices, cars, and homes in the futu

nt Grant Williamson among the Husky 100

His current research in the Holmberg Research Group is aimed at developing scalable syntheses of nanomaterials to improve battery performance and enable cheaper energy storage. "Cheaper energy storage compensates for the intermittency of solar and wind energy and supports mass-market electric vehicles, thereby minimizing climate change," Williamson explains. He is working to bridge the gap in renewable energy sources by fabricating next-gen materials that can improve battery life and function. In pursuit of this research, he has been awarded an NSF Graduate Research Fellowship and continues to be a trailblazer for the Molecular Engineering and Sciences Institute.

In addition to his academic pursuits, he is also a member of the Graduate and Professional Student Senate (GPSS) Science and Policy Steering Committee, which allows him to work to affect changes inside and outside the university community. Through the GPSS he has had the opportunity to engage with a diverse group of campus leaders and authored and passed a resolution supporting science-informed leadership in government at UW.



Grant Williamson

"My ethical responsibilities, as a leader in STEM, have driven me to build connections and drive societal progress outside of the classroom. As a UW Graduate and Professional Student Senate Science and Policy Steering Committee member, I focus on improving science communication to support better policy decisions."

– Grant Williamson,
MolE Ph.D. candidate

In November 2016 he helped organize a workshop with Sense about Science, a nonprofit that works to improve public discourse about science. Through this event, Grant had the opportunity to speak with the Painter's Union about photovoltaic (PV) glass, and he looks forward to continuing this work with other unions working in clean energy fields. He has also been to the state capitol in Olympia to speak with legislators about making smart energy policy that takes into account climate change.

Looking forward, Williamson hopes to be able to continue his career in academia as a professor and researcher in the clean energy field. He also plans to continue communicating with government officials about making informed decisions when it comes to climate change and energy policy.

Learn more about Grant Williamson and the work being done in the Holmberg Research Group by visiting holmberglab.washington.edu.

For more information on the Molecular Engineering Ph.D. program and its students, visit www.moles.washington.edu/phd.

MOLECULAR INTERACTIONS (CONTINUED FROM PAGE 1)

"The instruments are a great complement the MAF's other solid state analysis tools," observes MAF Director David Castner, "We now have the capability to characterize solution state molecular interactions between biotherapeutic molecules and their receptors, metabolites and delivery vehicles."

The core's users span academia and industry, bringing a broad range of projects to the facility. Academic researchers such as William Atkins and David Baker seek detailed understanding of how proteins fold and pharmacokinetic interactions affect drug clearance and efficacy, while regional biotech labs are developing drugs and cutting-edge therapeutics for the treatment of cancer, Hodgkin's lymphoma, and malaria. Others use the facility to characterize and quantitate their drug products and formulations for aggregate content, stability and affinity.

> **"We now have the capability to characterize solution state molecular interactions between biotherapeutic molecules and their receptors, metabolites and delivery vehicles."**
>
> – David Castner, MAF Director

Senior Research Scientist John Sumida notes that "specialized instruments or services at a commercial contract research organization represent a significant expense for many smaller companies and labs, and they are often essential to the studies required for FDA approval of new drugs. In addition to providing this instrumentation, we do a lot of troubleshooting, helping users with analyses that have proven problematic." Sumida brings a Ph.D. in physical organic chemistry and more than 7 years of experience working in this research area to the MAF.

As the original principal investigator on the LSDF-funded project, MolES Director Pat Stayton is pleased to see the resources integrated into the MAF. "We are excited to see how adding this area of expertise to our facility will accelerate the work of our interdisciplinary faculty across pharmacy, medicine, engineering, and sciences, and how we can continue to provide resources that will benefit our local biotech community."

AWARDS AND RECOGNITION

Cole DeForest

The National Science Foundation (NSF) awarded Assistant Professor **Cole DeForest** a 2017 Faculty Early Career Development (CAREER) award. The prestigious award recognizes teacher-scholars for outstanding research and a dedication to the integration of educational and research activities.

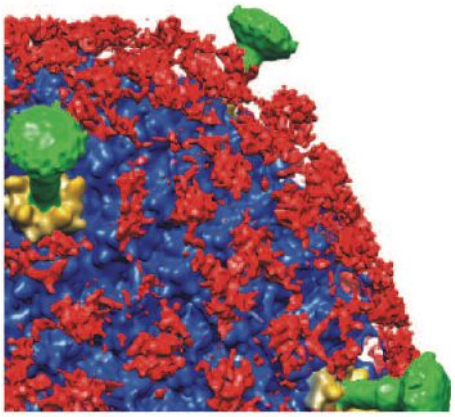
Kannan Krishan

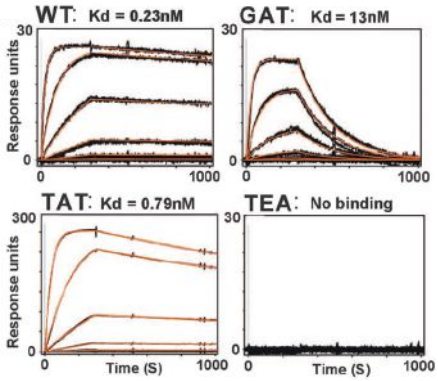
Professor **Kannan Krishnan** has won the prestigious Alexander von Humboldt Research Prize for his academic achievements. As part of this award Prof. Krishnan is invited to undertake long periods of research in collaboration with German scientists and institutions. Krishnan "is well recognized as an international expert in elucidating structure property relations in a wide range of magnetic and spintronics materials," said nominating Professor Michael Farle.

Corie Cobb

MolES is proud to welcome **Corie Cobb** to UW as a Washington Research Foundation Innovation Professor in Clean Energy and Associate Professor of Mechanical Engineering. The Mechanical Engineering department and the Clean Energy Institute partnered to help recruit Cobb, an expert in novel manufacturing and design methods for next-generation energy devices and materials, to UW. Professor Cobb's lab will be housed in the Molecular Engineering and Sciences Building.

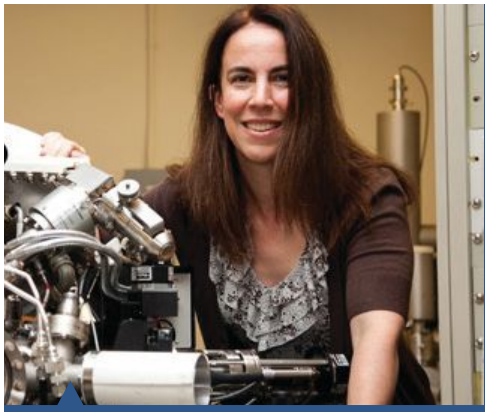
Doronin K, Flatt JW, Di Paolo NC, Khare R, Kalyuzhniy O, Acchione M, Sumida JP, Ohto U, Shimizu T, Akashi-Takamura S, Miyake K, Macdonald JW, Bammler TK, Beyer RP, Farin FM, Stewart PL, Shayakhmetov DM. "Coagulation factor X activates innate immunity to human species C adenovirus." Science (2012).



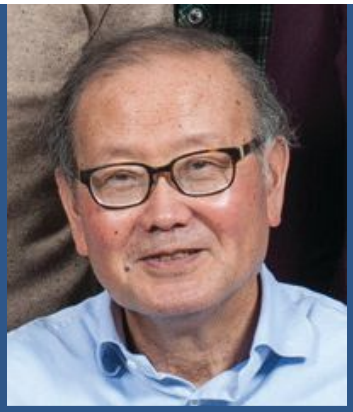


Left: *Coagulation Factor-X, (green), complexed with human species C adenovirus, HAdv. HAdv is immunogenic and results in potent immune and inflammatory responses which have been found to be lethal for immunocompromised individuals. Factor-X, FX, binding to HAdv is thought to be a trigger for this process.* **Right**: *Biacore SPR analysis to quantitate the affinity of FX for HAdv. FX was tested against three HAdv mutants in which single amino acid substitutions in the hexon capsid protein were performed. The TEA mutant demonstrate a loss in affinity for FX binding and in separate work failed to active IL-1β which plays a key role in the inflammatory cascade.*

Jonathan Posner



Lara Gamble



Minoru Taya

MolES faculty member **Jonathan Posner** and his colleagues, Sam Bowd and Per Reinhall, have been honored with UW Medicine's Inventor of the Year Award for their collaborative work developing a football helmet designed to mitigate the forces thought to contribute to concussions. The new helmets have been put into use by the UW Husky football team, and will now be available to select NCAA and NFL teams during the 2016 and 2017 seasons.

Molecular Analysis Facility Assistant Director **Lara Gamble,** was elected to the AVS (American Vacuum Society) Board of Directors for 2017-18 . AVS is an international community of scientists, engineers and instrument manufacturers which strives to promote research and communicate knowledge in the important areas of surface, interface, vacuum and thin film science/technology for the advancement of humankind.

Nabtesco Endowed Professor **Minoru Taya's** team will explore nanorobotics design based on magnetically-active helices for cancer diagnosis and treatment through a new $1.5 million Nano Robotics Initiative grant from the National Science Foundation. Through the support of the grant, Taya and his team hope to show how mechanical stress can be used to induce apoptosis/necrosis type cell death by using nanorobots under a magnetic field within an MRI chamber.

NEW CLEAN ENERGY FACILITY (CONTINUED FROM PAGE 1)

Located in a former sheet metal fabrication facility near UW's Seattle campus, the 15,000-square-foot Washington Clean Energy Testbeds provide researchers and cleantech businesses customized training and access to top-quality fabrication, characterization, and computational instruments. Specifically, these instruments are for printing, coating, and testing the materials and devices needed to achieve ultra-low-cost solar cells and batteries; as well as developing the system integration software and hardware to optimize the performance of devices and systems like vehicles, buildings, and the grid. At the Testbeds, users can:

"I wish these Testbeds existed when EnerG2 was developing its advanced carbon materials for energy storage."

– Rick Luebbe, CEO, EnerG2

- Print ultra-low-cost, thin-film solar cells and electronic devices using novel electronic inks.
- Fabricate and test new battery systems to dramatically increase performance without compromising safety.
- Develop and test energy management software that controls and optimizes how batteries, vehicles, and buildings integrate with a clean energy grid.

The Washington State Legislature provided UW $8 million to plan and design the Testbeds. CEI engaged UW faculty, regional cleantech leaders and national research institutions like the Pacific Northwest National Laboratory (PNNL) to create a facility that serves clean energy innovators. "The Washington Clean Energy Testbeds are a tremendous resource for Washington's and the world's visionary clean energy entrepreneurs and researchers," said Gov. Inslee. "I applaud CEI for building a center that will lead to the development of technologies to benefit our economy and environment. Our state's commitment to clean energy remains strong."

For comparison, access to public energy research and testbed facilities often involves a competitive application and approval process. The Washington Clean Energy Testbeds' open-access model requires only an initial consultation with Testbed management to ensure project feasibility and safety. Open-access is ideal for researchers and companies that want to rapidly advance their ideas.

"I wish these Testbeds existed when EnerG2 was developing its advanced carbon materials for energy storage," said EnerG2 CEO Rick Luebbe. "This specialized facility connects clean energy startups to a supportive university, talented people, and the necessary instruments. It's unlike anything in the country and offers a smart solution for slashing the time and funding needed to de-risk a technology concept."

Professor J. Devin MacKenzie, a seasoned cleantech entrepreneur

FORBES "30 UNDER 30 IN ENERGY" HAILS FROM A MOLECULAR ENGINEERING & SCIENCES LAB

Though still completing a postdoctoral fellowship at the University of Washington, Dr. Giles Eperon has made already his mark in the field of energy, at least according to Forbes, which listed Eperon on its "30 under 30 in Energy" list with other high-profile inventors and entrepreneurs this year. Eperon, who completed his Ph.D. at Oxford University, is currently working in the lab of UW Chemistry Professor and MolES Faculty David Ginger.

Giles Eperon (left) designs thin-film solar cells made from hybrid halide perovskites. He is one of the most cited young scientists working in the solar energy field.

Eperon is designing solar cells using hybrid halide perovskites, a class of mineral that holds great promise for cheap and efficient solar power. He has five patents and a long list of publications, including one that reported the perovskite formulations now widely used for record setting perovskite cells.

"Giles Eperon's Ph.D. work on earth-abundant perovskite semiconductors for low-cost, high-efficiency solar cells has already transformed how governments and industry worldwide are positioning hundreds of millions of dollars in investment in solar technologies, and he is arguably the most-cited, best-known scientist under 30 working in the field of solar energy," his postdoctoral advisor David Ginger observes.

In his recent publication in *Science*, Eperon and his collaborators showed that "by stacking multiple tailor-made perovskite modules we can exceed even the best solar panels of any type in the world, at much lower cost."

Eperon plans to commercialize technology related to his patents when he finishes his fellowship.

and global expert in electronic materials and emerging manufacturing methods for energy devices, displays and communication, will lead the Washington Clean Energy Testbeds. MacKenzie has founded and led five startup companies and holds over 110 patents and publications. In addition to leading the Testbeds and teaching at UW, he is currently the chief technical officer of Imprint Energy, a UC Berkeley spinout developing flexible, high-energy batteries based on large-area print manufacturing.

At the Testbeds, MacKenzie manages a staff of trained experts in fabrication and analysis of energy systems and devices. They work on-site to train users and support research and development efforts.

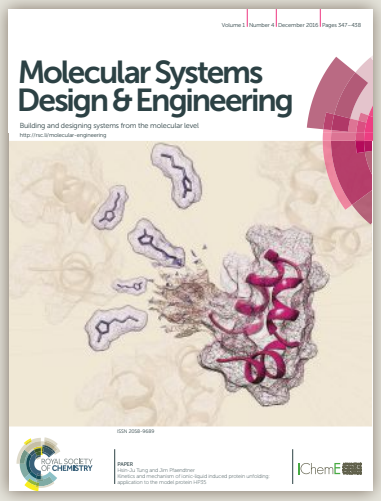
MolES professor Vince Holmberg at the opening of the Washington Clean Test Energy Testbeds

"CEI's vision for an open-access clean energy testbed model based at a world-class university with an innovation focus brought me from the Bay Area to Seattle," said MacKenzie. "I'm thrilled to help foster a community of distinguished faculty, bright students, and cleantech businesses that will work together to create solutions for a healthy planet."

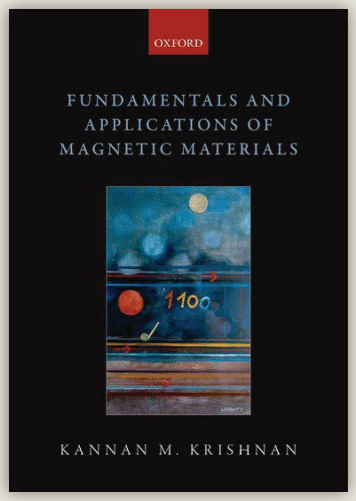
RECENT PUBLICATIONS OF NOTE

For a listing of publications by faculty associated with the Molecular Engineering & Sciences Institute, visit **www.moles.washington.edu/publications**

A new paper from Prof. **Elizabeth Nance** is on the cover of the *WIREs Nanomedicine and Nanobiotechnology*. Her article is on the Advanced Review Systems-level thinking for nanoparticle mediated therapeutic delivery to neurological diseases.



New research from Prof. **Jim Pfaendtner** is on the cover of the *Molecular Systems Design & Engineering*, a publication of the UK's Royal Society of Chemistry. In the article, Pfaendtner and colleagues demonstrate an approach to quantify protein unfolding times using molecular simulation in a greatly accelerated manner compared to standard MD simulations.



Prof. **Kannan M. Krishnan's** new textbook, *Fundamentals and Applications of Magnetic Materials*, was recently published by Oxford University Press this summer. His work has a unique multidisciplinary focus and tailored to a broad audience of physicists, materials scientists, engineers, chemists, biologists and medical doctors.

Molecular Engineering
& Sciences Institute

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UPCOMING EVENTS

2017 Life Science Innovation Northwest

May 23, 2017

Washington State Convention Center, Seattle

www.lifesciencewa.org

MolES Seminar: Jin Hyung Lee Associate Professor of Neurology, Neurosurgery, and Bioengineering, Stanford University

May 30, 2017

Mechanical Engineering Building 238 University of Washington, Seattle

www.moles.washington.edu

CleanTech Innovation Showcase

June 26, 2017

Bell Harbor International Conference Center, Seattle

www.cleantechalliance.org

ABOUT THE MOLECULAR ENGINEERING & SCIENCES INSTITUTE

The MolES Institute brings together teams from across the University of Washington campus to catalyze translational research in the cleantech and biotech areas. It is intended to serve both as an intellectual accelerator to bring fresh approaches and ideas to societal challenges and as a physical incubator where interdisciplinary teams can come together in a shared space. The Institute has more than 115 members from 14 departments.

The Institute is located in the Molecular Engineering and Sciences Building, a facility specially designed to promote collaborative molecular-scale research. The building houses 16 faculty members, 4 institutes and research centers, and a major instrumentation center. Together these centers provide state-of-the-art instrumentation for molecular characterization and analysis for the use of the UW research community and the larger non-profit and tech communities in Seattle.

The Institute is also creating and coordinating interdisciplinary education programs for undergraduate and graduate students. Drawing on the expertise of multiple departments, these programs teach students the fundamental aspects of molecular-level engineering through core courses and top-notch research opportunities.

CONTACT US

Website: www.moles.washington.edu
Email: MolES@uw.edu
Phone: 206-616-6627

Molecular Analysis Facility

The Molecular Analysis Facility (MAF) is a fully staffed instrumentation facility for users from the University of Washington, other universities, and industry. Capabilities include microscopy, spectroscopy, and surface science. Users can be trained to perform experiments independently, or an experienced staff member can perform experiments for you.

STAFF SCIENTISTS

The MAF employs a group of full-time staff scientists to help you design, perform, and troubleshoot your experiments. Contact the MAF with questions about instrumentation or to see if we have the right tool for your job.

Liam Bradshaw
XRD, Ellipsometer, GDOES, UPS
Expertise: Spectroscopy, nanoparticles, optics, inorganic chemistry, metalloenzymes

Scott Braswell
SEM, FIB, EDS
Expertise: Electron microscopy, FIB imaging/milling/lift-out, image processing, education, x-ray microanalysis

Micah Glaz
AFM, Raman, Confocal Microscope, Profilometer
Expertise: AFM, physical chemistry, organic/inorganic semiconductors, solar materials, microscopy, spectroscopy

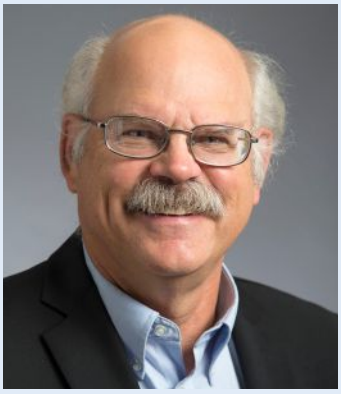
Dan Graham
ToF-SIMS, XPS
Expertise: Surface analysis of polymer and biological materials, 2D and 3D imaging, multivariate data analysis methods

Gerry Hammer
XPS, UPS
Expertise: Surface and interface analysis, metals, films, polymers, fibers, composites

Ellen Lavoie
TEM
Expertise: Electron microscopy, TEM, including preparation of materials, biological, and polymer samples

A Message from the Director

We have an impressive group of researchers at the University of Washington that continue to develop new innovative approaches to engineering novel materials and processes for biotech and clean tech. The mission of the Molecular Analysis Facility (MAF) is to provide UW researchers with the tools needed to characterize their state-of-the-art materials. Detailed and comprehensive material characterization not only documents what has been synthesized, but most importantly provides valuable feedback and insights into how to further improve those materials.



Just as the biotech and clean tech researchers continue to advance what their materials and processes can achieve, MAF is always looking for ways to advance and expand our materials characterization capabilities. We are pleased to announce that the Analytical Biopharmacy Core (ABC) was recently merged into MAF. ABC was established with funding from the Life Sciences Discovery Fund and has been supported by the School of Pharmacy and MolES. This merger significantly increases MAF's biotech capabilities by adding tools such as surface plasmon resonance (SPR) biosensing, analytical ultracentrifugation (AUC) and calorimetry, along with the expertise of Dr. John Sumida. If you are interested in using these tools in your research please contact John (jpsumida@uw.edu). We also recently expanded our scanning probe microscopy capabilities, with the transfer of an Asylum Cypher AFM and a Molecular Vista Photoinduced Force Microscope from the Ginger Lab to MAF. All UW researchers can now access these two tools by contacting Micah Glaz (mglz@uw.edu). Finally a new state-of-the-art x-ray diffractometer (XRD), purchased with funding from MAF and the Clean Energy Institute, has been ordered and is currently scheduled for delivery this coming May.

The advanced tools and expert staff at MAF are here to support your research and development projects. Please contact us for more information about our capabilities and how you can access our suite of tools.

Sincerely,

David Caster
Professor, Bioengineering and Chemical Engineering;
Director, Molecular Analysis Facility

Contact the Molecular Analysis Facility

Web site: **www.moles.washington.edu/MAF**
Email: **UWMAF@uw.edu**
Phone: **206-616-6627**

CASE STUDY

Characterization of Carbon Nanotubes in the MAF

Carbon nanotubes consist of a single layer atom thick of covalently bonded carbon atoms. These carbon atoms are bonded in such a way that they form a seamless tube. They are most popular for their remarkable thermal stability, high surface area and high conductivity. These single carbon thick tubes can come in multiple forms such as multiple layers of concentric tubes (multiwall carbon nanotubes), single wall nanotubes varying in diameter and length and even helical carbon nanotubes.

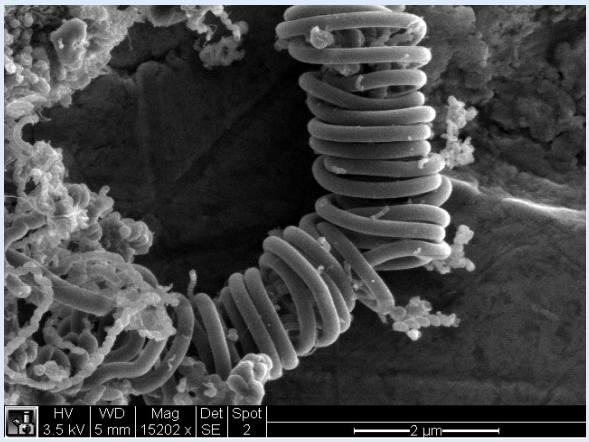
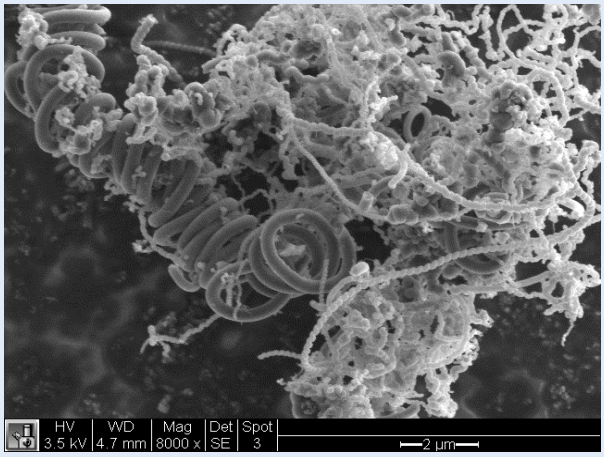


Figure 1: Helical carbon nanotubes imaged at low kV by SEM in the MAF at 15202x Mag (left) and 8000xMag (right)

Helical carbon nanotubes (HCNTs) were first predicted in 1993 by Itoh et al. and were first observed in 1994 by Zhang et al. Since then, scientists have directed much effort towards studies of the morphology and physical characteristics of carbon nanohelices, and have suggested potential applications due to their helical structure and unique physical properties. In the Anthony Dichiara lab (UW College of the Environment) the helices are coated with nickel particles to leverage their high surface area for use as a catalyst. Scanning electron microscopy (SEM) at the MAF is used to image carbon nanotube structures as seen in the example in Figure 1.

Bio-oil, a potential fuel source, is a mixture of compounds isolated from the fast pyrolysis of biomass. The bio-oil obtained directly from fast pyrolysis is incompatible with our pre-existing transportation infrastructure. However, removal of the oxygen containing groups (deoxygenation) should provide the upgraded bio-oil with qualities favorable for immediate integration with current fuel systems. The Resende group is investigating a catalyst to generate upgraded bio-oil using nickel ions deposited on a high surface area support such as HCNT's, allowing for high loading of nickel ions. The reaction rate and yield can be correlated with the degree of nickel incorporated as observed by SEM. The helices could upgrade a sustainably generated bio-oil to a refined fuel that can be used along with existing fuels, helping to solve the world's fuel crisis.



Data and text provided by MAF user Heather Wise from the Pacheo de Resende group University of Washington College of the Environment.

For more information, contact the Molecular Analysis Facility:

Website: **www.moles.washington.edu/MAF**
Email: **UWMAF@uw.edu**
Phone: **206-616-6627**