Georgia Tech
Renewable Bioproducts Institute

24 ANNUAL ACTIVITIES & ENGAGEMENT

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Message From the Executive Director

I'm excited to share with stakeholders of the Renewable Bioproducts Institute (RBI) our fiscal year (FY) 2024 Activities and Engagement Report. Many people make important contributions to RBI, and without everyone's commitment and hard work, none of the exciting outcomes in this report would be possible. Please accept my heartfelt thanks!

In FY2024, we awarded six new RBI Ph.D. Fellowships, a commitment of $2.4 million to the future of the pulp, paper, and broader bioproducts technologies in areas of national importance. These new projects included data science for packaging development, porous carbon materials from lignin, environmental assessment of fuel and chemical products from woody biomass, and pulp and paper emissions reductions. These fellowships will support nine students and 14 Principal Investigators (PIs) in eight Schools across four Colleges. Five of the PIs are new RBI-affiliated faculty, including Ebenezer Fanijo (Building Construction), Martha Grover (Chemical and Biomolecular Engineering), Kim Kurtis (Civil and Environmental Engineering), Micah Ziegler (Chemical and Biomolecular Engineering and Public Policy), and Jason Azoulay (Materials Science and Engineering and Chemistry and Biochemistry).

If you walked the corridors of the Paper Tricentennial Building over the last year, you would have noticed many places where construction and renovation are underway. This includes laboratories for new Georgia Tech faculty like Scott Danielson (Materials Science and Engineering); our multiphase forming facility supporting decarbonization in paper manufacturing; and labs associated with electron microscopy, X-ray photoelectron spectroscopy, and other materials characterization tools operated by the Institute for Matter and Systems (one of our collaborator Interdisciplinary Research Institutes).

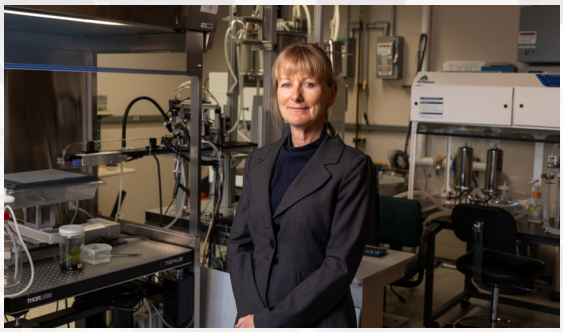
2024 was another record-breaking year in interdisciplinary proposal submissions resulting from RBI seed funding or cost-sharing. RBI-funded investigators submitted $57.7 million in proposals to federal and industrial opportunities. It was a strong year in receipt of funded awards supporting next-generation topics in decarbonizing the manufacturing of pulp and paper products, including a $3.1 million award for developing a net-zero CO2 emission papermaking technology and $2.2 million for advanced dewatering technologies, both of which resulted from RBI Fellowship investments in the past. In addition, based on RBI seed funding and facilities, 42 peer-reviewed papers were published - the list is presented toward the end of the report.

We continued our work on catalyzing and educating the Georgia Tech bioproducts community with a focus on issues of national importance. For example, RBI held a successful Spring 2024 Workshop entitled "The Emerging Bioeconomy and the Future of Biorefining," with speakers from Georgia Tech, other universities, national laboratories, and industry, featuring poster presentations from 34 RBI Fellows. The workshop had 95 participants. The Robert C. Williams Museum of Papermaking, associated with RBI, reached over 7,994 participants, most of whom were in-person, including over 2,300 Georgia Tech students who participated in programming that integrates art, history, and technology. The Tech Tactile Thursdays program, which offers Georgia Tech students and staff a much-needed artistic break from technology, was so popular that a second weekly event had to be opened.

I hope you can take a few moments and browse this report to learn about these and other accomplishments from the past fiscal year. Thank you for your partnership with Georgia Tech and RBI.

Carson Meredith
Executive Director, Renewable Bioproducts Institute

Georgia Tech Scientist Boosts Forestry Industry With Cutting-Edge Tree Cloning



Ulrika Egertsdotter, a principal research scientist at the Renewable Bioproducts Institute | Photo Credit: Chris McKenney

Georgia's forestry industry generates $40 billion annually, providing 140,000 jobs. The state is known for its timber, fiber, paper pulp, and other wood-derived products, which are exported worldwide.

Ulrika Egertsdotter, a principal research scientist at Georgia Tech's Renewable Bioproducts Institute, plays a key role in supporting the industry. Through her work, she helps Georgia tree growers propagate new plants that provide higher-quality wood products and offer greater resilience to climate change.

"Some say we shouldn't interfere with nature, but humans are demanding more and more from the Earth, faster than it can provide," Egertsdotter said. "We need to help nature produce at a sustainable rate and quality necessary for human requirements."

Her primary research involves applying new technologies and automation to produce improved conifer trees, which include spruce, cedar, and — most notably in Georgia — pine. These needle-bearing trees are some of the most important globally for providing wood and fiber.

Plant breeders want to reproduce trees or plants with excellent traits — for example, those that can grow in dry environments or resist fungal attacks. Developing a robust plant that meets these requirements can take decades, particularly with trees, which need many years to grow.

That's where Egertsdotter's work comes in. Scientific advancements have enabled researchers to design new plants, including trees that yield better wood products or are more resilient against extreme weather conditions such as drought. Producing enough of these special, superior plants requires efficient cloning techniques — otherwise, it would take years or even generations.

Cloning plants in vitro, or micropropagation, is exponentially faster than traditional cloning by cuttings and helps growers produce more trees and harvest high-quality timber on shorter timelines. For conifers, the favored micropropagation method is to clone the seeds by a technique called somatic embryogenesis (SE), which is the basis for making new and better conifer trees using biotechnological methods.

"In the lab, with one plant seed, we can make millions of plants from that same seed," Egertsdotter said.

Cloning Trees in the Lab

Cloning conifers like pines always starts with picking seeds from the cone. Then, in a sterile lab environment, researchers clean a single seed and extract an embryo from inside it. They place the embryo in a small dish with nutrients and plant-growth regulators that stimulate the embryo to form new embryos.

Postdoctoral fellow Cuong Le holds pecan tree shoots used to start in vitro cultures while researchers work to maintain established in vitro cultures under sterile conditions | Photo Credit: Chris McKenney

By repeatedly feeding the culture with the same treatments, the new embryos will continue to multiply into identical copies of the initial seed. Once the number of embryos has increased significantly, the researchers split them up into new plates. When, finally, many embryos have developed, other treatments are applied to make the embryos mature and eventually germinate into a new plant. "The biological process the lab

(somatic) embryo goes through to form the plant is the same biological process a seed embryo would go through if it was planted in the ground," Egertsdotter explained. "This method allows us to generate many plants from each valuable seed, instead of just one."

Automated Technologies

While micropropagation methods have been around for decades, they are expensive and labor-intensive and are not widely used outside of research labs. Egertsdotter works closely with engineers to develop and implement novel automation technologies that can produce affordable, high-quality plants through a system based on fluidics technology, image analysis, and AI-based selection. The SE Fluidics System is a unique facility developed at Georgia Tech for the fast processing of somatic embryos of any species. The system carries out rapid imaging of each embryo and then produces datasets to develop algorithms that select viable embryos for further processing. In addition to cloning selected plants from breeding programs, SE can also be used to add desired characteristics to trees and plants. Researchers have also started experimenting with the gene-editing tool CRISPR to modify the DNA sequences of some tree species.

Moving Forward

Because of human-caused climate change, the natural habitats of many important plants and crops have already been permanently altered or destroyed. For Egertsdotter, this adds urgency to her work. She is currently investigating how to develop pine trees more resistant to climate-related stresses, including pests and drought. Egertsdotter is also studying how to use biotechnological tools to create trees that capture carbon dioxide more efficiently. "We must support the plants we rely on by multiplying the specific plants that can survive in the future environment," Egertsdotter said. "We can also help other plants survive by genetic or genomic modifications to increase their adaptability." She added, "We will lose a lot of the natural resources we currently rely on if we wait for nature to, through natural selection, correct the negative impact of climate change. We are changing the natural world faster than evolution can keep up, so we must help accelerate the adaptation process." | **Catherine Barzler**

Shannon Johnson, research scientist III in the School of Mechanical Engineering, examines a young plant while working with the SE Fluidics System | Photo Credit: Chris McKenney

The team uses bioreactors for fast multiplication of young plants or maturation of somatic embryos which will later be harvested. Feeding is controlled electronically through a solenoid valve. | Photo Credit: Chris McKenney

Profile on Anna Doll – Education Curator at the Robert C. Williams Museum of Papermaking

Doll giving a tour of the Robert C. Williams Museum of Papermaking to K-12 Students

Anna Doll is the education curator at the Robert C. Williams Museum of Papermaking, located in Georgia Tech's Renewable Bioproducts Institute. Doll's day-to-day responsibilities, and the many projects she handles at the museum, bring tremendous value not only to the Georgia Tech community, but also to the papermaking community around the world.

With a degree in art education and a minor in art history, Doll began her career as an elementary school art teacher in Pinellas County, Florida. She then became the director of Museums for the Folk Pottery Museum of Northeast Georgia and the Sautee Nacoochee Cultural Center History Museum and Heritage Site.

In 2019, Doll joined the Robert C. Williams Museum of Papermaking team as its education curator. At the museum, she creates and manages programs that include educational tours, private and public workshops on papermaking, specialized workshops through creative collaborations with artists, collaborations with other campus units for STEAM activities, and community events for kindergarten through senior adult audiences.

"I didn't know a whole lot about papermaking when I first started here," admits Doll, "but I knew how to be an education curator." Her ability to swiftly absorb the history and concept of papermaking and translate it into engaging educational experiences has been instrumental in her success. Below are a few highlights of Doll's projects.

Museum Tours
Doll's daily activities include educational tours of the papermaking museum for groups of all ages. The tours range from introducing the papermaking process to elementary and middle school students to sharing the history and heritage of papermaking with adults. In addition, she conducts virtual programs for groups interested in the history of paper and the technological advances of the papermaking process since its invention many centuries ago.

Workshops
Doll is the point of contact for public and private workshop bookings. She also develops the concepts for these sessions, catering to groups with various interests (e.g., Girl Scouts, Boy Scouts, people with disabilities, teachers, artists, college students, and public groups). This spring, Doll's workshops included Suminagashi, Production Papermaking, Petal Fold Book, Paper Casting, and Magic Box: Jacob's Ladder.

In addition to conceptualizing and conducting tours and workshops, she designs curricula and other resources involving paper art and science for K-12 teachers to integrate into their art classes.

Big Paper Workshop – Convening Artists, Educators, and Community Members for a Transformative Experience in Papermaking
This spring, Doll and her colleague Jerushia Graham created a communal workshop called "Big Paper." Offered on multiple days, this project included five college groups from Georgia and Alabama and community groups from metro Atlanta who got to create a large sheet of paper from pulp. Participants beat plant material by hand to prepare the fiber and worked with Tom Balbo, founding director of the Morgan Conservatory, to create a huge 4'x6' sheet of paper that was mailed back to them once it was dry.

Through her work at the museum, Doll has cultivated relationships with various artists, all of whom collaborate with the museum to conduct workshops and create and showcase art exhibits.

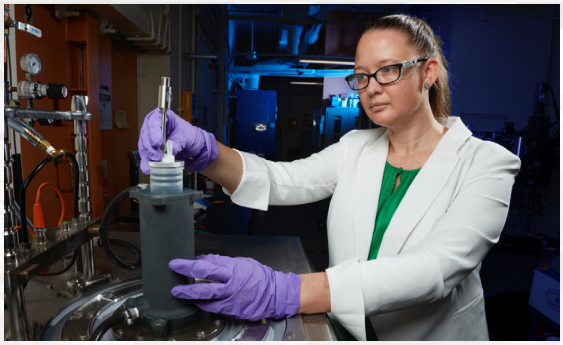
Additional Collaborations Across Campus
Doll partners with other units on campus to create programs. She collaborated with the Georgia Tech Library on a program called "Tech's Tactile Thursdays." Hosted on the first Thursday of each month, it allows students, faculty, and staff to work on hands-on projects related to paper and provides an opportunity for the largely technology-focused participants to take a break from their routine, relax, and explore their creative side and enhance their well-being.

Doll also has been an active educator at Georgia Tech Science and Engineering Day, which is part of the Atlanta Science Festival. This year, more than 3,000 K-12 students and parents visited Georgia Tech's campus to engage in hands-on STEAM activities. Representing the museum, Doll worked with families to make prints on a clamshell printing press featuring a custom-designed Buzz image (designed by Doll) on a postcard for the kids to take home. The activity showcased the rich history of the printing press and modern technology with a photopolymer printing plate.

Through these diverse projects and initiatives at the museum, Doll continues to make a difference in the world of papermaking. Looking ahead, she hopes to expand the museum's educational initiatives as well as the education team and its resources, and she envisions broadening the museum's reach and impact by offering free programs to schools through grants. She is also working with Georgia Tech faculty and researchers on museum research into the art of nano cellulose and plans to establish a paper and natural dye garden for teaching. | **Priya Devarajan**

Anna Doll, Tom Balbo and workshop participants during the Big Paper Workshop

Initiative Lead Profiles - Blair Brettmann, Will Gutekunst, Matthew Realff



Blair Brettmann (Photo credit: Garry McLeod/ Lawrence Livermore National Lab)

RBI Initiative Lead Profile: Blair Brettmann

Blair Brettmann, associate professor, Solvay Faculty Fellow, and Raymond and Stephanie Myers Faculty Fellow in the School of Chemical and Biomolecular Engineering, co-leads the interface of polymer science and wood-based materials initiative with Will Gutekunst at Georgia Tech's Renewable Bioproducts Institute.

Brettmann's current research focuses on developing technologies that enable multicomponent, rapidly customizable product design, with a specific focus on polymer systems.

Brettmann received her Ph.D. in chemical engineering at MIT in 2012 working with the Novartis-MIT Center for Continuous Manufacturing under Bernhardt Trout. Later, she worked on polymer-based wet coatings and dispersions for various applications at Saint-Gobain Ceramics and Plastics. She went on to serve as a postdoctoral researcher in the Institute for Molecular Engineering at the University of Chicago with Matthew Tirrell. Below is a brief Q&A with Brettmann in which she discusses her research focus areas and how they influence the interface of polymer science and wood-based materials research at Georgia Tech.

Q&A

What is your field of expertise and at what point in your life did you first become interested in this area?

My expertise is in polymer science and materials design for manufacturability. I got excited about this area after my Ph.D. when I worked for Saint-Gobain and saw firsthand the challenges of bringing new products to market, especially those made of complex mixtures of materials.

What questions or challenges sparked your current renewable bioproducts research? What are the big issues facing your research area right now?

Sustainability of materials and process is a top priority right now across many industries, and renewable bioproducts research is helping to improve this. But it is still tough to design and scale up products made with these materials because of the heterogeneity of the raw bio-based materials and recycled materials that now serve as the raw materials. Engineers are essential to design systems that can be robust despite the heterogeneities and still produce consistent, high-quality products.

What interests you the most in leading the research initiative on the interface of polymer science and wood-based materials? Why is your initiative important to the development of Georgia Tech's Renewable Bioproducts research strategy?

One of the most promising directions to decrease the impact of plastics on the environment is to replace some of the synthetic plastic materials with natural products, such as cellulose from wood. My initiative aims to build better connections between polymer scientists working to design improved plastics and experts in bio-based materials to seed research that can work toward this goal. Polymers also serve as important tools to improve the properties of cellulose and wood-based products and can enable new materials with increased functionality that still have sustainable materials at their core.

What are the broader global and social benefits of the research you and your team conduct on the interface of polymer science and wood-based materials?

We work to improve the sustainability of material products while addressing specific challenges

related to manufacturing and scale-up, which can speed up the adoption of these more sustainable products in industry. We take a wide view of the problem and have even worked on a project to understand consumer choices in recycling: If people don't recycle the material, our efforts to make recyclable products will not have an impact!

What are your plans for engaging a wider Georgia Tech faculty pool with the broader renewable bioproducts community?

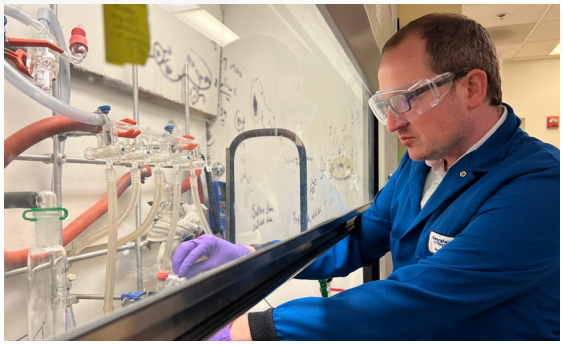
Using symposia, social events, and student-centered networking, I will bring the broad Georgia Tech Polymer Network community together with the RBI community.

What are your hobbies?

Water polo and swimming. I train with the Atlanta Rainbow Trout, who practice at the Georgia Tech pool.

Who has influenced you the most?

I'm constantly learning from people around me!



RBI Initiative Lead Profile: Will Gutekunst

Will Gutekunst, associate professor in the School of Chemistry and Biochemistry at Georgia Tech, co-leads the interface of polymer science and wood-based materials initiative along with Blair Brettmann at the Renewable Bioproducts Institute (RBI). Gutekunst's research explores the design of novel monomers for the design of recyclable polymers for a circular economy, fluxional materials, and 3D-printable ceramics.

Below is a brief Q&A with Gutekunst where he discusses his research focus areas and how they influence the interface of polymer science and wood-based materials initiative at Georgia Tech.

Q&A

What is your field of expertise and at what point in your life did you first become interested in this area?

My graduate training is in synthetic organic chemistry, and I focused on basic science problems at that time. Toward the end of my Ph.D., I became interested in applying my skill set to new research directions that could have a more direct impact on society. This led me to pursue postdoctoral research in polymer chemistry, which has been a source of inspiration ever since.

What questions or challenges sparked your current renewable bioproducts research? What are the big issues facing your research area right now?

My first project in this space was initiated shortly after I arrived at Georgia Tech through RBI funding opportunities, and it has continued to be a theme ever since. One of the critical problems in my research is identifying monomers that can polymerize and depolymerize on command. This involves balancing the driving force of polymerization (enthalpy) with the unfavorable process of confining multiple monomers to a single chain (entropy). While we are making considerable progress in engineering appropriate polymerization enthalpies into monomers, the entropic side of the problem remains a significant challenge.

What interests you the most in leading the research initiative on the interface of polymer science and wood-based materials? Why is your initiative important to the development of Georgia Tech's renewable bioproducts research strategy?

The most exciting aspect of the initiative is the ability to bring together multiple strengths of Georgia Tech to work on a central goal. Solving problems at this interface involves the collaborative efforts of researchers in chemistry, processing, separations, and even data science. Identifying and gathering synergistic teams is

critical to address this problem and additional goals in renewable bioproducts.

What are the broader global and social benefits of the research you and your team conduct on the interface of polymer science and wood-based materials?

The goal of this research is to develop materials that are more recyclable and are derived from abundant feedstocks, which are two big problems rolled into one. The eventual product of this research will be access to materials that are more compatible with the environment while also drastically reducing the waste output of society.

What are your plans for engaging a wider Georgia Tech faculty pool with the broader renewable bioproducts community?

Through the merger of the Georgia Tech Polymer Network with RBI, we can start to forge collaborations across a broader swath of the Georgia Tech community. This includes the organization of workshops, making connections between different student groups, and the development of center grants to tackle grand challenges in the field.

What are your hobbies?

In my free time, I enjoy reading (non-science), pottery, and hiking.

Who has influenced you the most?

My Ph.D. advisor (Phil Baran) and my postdoctoral advisor (Craig Hawker) both stand out in their impact on my scientific career. Through their guidance, I learned how to properly think about science and to always look ahead for the next big problem.

RBI Initiative Lead Profile: Matthew Realff

Matthew Realff, professor and David Wang Sr. Fellow in the School of Chemical and Biomolecular Engineering, leads the Circular Carbon Economy Research Initiative in the Strategic Energy Institute and the Next Generation Refineries Research Initiative in the Renewable Bioproducts Institute at Georgia Tech. Realff co-directs the Direct Air Capture Center (DirACC), which coordinates research across the Institute aimed at the removal of carbon dioxide (CO2) from the atmosphere. Realff's broad research interests are in the areas of process design, simulation, and scheduling. His current research is focused on the design and operation of processes that minimize waste production by recovery of useful products from waste streams, and the design of processes based on biomass inputs. In particular, he is interested in carbon capture processes both from flue gas and dilute capture from air as well as the analysis and design of processes that use biomass. Below is a brief Q&A with Realff where he discusses his research focus areas and how it influences the circular carbon economy research initiatives at Georgia Tech.

Q&A

What is your field of expertise and at what point in your life did you first become interested in this area?

My background is in chemical engineering with a focus on process design and simulation, which is part of the field of process systems engineering. I have been interested in this general topic since first setting foot on the campus of Imperial College London in 1982, and subsequently pursued it as my Ph.D. topic. I first started thinking about direct air capture of CO2 in 2011 and about circular carbon from CO2 in 2016.

What questions or challenges sparked your current energy research? What are the big issues facing your research area right now?

I believe that managing CO2 emissions will be the biggest challenge of the next 50 to 100 years. We will need to have negative emissions, as we are emitting too much, and pulling CO2 directly out of the atmosphere will be required because we are going to continue to emit. Creating technological solutions to provide negative emissions is one of the biggest challenges, as they need to be cost-effective and environmentally and socially less damaging than the emissions they capture. The biggest issue facing my research is understanding the phenomena that are involved in direct air capture and translating that understanding into engineered systems that are low-cost, have low environmental impact, and are socially beneficial.

What interests you the most leading the research initiative on circular carbon economy? Why is your initiative important to the development of Georgia Tech's energy research strategy?

The circular carbon economy is a systems problem in the broadest sense. This means that we must embrace a multidisciplinary approach to synthesize effective solutions. I want to emphasize the word "effective" here — we must embrace a wide range of measures of performance from energy efficiency to social justice because without improving along many dimensions we will be unlikely to be successful. It is this multidimensional, multidisciplinary research effort that interests me, as I love to find ways to bring people together to synthesize different knowledge into effective solutions. Georgia Tech is a world leader in direct air capture technology — as demonstrated by our new Direct Air Capture Center (DirACC). Our advances in this topic area can provide a base from which to develop approaches to carbon utilization, and other research efforts in electro, bio, and thermo chemical technologies can enable closed pathways using carbon as an energy carrier.

What are the broader global and social benefits of the research you and your team conduct on circular carbon economy?

One vision for our energy and material systems is to have a much greater local production and consumption of energy using renewable resources. A circular carbon economy based on CO2 from the air; water from local sources including the air; and solar, wind, or biomass-based energy could be local and would have many transactions between local parties. This could serve to not only reduce global emissions but also to provide more opportunities for communities to benefit from the production of energy as opposed to having many transactions that transfer money outside of the community.

What are your plans for engaging a wider Georgia Tech faculty pool with the broader energy community?

DirACC is one way we hope to connect faculty to the ecosystem of companies that are developing and deploying DAC technology. We hope that the challenges that these companies are articulating can be translated into research topics for the faculty affiliated with the center. The Department of Energy's efforts to establish the DAC Hubs provides us with other opportunities to engage faculty around social and environmental justice issues associated with deploying energy technologies such as direct air capture. I hope that faculty will see themselves participating in these efforts and reach out to be included in the network of researchers on these topics.

What are your hobbies?

My main hobby is playing a card game called Magic: The Gathering. I have played this since 1994 and have enjoyed many friendships formed as a dueling wizard. I also enjoy reading, particularly science fiction and steampunk literature, as well as history.

Who has influenced you the most?

Professor Roger Sargent at Imperial College was one of the founders of the field of process systems engineering. His speech on elevation to the position of professor at Imperial in 1963 has had a profound impact on the direction of my research and educational activities.

Georgia Forestry Association Magazine Features the Renewable Bioproducts Institute

Georgia Forestry Association members receive Georgia Forestry Magazine four times per year. The magazine brings together writers and leaders from the Georgia Forestry Association, Georgia Forestry Commission, and Georgia Sustainable Forestry Initiative. The magazine's dynamic content is focused on keeping its audience connected to resources and empowered to make good decisions about their forestland asset.

Front Cover of the Summer 2024 Georgia Forestry Magazine

In the Summer 2024 issue, the magazine has featured the Georgia Tech Renewable Bioproducts Institute and its faculty researchers Anthony J. "Bo" Arduengo, professor of practice in the School of Chemistry and Biochemistry, Matt McDowell, Carter N. Paden, Jr. Distinguished Chair and associate professor in the School of Materials Science and Engineering, and Meisha Shofner, professor in the School of Materials Science and Engineering. The feature titled 'The Green Gusher: How Wood-Based Innovations Are Revolutionizing Sustainability and Technology,' was written by John Casey and discussed how wood-based innovations are revolutionizing sustainability and technology in the forestry industry and included Georgia Tech's forestry in focus video that included interviews with the three researchers.

TAPPI Student Career Fair 2024

The TAPPI Student Chapter hosted a career fair on Thursday, September 12 at the Renewable Bioproducts Institute. The event provided an excellent opportunity for undergraduate and graduate students, and professionals in the pulp and paper industry to connect, network, and explore career opportunities, including potential internships and full-time positions with leading companies. The fair attracted 45 representatives from 15 companies that attended the event and offered internships, full-time and co-ops jobs for both graduates and undergraduates.

TAPPI Student Chapter Career Fair hosted at the Renewable Bioproducts Institute

Spring Workshop Engages Diverse Stakeholders in Shaping the Future of Biorefining and the Bioeconomy

With the nation's goals to net zero well underway and the world moving toward sustainable production methods, biorefineries play a crucial role in our transition to a greener future. These multifaceted facilities convert biomass into biofuels, biochemicals, and bioproducts; foster a circular economy; and reduce reliance on fossil fuels while promoting environmentally friendly industrial practices.

The Renewable Bioproducts Institute (RBI) at Georgia Tech recently hosted a workshop on the Emerging Bioeconomy and the Future of Biorefining. The event cultivated new partnerships as more than 75 attendees from academia, national laboratories, and industry shared and learned about the cutting-edge developments in the emerging field.

From Left to Right: Gary Black, Bo Arduengo, and Andy Bommarius (RBI Strategic Initiative Lead) from the ReWOOD Initiative, Larissa Fenn from RYAM, Andreas Villegas, President of the Georgia Forrest Association and Keynote Speaker, Chris Luettgen RBI Strategic Initiative Lead, Carsten Sievers, RBI Strategic Initiative Lead, Matthew Realff, RBI Strategic Initiative Lead, Carson Meredith, RBI Executive Director, and Valerie Thomas, RBI Strategic Initiative Lead.

Carson Meredith, executive director of RBI, said, "The workshop provided an immersive experience for the attendees with access to knowledge, opportunities to network, and a platform for collaboration to positively impact their understanding and involvement in this rapidly evolving field. I saw a lot of human connections being made, a lot of people shaking hands, and having conversations off to the side. That's exactly why we hold such workshops — to exchange ideas within the Institute as well as between researchers in universities, industry, and national labs."

The program started with a keynote by B. Frank Gupton, professor of chemical and life science engineering at Virginia Commonwealth University, on creating resilient national supply chains for essential medicines and the need for waste reduction through process chemistry improvements to reduce the carbon footprint in the pharmaceutical industry.

Various presentations from RBI's research faculty demonstrated the depth of research in the field of bioeconomy and biorefineries. Topics included integrated biorefining processes by multicomponent separations and catalytic conversion, lignin-derived phenol as the new platform of biorefineries, catalytic conversion of organic acids, data-driven biorefinery process control, hot topics in lifecycle assessment, and more.

A highlight of the annual workshop was the student poster session that showcased the diversity of research happening in the renewable bioproducts field. Over 25 RBI Fellows, spanning chemical and biomolecular engineering, mechanical engineering, materials science and engineering, civil and environmental engineering, and chemistry and biochemistry presented their research to a highly engaged audience.

Andreas Villegas, president of the Georgia Forestry Association and the dinner keynote speaker, addressed the need for educating the community about working forests and their potential to create carbon-neutral products and reduce greenhouse gas emissions. Working forests in the state of Georgia are managed with a growth-over-harvest-rate of 50% and are a natural solution to the major challenges in sustainable forests and communities.

Student Panel at the RBI Spring Workshop

2024 RBI Student Fellows at the Workshop

Blake Simmons, keynote speaker from the Lawrence Berkeley National Laboratory, discussed the importance of intellectual property models and licensing technology models that will allow companies to access new processes emerging in the field.

Mi Li, assistant professor of biorefinery and sustainable materials from the University of Tennessee, presented his research on the modification of plant cell walls, while Bronson P. Bollock, professor of forest biometrics and quantitative timber management at the University of Georgia, presented the current issues and factors in the quantification of forest biomass feedstocks.

Kim Nelson, the chief technology officer of GranBio, addressed the opportunities and challenges in meeting the global demand for sustainable aviation fuel (SAF) and low-carbon bioproducts. Nelson presented GranBio's patented AVAP technology that uses woody biomass to produce SAF, renewable diesel, electricity, and other byproducts like BioPlus nanocellulose for tires in the process.

"At this moment, there is a tremendous federal, state, and industrial focus on developing the U.S. bioeconomy," Meredith said. "RBI's vision is that pulp producers and users of wood extractives and byproducts have an opportunity to develop higher margin products from woody biomass residues, including plastics, pharmaceuticals, and fuels, without disrupting current paper and lumber markets. Traditional petrochemical producers of these products have an opportunity to substitute more carbon-neutral sources as feedstocks. Our workshop sought a conversation around the opportunities and challenges from feedstock to the marketplace. | **Priya Devarajan**

Update on the ReWOOD Center of the Renewable Bioproducts Institute

In May 2023, the Georgia Tech Renewable Bioproducts Institute (RBI) launched a science and technology research center called ReWOOD. ReWOOD, abbreviated from "Renewables-based economy from WOOD" focuses on a burgeoning field of science called Xylochemistry that makes use of sustainable plant-based raw materials to develop industrial products ranging from jet fuel to industrial solvents to generic pharmaceutical additives and more. ReWOOD is sponsored by RBI through its endowment-funded fellowships and is developing a corporate affiliate program.

There has been a frenzy of activity among the core team members since the inception of the ReWOOD center, showing consistent progress toward its goal of increased utilization of wood biomass into value added materials and chemicals.

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External Advisory Board (EAB)
The ReWOOD external advisory board was kicked off in March 2024 and since then, the EAB has added new members. Currently, there are members from nine organizations that are part of the EAB. The board is expected to have a meeting in January 2025.

Proposals
The ReWOOD team has submitted a proposal to the NSF-TIP Regional Innovation Engine called the Conservation, Use, and Local Economies (Cúlé) Sustainability Project. ReWOOD has partnered with the Lower Muskogee Creek Tribe for the project with Anthony J. "Bo" Arduengo, professor of the practice in the School of Chemistry and Biochemistry as the Principal Investigator (PI) and the Muskogee Creek Tribe as the lead organization. The name Cúlé comes from the Muskogee word for pine - the

tree that underpins so many ReWOOD and Cúlé technologies and processes.

The ReWOOD team has submitted a full proposal, that is pending, to the Defense Advanced Research Projects Agency (DARPA). The topic of the proposal is on-demand acetylene generation with Stefan France, professor and associate chair for Graduate Studies in the School of Chemistry and Biochemistry as the PI.

The ReWOOD team submitted a full proposal to the National Science Foundation (NSF) Centers for Chemical Innovation (CCI) under the title "Center for Renewables-based Chemistries from Wood (CRCW)." The proposal included Georgia Tech as the lead organization with Stefan France, professor and associate chair for Graduate Studies in the School of Chemistry and Biochemistry as the Principal Investigator (PI) and Kennesaw State University, University of Alabama, and University of Florida as subcontractors. Unfortunately, the proposal was declined but work on a new NSF-sponsored Science and Technology Center (STC) proposal is now underway.

New Members

Pine Chemicals Association (PCA) International joined the ReWOOD Center as an academic member in 2024. Stefan France from the ReWOOD team attended the PCA National Meeting in May 2024.

Publications

Azuero-Pedraza C.G., Lauri P., Augustynczik A.L.D., and Thomas V.M. "Managing Forests for Biodiversity Conservation and Climate Change Mitigation." Environmental Science & Technology. 2024, 58(21), 9175-9186. DOI: 10.1021/acs.est.3c07163

Azuero-Pedraza C.G., Thomas V.M. "Incorporating biodiversity impacts in land use decisions." Ecological Modelling 2024, 497, 110852. DOI: 10.1016/j.ecolmodel.2024.110852

Benda M. C., Evans C, Yuan S., McClish I. M., Berkey W.J., Areheart H.E., Arnold E.S., Tang M.L., France S. "Modular Enantioselective Total Syntheses of the erythro-7,9-Dihydroxy- and 9-Hydroxy-7-keto-8,4-Oxyneolignans." J. Org. Chem. 2024, 89(14), 9910–9922. DOI: 10.1021/acs.joc.4c00710

List of 2024 RBI Publications

Anglou E., Chang Y., Bradley W., Sievers C., and Boukouvala F. "Modeling Mechanochemical Depolymerization of PET in Ball-Mill Reactors Using DEM Simulations." ACS Sustainable Chemistry and Engineering. 2024, 12 (24), 9003 - 9017. DOI: 10.1021/acssuschemeng.3c06081.

Athanasiou C., Deng B., and Hassen A. A. "Integrating Experiments, Simulations, and Artificial Intelligence to Accelerate the Discovery of High-Performance Green Composites." AIAA SCITECH. 2024, Forum, 0041. DOI: 10.2514/6.2024-0041.

Baker E., Carley S., Castellanos S., Nock D., Bozeman J.F., III, Konisky D., Monyei C.G., Shah M., and Sovacool B. "Metrics for Decision-Making in Energy Justice." Annual Review of Environment and Resources. 2023, 48, 737-760. DOI: 10.1146/annurev-environ-112621-063400.

Benda M.C., Evans C., Yuan S., McClish I.M., Berkey W.J., Areheart H.E., Arnold E.S., Tang M.L., and France S. Modular Enantioselective Total Syntheses of the erythro-7,9-Dihydroxy- and 9-Hydroxy-7-Keto-8,4'-Oxyneolignans. Journal of Organic Chemistry. 2024, 89 (14), 9910 - 9922. DOI: 10.1021/acs.joc.4c00710.

Chipoco Haro D. A., Barrera L., Iriawan H., Herzog A., Tian N., Medford A., Shao-Horn Y., Alamgir, F.M., and Hatzell M. C. "Electrocatalysts for Inorganic and Organic Waste Nitrogen Conversion." ACS Catalysis. 2024, 14 (13), 9752–9775. DOI: 10.1021/acscatal.4c01398.

Karahan D. T., Ranjan D., and Aidun C. K. "A Finite-Volume Framework to Solve the Fokker-Planck Equation for Fiber Orientation Kinetics." Journal of Non-Newtonian Fluid Mechanics. 2024, 325, p. 105 199. DOI: 10.1016/j.jnnfm.2024.105199.

Dong H., Tang S., Zhang L., Tong Z., Wu Z., Zhan P., Shao L., Qing Y., and Liu J. "Wood-Derived Bio-Coating Materials Incorporating Hydrophobic Lignin and Hierarchically Porous Biochar for High-Efficiency Coating Slow-Release Fertilizers." International Journal of Biological Macromolecules. 2023, 242, art. no. 124769. DOI: 10.1016/j.ijbiomac.2023.124769.

Feliachi Y., Roy A., Ren Y., Finn M.G., and Lively R.P. "Solid-State Crosslinking of Thin Film Composite Membranes for Organic Solvent Reverse Osmosis Separations." Journal of Membrane Science. 2024, 695, 122462, ISSN 0376-7388. DOI: 10.1016/j.memsci.2024.122462.

Fu Q., Avendano M., Bentley J.A., Tran Q., Shofner M. L., Sinquefield S A., Realff M. J., and Nair S. "Recovery and Enrichment of Organic Acids from Kraft Black Liquor by Simulated Moving Bed Adsorption." ACS Sustainable Chemistry & Engineering. 2024, 12 (9), 3736-3744. DOI: 10.1021/acssuschemeng.3c07534.

Gao J., Wahlen A., Ju C., Chen Y., Lan G., and Tong Z. "Reinforcement Learning-Based Control for Waste Biorefining Processes Under Uncertainty." Communications Engineering. 2024, 3(1), 38. DOI: 10.1038/s44172-024-00183-7.

García Cárcamo R.A., Xie T., Hare B.J., Sievers C., and Getman R.B., "Active Sites and Mechanism of Aqueous Phase Methanol Dehydrogenation on Pt/Al2O3 Catalysts." Journal of Catalysis. 2024, 435, 115562. DOI: 10.1016/j.jcat.2024.115562.

Gokhale D., Stathatou P.M., Athanasiou C.E., and Doyle P.S. "Yeast-Laden Hydrogel Capsules for Scalable Trace Lead Removal From Water." RSC Sustainability. 2024, 2 (6), pp. 1761 - 1772. DOI: 10.1039/d4su00052h.

Hare B.J., Garcia Carcamo R.A., Daemen L., Cheng Y.Q., Getman R.B., and Sievers C. "Poisoning of Pt/'-Al2O3 Aqueous Phase Reforming Catalysts by Ketone and Diketone-Derived Surface Species." ACS Catalysis. 2024, 14, 1480–1493. DOI: 10.1021/acscatal.3c04774.

Hebisch K.L., Chmielniak P.A., Watson R., Leyshon D., Kimmich B., Xu R., Galfond B., and Sievers C. "Unit Cell Distortion of Ferrierite Induced by Carbonaceous Deposits During Skeletal Isomerization of 1-Butene." Chemical Engineering Journal. 2023, 476, art. no. 146470. DOI: 10.1016/j.cej.2023.146470.

Hebisch K.L., Goel R., Gołąbek K., Chmielniak P.A., and Sievers C. "Synergy between Brønsted Acid Sites and Carbonaceous Deposits during Skeletal 1-Butene Isomerization over Ferrierite." ACS Catalysis. 2024, 14 (13), pp. 10280 - 10294. DOI: 10.1021/acscatal.4c01898.

Huang P-W., Song H., Yoo J., Chipoco Haro D. A., Mo Lee H., Medford A., and Hatzell M.C. "Impact of Local Microenvironments on the Selectivity of Electrocatalytic Nitrate Reduction in a BPM-MEA System." Adv. Energy Mater. 2024, 2304202. DOI: 10.1002/aenm.202304202.

Ji Y., Shen D.E., Lu Y., Schueneman G.T., Shofner M.L., and Meredith J.C. "Aqueous-Based Recycling of Cellulose Nanocrystal / Chitin Nanowhisker Barrier Coatings." ACS Sustainable Chemistry and Engineering. 2023, 11, 10874–10883. DOI: 10.1021/acssuschemeng.3c02457.

Juang J., Williams W.G., Ramshankar A.T., Schmidt J., Xuan K., and Bozeman J.F. III. "A Multi-Scale Lifecycle and Technoeconomic Framework for Higher Education Fleet Electrification." Sci Rep, 2024, 14, 4938. DOI: 10.1038/s41598-024-54752-z.

Kim J. E., and Wang Y. "Quantum Approximate Bayesian Optimization Algorithms With Two Mixers and Uncertainty Quantification." IEEE Transactions on Quantum Engineering, 4, pp. 1-17, 2023, Art no. 3102817. DOI: 10.1109/TQE.2023.3327055.

Kim J. E., and Wang Y. "Topology Optimization With Quantum Approximate Bayesian Optimization Algorithm." Proceedings of the ASME 2023 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 3B: 49th Design Automation Conference (DAC). Boston, Massachusetts, USA. August 20–23, 2023. V03BT03A034. ASME. DOI: 10.1115/DETC2023-116549.

Le K.-C., Johnson S., Aidun C.K., Egertsdotter U. "In Vitro Propagation of the Blueberry 'Blue Suede™' (Vaccinium hybrid) in Semi-Solid Medium and Temporary Immersion Bioreactors." Plants. 2023, 12 (15), art. no. 2752. DOI: 10.3390/plants12152752.

Liu R., Li Q., Gan L., Chen Y. and Tong Z. "Robust, versatile, and hemicellulose-derived biocomposite Janus membrane for saline wastewater desalination." Journal of Membrane Science. 2024, 697, 122566. DOI: 10.1016/j.memsci.2024.122566.

Ma C., Sinquefield S.A., Wang Z., Shofner M.L., and Nair S. "Cross-Flow Separation Characteristics and Piloting of Graphene Oxide Nanofiltration Membrane Sheets and Tubes for Kraft Black Liquor Concentration." TAPPI Journal. 2023, 22 (9), 585-597. DOI: 10.1016/j.memsci.2024.122566.

Movva S., Burrell R.K., Garmestani H., and Jacob K.I. "Characterization of Hardness and Elastic Modulus Using Nanoindentation and Correlation with Wear Behavior of UHMWPE During Uniaxial Tension." Journal of the Mechanical Behavior of Biomedical Materials. 2023, 147, art. no. 106142. DOI: 10.1016/j.jmbbm.2023.106142.

Movva S., Burrell R.K., Garmestani H., and Jacob K.I. "Wear Resistance and Microstructure of Ultra High Molecular Weight Polyethylene During Uniaxial Tension." Tribology Letters. 2024, 72 (1), art. no. 2. DOI: 10.1007/s11249-023-01797-2.

Ojelade O. A., Fu Q., Nair S., and Jones C. W. "Catalytic Upgrading of a Mixed Hydroxy Acid Feedstock Derived from Kraft Black Liquor." ACS Sustainable Chemistry and Engineering. 2024, 12 (24). DOI: 10.1021/acssuschemeng.4c00212.

Park J., Maier J.S., Evans C., Hatzell M.C., France S., Sievers C., and Bommarius A.S. "One-Pot Mechanochemical Hydrogenation and Acetylation of 4-Nitrophenol to 4-Aminophenol and Paracetamol." Green Chem. 2024, 26 (7), 4079–4091. DOI: 10.1039/D3GC04281B.

Peng W., Bao H., Wang Y., Cote E., J. Sagues W.J., Hagelin-Weaver H., Gao J., Xiao D., and Tong Z. "Selective Depolymerization of Lignin Towards Isolated Phenolic Acids Under Mild Conditions." ChemSusChem. 2023, 16 (20). p.e202300750. DOI: 10.1002/cssc.202300750.

Realff M.J., and Tajvidi M. "From Circular to Elliptical: A Useful Reformulation of the Closed Loop Economy?" Journal of Advanced Manufacturing and Processing. 2024, 6 (2). art. no. e10174. DOI: 10.1002/amp2.10174.

Ronglan E., Rubio A.P., da Silva A.O., Fan D., Gair J.L. Jr., Stathatou P.M., Bastidas C., Strand E., Ferrandis J.D.A., Gershenfeld N., and Triantafyllou M.S. "Architected Materials for Artificial Reefs to Increase Storm Energy Dissipation." PNAS Nexus. 2024, 3 (3). DOI: 10.1093/pnasnexus/pgae101.

Song H., Chipoco Haro D. A., Huang P-W., Barrera L., and Hatzell M. C. "Progress in Photochemical and Electrochemical C–N Bond Formation for Urea Synthesis." Acc. Chem. 2023, 56 (21), 2944-2953. DOI: 10.1021/acs.accounts.3c00424.

Stathatou P. M., Corbin L., Meredith J. C., and Garmulewicz A. "Biomaterials and Regenerative Agriculture: A Methodological Framework to Enable Circular Transitions." Sustainability. 2023, 15(19), 14306. DOI: 10.3390/su151914306.

Su Y., Xiong W., Yue L., Paul M. K., Otte K.S., Bacsa J., Qi H. J., and Gutekunst W.R. "Michael Addition-Elimination Ring-Opening Polymerization." J. Am. Chem. Soc. 2024, 146 (26), 18074–18082. DOI: 10.1021/jacs.4c05054.

Tang S., Zhang L., Tong Z., Wu Z., Wang H., Zhan P., Shao L., Qing Y., Wu Y., and Liu J. "Encapsulated Lignin-Based Slow-Release Manganese Fertilizer with Reduced Cadmium Accumulation in Rice (Oryza sativa L.)." International Journal of Biological Macromolecules. 2024, 262, art. no. 130019. DOI: 10.1016/j.ijbiomac.2024.130019.

Wang Y., Kim J. E., and Suresh K. "Opportunities and Challenges of Quantum Computing for Engineering Optimization." ASME. J. Comput. Inf. Sci. Eng. 2023, 23 (6), 060817. DOI: 10.1115/1.4062969.

Yue L., Su Y., Li M., Yu L., Sun X., Cho J., Brettmann B., Gutekunst W.R., Ramprasad R., and Qi H.J. "Chemical Circularity in 3D printing with biobased-valerolactone." Advanced Materials. 2024. DOI: 10.1002/adma.202310040.

Yunus A. I., and Fu G. Y. "Selecting the Effective Biochar for Removal of Pollutants from Highway Stormwater Runoff." Journal of Environmental Engineering. 150(7), 04024027. DOI: 10.1061/JOEEDU.EEENG-7417.

Zaw K.S.K., Ma C., Wang Z., Shofner M.L., and Nair S. "Effects of Graphene Oxide Membrane Thickness Reduction on Microstructure and Crossflow Separation Performance in Kraft Black Liquor Dewatering." Chemical Engineering Science. 2023, 281, 119194. DOI: 10.1016/j.ces.2023.119194.

Zhang L., Gregory S.A., Malinowski K., Atassi A., Freychet G., and Losego M.D. "Vapor Phase Infiltration of Titanium Oxide into P3HT to Create Organic-Inorganic Hybrid Photocatalysts." ACS Applied Materials & Interfaces. 2024, 16 (26). DOI: 10.1021/acsami.3c16469.

Zhang M., Kim M., Choi W., Choi J., Kim D.H., Liu Y., and Lin Z. "Chiral Macromolecules and Supramolecular Assemblies: Synthesis, Properties and Applications." Progress in Polymer Science. 2024, 151, 101800. DOI: 10.1016/j.progpolymsci.2024.101800.

Zhang M., Choi W., Kim M., et al. "Recent Advances in Environmentally Friendly Dual-crosslinking Polymer Networks." Angewandte Chemie International Edition. 2024, 63 (24). DOI: 10.1002/anie.202318035.

Zinke A., Pottackal N., Zahin F., Nur M., Ahmed F., Ji Y., Mohammed Z., Meyer M.D., Miller C., Bennett M.R., Rangari V., Meredith J.C., Ajayan P.M., and Rahman M. "Preserving Fresh Eggs via Egg-Derived Bionanocomposite Coating." Advanced Functional Materials. 2024, 2310091. DOI: 10.1002/adfm.202310091.

List of 2024 RBI Fellows

Name	School	Project	Advisors
Jay Baek	MSE	Sustainable & cost-effective treatment of pulp & paper effluent	Christos Athanassiou, Patritsia Stathatou
Rebecca Banner	MSE	Fabrication of transistor paper for on-demand microelectronics	Michael Filler, Eric Vogel, Victor Breedveld
William J. Berkey	CHEM	The synthesis of enantiopure heterocycles from carbohydrate derived furans	Stefan France, Chris Jones
Danae A. Chipoco Haro	MSE	Electrocatalysis for a bioeconomy: nitrate reduction and lignin oxidation for value added products	Marta Hatzell, Faisal Alamgir
Woosung Choi	MSE	Recyclable, degradable star-like polymer with barrier properties for next-generation packaging	Vladimir Tsukruk
Shaafique Chowdhury	ChBE	Lignin-derived biodegradable bio latex	Pamela Peralta-Yahya
Yacine Feliachi	ChBE	Crosslinked TFC membranes for complex organic mixture separations	Ryan Lively, M.G. Finn
Elyssa Ferguson	ME	Sustainably sourced natural fibers for thermal insulation in buildings	Akanksha K. Menon
Gard Gudvangen	CHEM	Solvents from lignocellulose – A synthetic renaissance for a sustainable feedstock	Anthony Arduengo, Andreas Bommarius Stefan France, Jake Soper
Tanner J. Hickman	ChBE	Making polysaccharide-based barrier films work in high humidity	Carson Meredith, Natalie Stingelin
Amirhosein Ilbeygi	ME	Advances in refining & stock prep for better product quality at lower energy consumption in MP Forming	Cyrus Aidun, Chris Luettgen, Julene Tong
Hsiang-Ju (James) Kai	ChBE	Unraveling the physical chemistry of polyolefin-cellulose interfaces	Natalie Stingelin
Dogukan T Karahan	ME	Fiber orientation analysis in the entire headbox	Cyrus Aidun, Devesh Ranjan
Elnaz Jamshidi	MSE	Sustainable bonding: enhancing wood strands through sodium hydroxide immersion without traditional adhesives	Asha Menon, Joe Bozeman, Kyriaki Kalaitzidou
Jungin E. Kim	ME	Optimizing properties of biodegradable co-polymers	Yan Wang, Karl Jacob
Akanksha Lakra	ChBE	Functionalization of cellulose nanocrystals with atomically precise metal nanoclusters	Julene Tong, Cyrus Aidun, Chris Luettgen
Geng-Sheng Lin	ChBE	Triboelectric membrane sensor for heavy metal removal and detection	Julene Tong, George Lan
Opeyemi A. Ojelade	ChBE	Catalytic upgrading of kraft black liquor-derived hydroxy acids	Sankar Nair, Chris Jones
Jimin Park	ChBE	One-pot mechanochemical hydrogenation and acetylation of 4-nitrophenol to paracetamol	Andreas Bommarius, Carsten Sievers, Marta Hatzell
Kim Anh Pham	MSE	The effect of CNC coatings on glass fiber composite performance	Kyriaki Kalaitzidou, Karl Jacob, Tequila Harris
Erin V. Phillips	CHEM	Mechanocatalytic arylation of diazonium salts using piezoelectric catalysts	Carsten Sievers, Marta Hatzell
Arjun Thangaraj Ramshankar	CEE	Deconstructing the US construction sector: Advancing sustainability in the built environment using a life cycle approach	Akanksha K. Menon, Joe Bozeman, Kyriaki Kalaitzidou
Michael Rettstatt	ChBE	Mechanism of aqueous phase reforming of organics over bimetallic catalysts	Carsten Sievers, Sankar Nair
Javaz Rolle	ChBE	Durable bio-based coatings for packaging applications	Carson Meredith, Natalie Stingelin
Fariha Rubaiya	MSE	Exploring out-of-plane auxetic response in cellulose nanofibrils (CNFs) film	Meisha Shofner, Lauren Garten

Lilly Schroer	MSE	Leveraging strain field mining to map the heterogeneity of network structured materials	Chris Muhlstein
Talia Thomas	ME	Functionalized cellulose & lignin materials for next generation battery materials	Matthew McDowell
Quyen (Peter) Tran	ChBE	A pathway for integration of kraft processing with black liquor fractionation, chemical production, and CCS	Natalie Stingelin, Thomas Gartner
Preksha Vichare	MSE	Improving mechanical dewatering of paper	Victor Breedveld, Chris Luettgen, Valerie Thomas, Blair Brettmann
David Witdorchic	ChBE	Introduction of nitrogen Into woody biomass	Andy Bommarius
Andrew K. Wu	ChBE	Bio-based thermo-reversible tie layer for recyclable multilayer packaging	Natalie Stingelin, Kyriaki Kalaitzidou, Karl Jacob
Xintong Xu	ChBE	Data-driven process for aviation fuels and biochemicals from forestry residues	Zhaohui Tong, Carson Meredith
Ahmed Yunus	CEE	Anaerobic membrane bioreactor co-digestion of pulp and paper processing wastewater and solid wastes: performance assessment and optimization	Joe Bozeman, Yongsheng Chen
Kaung Su Khin Zaw	ChBE	Lignin micro- and nano particles (LMNP) production from pulp and paper, and biorefinery lignin streams	Sankar Nair, Meisha Shofner, Scott Sinquefield
Li Zhang	MSE	Using ALD to alter biodegradation in cellulosic fabrics	Mark Losego, Todd Sulchek

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