Science Alliance

ANNUAL REPORT

2022–2023

THEC State Appropriations Request 2024-2025

SCIENCE ALLIANCE

THE UNIVERSITY OF TENNESSEE

Oak Ridge Innovation Institute


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Executive Summary

Next year, Science Alliance will mark its 40th anniversary as a Tennessee Center of Excellence, making it one of, if not, the longest continually operating organization in East Tennessee that nurtures the advancement of science, technology, engineering, and math (STEM) education and research by supporting collaborations between the University of Tennessee, Knoxville and Oak Ridge National Laboratory.

Just as science continues to evolve to meet society's needs, the Science Alliance is evolving in the ways it supports and encourages the work of UT researchers. The most significant change to the center is that the Science Alliance is now part of the University of Tennessee-Oak Ridge Innovation Institute (UT-ORII), which allows the Tennessee Higher Education Commission's $4,183,794 investment to be synergistically leveraged with the ~$80M 10-year state investment in UT-ORII, and the ~$20M in federal funds and ~$16M in cost share from the UT System. Inclusion in the UT-ORII portfolio of programs allows the Science Alliance to maintain its mission of supporting collaborative research and join educational opportunities on the Knoxville campus, while providing participants with the opportunity to be linked to opportunities at other UT campuses included in UT-ORII's statewide and national initiatives.

An example of the power of these partnerships is the success of the Student Mentoring and Research Training (SMaRT) program. With an eye on the future, this summer internship program seeks to recruit some of the country's best and brightest students to work on cutting-edge research projects that are jointly conducted by teams of ORNL and UT researchers. Through our partnership with the UT Graduate School and the UT-ORII Department of Energy Office of Energy Efficiency & Renewable Energy (EERE) grant, the SMaRT program has expanded from an initial cohort of 10 to now hosting approximately 45 students each year. Having experienced the expertise and opportunities we have at UT and ORNL, our hope is that these stellar students choose UT for their graduate studies and then build their careers in Tennessee. In the coming year, we also will be partnering with the newly established National Science Foundation Center for Advanced Materials & Manufacturing-Materials Research Science & Engineering Center to recruit an even larger cohort of undergraduate interns.

To nurture graduate students already engaged in research at UT, the Science Alliance provides direct funding to departments across campus and funds individual student awards through the Graduate Advancement, Training and Education (GATE) program.

To date, the SMaRT and GATE programs together have represented an investment of more than $4.46 million in the future of research in Tennessee and beyond.

Another major effort underway is the streamlining and updating of our seed programs, including the Support for Affiliated Research Teams (StART) and the Partnership and Collaborative Teams (PACT) programs, which foster partnerships between UT and ORNL researchers. Launched in 2019, StART focuses on supporting UT faculty members who are early in their careers by providing up to two years of funding for them to explore first and new collaborations with ORNL researchers and to lay the groundwork for novel research paths. The PACT program, which began in fiscal year 2020-21, nurtures greater interactions between UT and ORNL and promotes meritorious research. Exciting changes are in the works that will allow greater engagement with ORNL researchers, and we look forward to unveiling the positive changes to these programs in the coming year.

This report will give an overview of the programs within the Science Alliance. It also will introduce you to some of the faculty and students engaged in transformative joint research that leverages the unique capabilities of both UT and ORNL to address critical needs in order to ensure the continued security and prosperity of our nation. The Science Alliance is proud to be a force in supporting exceptional new and seasoned scientists. Together, we are striving to make Tennessee a leader in innovation.

Science Alliance Overview

Since it was established in 1984, the Science Alliance has sought to encourage and support great science, discovery and innovation by improving science programs at UT Knoxville, and increasing collaboration between UT and ORNL. State funds and matching funds from UT have fueled this work.

Science Alliance funding is one critical way that the partnership between UT and ORNL is further advanced. Funds support a variety of significant investments in people and collaborations. As part of the UT-Oak Ridge Innovation Institute (UT-ORII), the Science Alliance continues to support strategic areas of importance to both organizations. This partnership has provided opportunities to increase the impact of the Science Alliance programs by synergistically integrating them with other programs within the UT-ORII portfolio.

Many of our current collaborative research projects funded through the Science Alliance support strategic areas of importance to UT and ORNL. Clean manufacturing, advanced materials, computational science and systems biology are currently among the most prominent UT-ORNL collaborative areas receiving support. The yearly state investment in this important collaboration is instrumental in allowing the Science Alliance to continue to provide opportunities for supporting current and emerging collaborations between researchers from both institutions.

Great science and discovery come when people-to-people interactions are optimized, and the Science Alliance remains committed to fostering and enabling these critical interactions. We believe that our programs play a vital role in leveraging the federal investments made at ORNL and UT in our areas of collaborative research and development.

Photo Courtesy of ORNL, Carlos Jones

MISSION

The Science Alliance was established in 1984 to improve selected science programs at the University of Tennessee, Knoxville, and to increase collaboration between the university and Oak Ridge National Laboratory (ORNL).

The Science Alliance is composed of four divisions, the original three being Biological Sciences, Chemical Sciences, and Physical Sciences. A fourth division, Mathematics and Computer Science, was added in 1986.

The Science Alliance seeks to fulfill its mission by:

- Creating a strong formal bond between UT and ORNL
- Hiring and supporting joint UT-ORNL distinguished scientists
- Seeding and supporting joint UT-ORNL research programs
- Sharing resources and building areas of common strength at UT and ORNL, as well as with industry and other institutions
- Bringing UT and ORNL together to support technology transfer
- Providing incentives to attract and retain exceptional faculty and students
- Strengthening graduate and undergraduate opportunities
- Growing government and industrial support of the shared research enterprise
- Increasing public and professional awareness of UT-ORNL partnerships

Goals & Future Plans

In its four decades of existence, the Science Alliance has looked for ways to encourage and support meaningful collaborations between UT Knoxville and ORNL.

Now part of UT-Oak Ridge Innovation Institute (UT-ORII), the Science Alliance has a strong dossier of programs, from seed programs that encourage early career faculty and support high-performing faculty, to programs that nurture undergraduates and graduate students.

We are currently looking at some exciting ways to streamline and improve our seed programs, and hope to announce those changes this year. Meanwhile, here's a snapshot of Science Alliance programs that have supported joint research between UT and ORNL during the past fiscal year:

The **Student Mentoring and Research Training Education (SMaRT) program**, which began in fiscal year 2019-2020, promotes research and harnesses the unique partnership between UT and ORNL by funding paid undergraduate internships. This year, the Science Alliance worked with the UT Graduate School and Oak Ridge Associated University (ORAU) to recruit 45 of the nation's brightest undergraduates from 26 universities across the country to work with UT faculty and ORNL researchers during the summer. Students were housed on campus for 10 weeks while they engaged in ORNL-related research and professional development opportunities. At a research symposium at the conclusion of the program, students delivered formal presentations and posters to an audience of their peers, faculty members and administrators. Our hope is that many of these exceptional young scientists choose UT for grad school and then go on to forge careers in Tennessee. To date, SMaRT program funding has been $1,882,443.

The **Graduate Advancement, Training and Education (GATE) program** provides funding to graduate students working on important, collaborative research. In its first three years, from August 2020 to June 2023, the program has fully supported graduate research assistantships for 35 students and provided them with funding totaling $2,581,096. The next cohort of GATE students was selected at the end of the 2022-23 academic year and began receiving funding on August 1, 2023. In addition, the Science Alliance provides funding to support graduate students to many departments across campus. Together, these efforts help develop future research professionals.

The **Support for Affiliated Research Teams (StART) program**, which began in the 2019-2020 fiscal year, provides UT faculty members with up to two years of funding to explore first and new collaborations with ORNL researchers. Awardees qualify for the second year of funding when they produce an external proposal that includes the participation of both ORNL and UT. Since the program's inception, funding has totaled $2,044,545. This past fiscal year's funding for StART totaled $720,675, with six faculty members receiving first-year funding and four receiving funding for all or part of a second year. Collectively, those faculty are working with 8 undergraduates, 14 graduate students and two post-docs.

The Partnership and Collaborative Teams (PACT) program, which started in 2020-21 and granted its first award in February 2022, is designed to develop research communities that will foster greater interactions between UT and ORNL, and lead to increased meritorious research. Past-year funding totaled $656,836. Since its inception, program funding has totaled $855,002.

> *"I would not have thought of applying to UTK if it weren't for the SMaRT program."*
>
> *Kyle Sprecker, Current UTK Graduate Student & Former SMaRT Intern from University of Wisconsin-Madison*

SMaRT

STUDENT MENTORING & RESEARCH TRAINING

This summer, the Science Alliance welcomed its largest group of undergraduate interns yet, to its Student Mentoring and Research Training (SMaRT) internship program.

For 10 weeks, 45 students from 26 colleges and universities, including six historically black colleges and universities, had the unique opportunity to work alongside UT and Oak Ridge National Laboratory researchers to tackle some of our nation's most critical research challenges.

The Science Alliance launched the SMaRT program in 2020. Due to restrictions during the pandemic, our 2020 interns were limited to a virtual, remote experience. In 2021, we were able to invite 18 SMaRT interns to the UT Knoxville campus for hands-on research experiences, but COVID restrictions still prohibited us from taking the interns to ORNL. In 2022, with COVID restrictions lifted, we were able to provide our interns with the joint UT-ORNL experience that has truly made SMaRT the prominent, competitive program that it has become.

Attracting Top Students to UT Grad School

Our ultimate goal with the SMaRT program is to recruit the nation's best and brightest undergraduates to UT for graduate school and to Tennessee to build their careers. Our initial results are good, with about 25 percent of our interns from the first three years of the program applying for or enrolled in UTK graduate programs; and we're working hard to increase that number even more.

The majority of our students tell us that the opportunity to work with researchers at UT and at the world's premier research institution, ORNL is the reason they applied to the SMaRT internship program and choose UT over other graduate research programs. We also know that our East Tennessee location makes us an ideal choice. To showcase this, we provide our interns with information on possible weekend adventures to encourage the students to explore the beauty and wonder of our region. In 2023, one of our group activities was a Smokies baseball game in Sevierville.

> *"The SMaRT program taught me to think on my feet, to solve problems."*
>
> *Bryson Hedrick, Appalachian State University*

'Team Science' Experience

Before the students arrive for their 10-week research experience, they are broken into teams of 3-5 students and matched with UT and ORNL researchers and graduate students who serve as their mentors throughout the program.

The teams focus on research topics related to four targeted interdisciplinary areas*:

1. Electrochemical energy systems
2. Advanced science and engineering of materials and manufacturing
3. Predictive systems biology for circular and sustainable economies
4. Autonomous, smart, secure and resilient energy systems

*Data science and engineering threads are woven through each of these four areas.

The SMaRT program provides a "team science" interdisciplinary experience that students simply cannot get in a typical classroom. Interns gain firsthand research experience in emerging fields, while working with state-of-the-art research instruments at UT and ORNL.

The students also prepare CVs and personal statements for future opportunities. At the end of the program, each student is expected to make a short presentation before his or her peers and prepare a scientific poster.

All of these experiences help prepare our interns for graduate school and exciting and rewarding careers.

Enhanced by Industry Partnerships

Several of our SMaRT interns' research was enhanced by our partnerships with some of Tennessee's industry leaders, like Denso Manufacturing. Three of our 2023 interns worked on programming a donated assembly line robot from Denso. The students created a gripper piece for the robot and programmed it to draw the designs they created.

The work these students did will expand beyond the 10 weeks they spent in the manufacturing lab. New to UTK last fall was the establishment of a National Science Foundation Engineering Research Center, where UTK works with four other universities on advanced manufacturing research.

"What the SMaRT students were able to work on was the University of Tennessee robotic training cell and use that to carry out a demonstration activity," said Tony Schmitz, a UT-ORNL joint faculty member and SMaRT mentor. "It's not just work in my laboratory, but also this giant consortium of five universities and multiple companies where their work will live on, because we'll take what they did, share it with the other universities, and continue to grow."

The interns take back to school an understanding of how their subject area can be applied outside of the classroom and into the real world.

GATE AWARDEES

The Science Alliance has a long history of supporting graduate students via assistantships and fellowships awarded by individual departments, now known as the Graduate Advancement, Training, and Education (GATE) program, to support meritorious, collaborative research between the university and ORNL. This program will continue to provide opportunities to students currently studying at our university and will also help recruit the next generation of scientists moving forward. We are now beginning the next phase of this program by offering full graduate research assistantships to students based on the merit of their research. GATE awardees receive a 12-month appointment, including a stipend, tuition waiver, and health insurance.

SHAMIUL ALAM

Electrical Engineering & Computer Science

Shamiul Alam's research on the development of device models and circuits is aimed at enabling next-generation memory, logic and logic-in-memory systems utilizing semiconducting, superconducting and topological devices. The outcomes of his research carry significant implications for artificial intelligence, high-performance computing and quantum computing. Alam is focused on utilizing a novel memory device, known as UltraRAM, to create a universal memory system that can function as a long-term storage and as active memory. He intends to expand his research by designing a unique compute-in-memory system that will exploit the inherent properties of UltraRAM.

FIDAA ALI

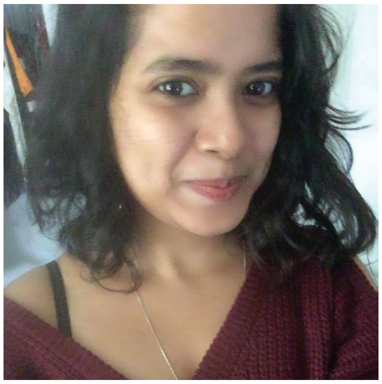
Genome Science & Technology

Fidaa Ali's research focuses on characterizing and solving the structure of different oligomeric forms of photosystem I (PSI) from thermophilic cyanobacteria in their native membrane environment. She is using non-detergent methods to extract and stabilize the protein complexes and employ a variety of biochemical and biophysical analyses, as well as computational methods to characterize them and gain insight into the distribution of lipids around these complexes.

CHARLES AMOO

Energy Science & Engineering

Charles Amoo is working on DOE's Weatherization Assistance Program, aimed at reducing energy costs for low-income households by increasing the energy efficiency of their homes. Amoo aims to improve existing energy audit software by developing features that are relevant and user-friendly, and training energy auditors on these tools. Through his research, Amoo hopes to help the millions of households that need weatherization assistance.



SHIKHA BANGAR

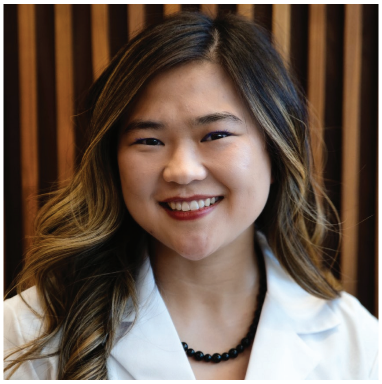
Physics

Shikha Bangar's work focuses on Novel Algorithms for NISQ Devices. Bangar is developing quantum algorithms that can be implemented on current quantum technologies. She is designing a continuous-variable (CV) quantum neural network protocol that can be realized experimentally. This protocol uses only Gaussian gates, and nonlinearity is introduced through measurements on ancillary qumodes. Next, she will investigate the power of CV quantum neural networks and compare them with their classical counterparts.

IAN COX

Physics

Ian Cox is collaborating with ORNL and other institutions to study the decays of exotic isotopes using the FRIB Decay Station Initiator (FDSi). FDSi allows for the combination of high-resolution gamma and neutron spectroscopy with total absorption gamma spectroscopy to measure excited states in nuclei. These results allow insight into interactions between protons and neutrons in the nucleus, thus helping to provide better models for astrophysical applications. An upcoming experiment will attempt to measure the superallowed alpha decay of 104Te to provide needed insight into how protons and neutrons cluster together.



PRESLEY DOWKER

Nutrition

Presley Dowker's research focuses on identifying and characterizing novel pharmacological and diet-based approaches to treat and prevent obesity and its associated metabolic consequences. This is achieved through the use of in vitro (cell culture) and in vivo (mice work) models which allows her to characterize the function and contribution of key metabolic proteins and enzymes related to the pathogenesis of obesity. Dowker's overarching goal is to identify novel strategies that will alleviate or treat metabolic diseases through the use of pharmacological, genetic or nutritional approaches.

JOHN HIRTZ

Nuclear Engineering

John Hirtz is investigating the structural changes of spinel oxides in extreme conditions. His focus is on creating sample environments at extreme pressure and high temperature with the ability to perform in situ characterization. These measurements are performed at multiple beam lines at Argonne National Laboratory and ORNL. Hirtz has previously worked on the irradiation response of implanted helium bubbles in metal matrices and other general high-pressure work.

KRISTEN KENNISON

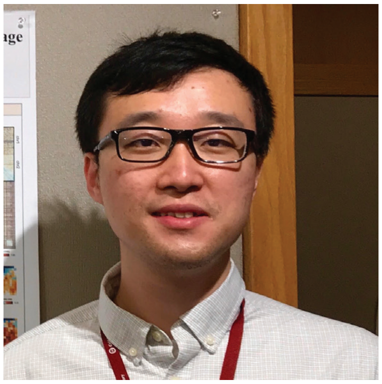
Chemistry

Kristen Kennison's research focuses on a poorly understood characteristic of the plasma membrane, transbilayer compositional asymmetry. She is characterizing asymmetric bilayers that mimic eukaryotic plasma membranes to reveal information about interleaflet coupling. Kennison's work involves producing symmetric and asymmetric giant unilamellar vesicles and large unilamellar vesicles utilizing methods such as calcium-induced hemifusion and methyl-beta-cyclodextrin exchange. She has utilized many different techniques to characterize these model membranes.

PAYCHUDA KRITPRAJUN

Electrical Engineering

Paychuda Kritprajun is studying the impact of grid-connected photovoltaic with supercapacitor systems (PVSS) on power grids. To investigate its behavior under power system transient events, she developed a converter-based supercapacitor emulator with PV on a real-time reconfigurable hardware testbed (HTB) platform. Kritprajun's research aims to develop the control of PVSS to ensure its availability to provide grid services under severe events, while maintaining the safe operations of both PVSS and power grids and helping PV generation sources ride through major grid disturbances without disconnecting from the grid.



HENG LI

Biochemistry, Cellular & Molecular Biology

Heng Li studies how local chromosome domain structures are reinforced in response to X-ray irradiation. Li is interested in studying the impact of cellular sensitivity to subsequent rounds of radiation determined by the initial response and comparing the influence of different types of radiation, such as alpha particles on 3D chromosome structure. This work will improve our ability to understand and develop effective radiation combination therapies and enhance cancer susceptibility to radiotherapy.

DIYI LIU

Civil & Environmental Engineering

Diyi Liu's research focuses on tackling engineering problems in the transportation field using emerging and innovative methodologies and technologies, including statistical machine learning, data science and numerical optimization. Liu's research is threefold: (1) to understand transportation and its pattern using statistical approach; (2) to enhance the "total benefits" of traffic through better control algorithms; (3) to make new theoretical and practical contributions about different methods through studying the hard transportation-related topics like intelligent carpool matching, truck volume identification, etc.

MIRKA MANDICH

Energy Science & Engineering

Mirka Mandich researches experimental characterization of plasma flow using laser spectroscopy. Mandich would like to design a mobile diagnostic platform capable of Thomson scattering and optical emission spectroscopy to deploy to different facilities. Mandich has employed other spectroscopy techniques such as absorption spectroscopy for aerospace plasma applications and schlieren imaging with electrothermal arcs, and looks forward to developing new techniques that make use of advancements in plasma physics, optical engineering, and machine learning.

SAYLI MULAY

Microbiology

As the Earth warms, the permafrost in the Arctic subsurface is thawing, resulting in part of the carbon pool vulnerable to decomposability due to the increased activity of microbes. Mulay is working on Arctic subsurface samples collected from Svalbard, Norway to identify active microbial population during permafrost thaw. She is using a molecular based activity detection technique to identify and isolate active microbes from the thawed permafrost. This research will help us understand the microbial communities that dominate the thawing Arctic subsurface and their processes.

ROUNAK PATRA

Biosystems Engineering & Soil Science

Rounak Patra's research focuses on C isotopes to understand subsoil carbon dynamics. Our current understanding of soil organic carbon (C) dynamics is mainly derived from topsoil studies. Theoretically, subsoil possesses ideal traits for long-term C storage, yet the mechanistic understanding of fulfilling such potential is largely unknown. In Patra's dissertation research, they leverage stable C isotopes to study active microbial functional traits associated with C cycling to understand subsoil carbon dynamics under highly managed ecosystems.

ANJALI RATHORE

Physics & Astronomy

Anjali Rathore's research focus is to confirm the existence and comprehend fundamental physics of topological protected bound states, such as 1D edge states and 2D surface states. For this work, she plans to synthesize topological materials by molecular beam epitaxy technique along with characterization of different topological phases and systematic analysis of unique fundamental properties of topological bound states. Rathore wants to investigate the fundamental physics underlying topological elemental thin films and to further develop intriguing devices with potential applications in the field of electronics and quantum computation.

CHARLES RUSSELL

Biochemistry, Cellular & Molecular Biology

Charles Russell studies the pore formation mechanism of the virulent peptide, candidalysin, that is required for Candida albicans pathogenesis. Russell is interested in the physical influence that plasma membrane lipids have on protein structure and function. Understanding the mechanism of candidalysin self-assembly and pore formation will inform new avenues to treat C. albicans infection and can also be utilized in other biomedical applications.

RYAN SPENCER

Mechanical, Aerospace, & Biomedical Engineering

Ryan Spencer works with nondestructive evaluation (NDE) tools that will be integrated into advanced manufacturing methods in order to provide high quality and defect-free components. Spencer's research focuses on large-scale additive manufacturing methods that are still prone to defect development during the fabrication process. By applying acoustic emission, a leading NDE technique, as structural health monitoring, Spencer will measure stress waves caused by initial failure points, such as cracking. This method will provide early detection of defects during the print process and allow the ability to take preventative action.

SOPHIA TURNER

Ecology & Evolutionary Biology

Sophia Turner's research focuses on the role of changing biotic interactions for plant resource allocation. Using field and experimental research to combine traditional ecological techniques with molecular methods, Turner seeks to test how host-specific species interactions change across the range of her study species, Solidago altissima (Tall Goldenrod). Her work incorporates plant-insect-microbe interactions to identify and predict how plant populations respond to changing multispecies interactions and determine mismatches in plant phenology and local species abundances.

SANJITA WASTI

Mechanical Engineering

Sanjita Wasti works on the manufacturing and characterization of different types of composite materials. Her research focuses on the development and processing of natural and hybrid fiber-reinforced composites for automotive applications. Poor compatibility between the natural fiber and polymer matrix is one of the major bottlenecks that limits the wide range application of natural fiber composites. Wasti also is working on different techniques to improve the interface between the natural fiber and polymer matrix.

HYUN SEOK YOON

Ecology & Evolutionary Biology

Hyun Yoon is interested in aquatic species conservation. Yoon is currently working on projecting how the range of freshwater fish and mussel species will shift in the future due to climate change and hydropower/thermoelectric plants operation. He is doing this using species distribution modeling to calculate the likelihood of occurrence of species using predictors such as temperature and flow of the streams simulated through the water balance model. Based on the projected change in species distribution, Yoon will conduct an economic risk calculation from potential fluctuation in the species monitoring and mitigation cost for the hydropower plant operations.

JACKIE ZHENG

Energy Science & Engineering

As a member of ORNL's Soft Matter Group, Zheng's research focuses on the development of organocatalysts for polymer deconstruction and the upcycling of these deconstructed polymers into stronger and more valuable materials. Zheng also is working on the commercialization of plastic upcycling technologies to advance closed-loop circularity of plastic waste to renewed materials and divert them from landfills.

StART Awardees

Support for Affiliated Research Teams

The Support for Affiliated Research Teams (StART) program provides funding for up to two years to faculty members exploring first and new collaborations with ORNL researchers. Funded proposals are eligible for second-year funding following a performance-based evaluation, including the preparation of an external proposal.

StART is the first Science Alliance program to offer two semi-annual deadlines, in an effort to provide faculty members with greater flexibility and additional access to funding throughout the year. In its fourth year, the StART program funded 10 projects in areas ranging from machine learning in materials science to neuromorphic computing.

StART Awardee

John Brantley

CHEMISTRY

Plastic is everywhere—from food and drink containers to kids' toys to car parts.

"We produce billions of tons of plastic waste every year, and many of these materials end up in landfills and they eventually infiltrate the environment," said Brantley, an assistant professor of chemistry.

His StART project focuses on developing new techniques for breaking down plastic waste into useful building blocks that can then be used to make things like fuels, lubricants, or even new plastic materials.

"'Upcycling' is becoming a very active area of research," Brantley said. "We are trying to develop technologies that provide a new pathway for taking an unwanted plastic and converting it into something more valuable."

Brantley says his initial focus—trying to use chemical reactions to change the structures of polymers—shifted based on his team's research over the past year.

"We actually discovered that we could use light and an organic catalyst to transform plastics, or polymers, into smaller units that can be reconfigured into new materials," he said.

Brantley said the chemistry works with both natural sunlight and artificial light. "And it doesn't require any special precautions to exclude air or water, which makes it a potentially valuable technology for dealing with plastic waste, especially in remote areas.

"In a related development, we found that we could also use electricity (electrochemistry) to achieve very similar outcomes," he said. This facet of their research was accepted for publication in the Journal of the American Chemical Society.

Brantley's research is getting attention. His group recently submitted an invited proposal to NSF for the Critical Aspects of Sustainability (CAS): Innovative Solutions to Sustainable Chemistry. They've also been invited to submit a proposal to the Army Research Office on a project that was directly inspired by their StART award.

Brantley said the team has branched into two new areas in 2023: 1) photoredox-mediated CH activations (with an emphasis on understanding how we can selectively upcycle waste plastics using light), and 2) electroreductive depolymerizations (basically turning polymers back into their monomers using only electricity).

Brantley's collaborators include Brian Long, associate professor of chemistry, and Tomonori Saito, a research scientist in ORNL's Chemical Sciences Division, who is interested in energy-related applications of polymers.

StART Awardee

Subhadeep Chakraborty

MECHANICAL, AEROSPACE & BIOMEDICAL ENGINEERING

Driver inattention is the leading cause of traffic accidents in the U.S., resulting in thousands of deaths per year. Inattention can be the result of driver fatigue, texting, loud music, or even daydreaming. With more automated vehicles (AVs) on the road, the effect of driver distraction on road safety has become even more nuanced.

"From a driver-perspective, vehicle autonomy in its current state seems to be fundamentally self-contradictory", said Subhadeep Chakraborty, Associate Professor of Mechanical, Aerospace, and Biomedical Engineering. "For example, an Advanced Driver Assistance System (ADAS) may promise automated driving, but urge drivers to be constantly engaged in the process of driving. The expectation that the driver would remain cognitively fully involved in the driving process, while being physically driven by AI in a Level 3 and 4 AV seems to be fundamentally unrealistic."

From this perspective, a robust driver monitoring system seems almost imperative to the success of the AV industry. Biometric sensing is the process of gathering information about a human, in this case the driver of a vehicle, such as where they are looking or their heart rate. Data gathered from a driver can subsequently be cross referenced with information about the vehicle itself and its surroundings to assess the situation and determine if the driver is behaving normally.

"Our physiological responses are tied to what the vehicle is doing and what is going on around the vehicle at the same time," said Chakraborty. "Looking at these three things simultaneously allows us to determine if a driver's behavior is normal or something that could become unsafe. Especially, when it comes to AVs, what is considered "safe" and "unsafe" is also not really clear – for example, a level 2 AV might safely allow the driver to take their hands off the steering wheel momentarily (say, to open a bottle of water) on a relatively empty highway. Still that same task would be dangerous in a Level 1 vehicle, or a Level 2 vehicle on a busy urban road."

In tests carried out at the University of Tennessee, vehicle, driver, and roadway data were collected using multiple sensors, both virtual and physical using a simulator that was developed in-house. The Virtual Reality (VR) simulation was designed with two-way traffic on a curvy mountainous road populated with other AI driven vehicles to simulate realistic driving behavior. Two simple experiments with visual and cognitive distraction were designed to distract the driver while asking them to drive naturally.

According to Chakraborty's research, from these tests, it may be broadly conjectured that visual distraction mostly manifests in difficulty in lane keeping, while cognitive load results in poor car following. Importantly, the reverse is not true, i.e., the drivers have no problem keeping to the lane boundaries when they are asked to perform memory intensive cognitive tasks and have no noticeable difficulties following a car when they have to take their eyes off the road for short but frequent durations.

These results are not entirely new, said Chakraborty, but, in the context of cooperative driving, these findings now hint at new possibilities of developing a driving framework that emphasizes dynamic task distribution. In such an interaction paradigm, humans and AI handle what they are each adept at and decrease the possibility of a conflict between the driver's intent and the machine's.

StART Awardee

Brett Compton

MECHANICAL, AEROSPACE & BIOMEDICAL ENGINEERING

As a high school student, Brett Compton wanted to be a race car driver. He was intrigued by internal combustion engines. Compton, now an associate professor of mechanical engineering, interned at Porsche while in college and discovered he was more curious about the materials used to make the engines than the engines themselves.

That, combined with a lifelong interest in pottery-making, helped lead him into materials science and mechanical engineering. His StART project involves trying to create ceramic materials with high damage tolerance.

"Ceramic materials maintain good strength and stiffness at elevated temperatures, but they're lacking in toughness or damage tolerance," he said.

Think about a coffee mug and a plastic cup: The coffee mug withstands high temperatures while the plastic cup melts. But if they're dropped, the coffee mug shatters, and the plastic cup bounces.

"It's a very tricky challenge to balance high strength and high damage tolerance, even more so at high temperature," Compton said, explaining that he's using precision additive manufacturing, or 3D printing, to create new damage tolerant hybrid ceramic materials for high temperature applications.

"One of the ways to improve damage tolerance is by adding in weak spots in a controlled pattern," he said.

A good example is a brick wall. Thanks to the architectural design – individual bricks surrounded by mortar – a crack is confined to zigzagging through the mortar rather than running straight through the bricks and destroying the wall.

Compton and his colleagues are using the brick-and-mortar wall concept. They plan to use additive manufacturing to aluminum oxide beams or "bricks," then infiltrate them with a "mortar" of phenolic resin that converts to porous carbon when heat treated.

They've started by printing and testing tiny aluminum oxide beams with the goal of making the smallest structures possible because they will be the strongest. Next, they'll add the resin "mortar" and repeat the strength tests.

"If we prove that this works in simple test cases, we can apply the same approach to design a wide range of components with enhanced toughness and excellent temperature stability," he said.

Compton said potential areas of application include power generation, aerospace, and transportation sectors.

His collaborators include Corson Cramer, a research and development associate at ORNL, and Shradha Agarwal, a research scientist in UT's Department of Nuclear Engineering. Compton's team is considering how the research might be applied to create materials resistant to neutron damage. They are preparing a white paper on their research in hopes of securing funding from the Department of Energy.

StART Awardee

Colleen Crouch

MECHANICAL, AEROSPACE & BIOMEDICAL ENGINEERING

Colleen Crouch, an assistant professor of mechanical and biomedical engineering, is using a StART grant to study the molecular biochemistry of the brain as it relates to Alzheimer's disease.

"Alzheimer's disease is the sixth leading cause of death in the United States and the fifth leading cause of death for Americans older than 65. It is a complex neurodegenerative disorder, and the exact underlying mechanisms for disease initiation and progression are not yet fully understood," said Crouch, who is working with Thanh Do, an assistant professor of chemistry; Rebecca Prosser, a professor of biochemistry and cellular and molecular biology; and Daniel Jacobsen, an ORNL computational biologist and an expert in artificial intelligence.

Experts have long thought plaques–protein clumps that disrupt cell function in the brain–caused Alzheimer's disease.

"But it has been shown that there are people who donate their brains to science who have plaques but were never diagnosed with Alzheimer's," Crouch said.

While plaques are likely a piece of the puzzle, it's possible that other factors flip the switch, causing a person to develop Alzheimer's.

"Our long-term goal is to distinguish the contribution of age and genetics on changes in brain biochemistry that lead to cognitive deficits in Alzheimer's disease," the team wrote in their StART grant proposal.

The team purchases mice that have been genetically modified to mimic the symptoms of Alzheimer's. The mice brains are harvested, flash-frozen to preserve the molecules, and then sliced into thin layers for examination.

They use computational algorithms to analyze data generated from mass spectrometry imaging, microscopy-guided single-cell mass spectrometry profiling, and spatial RNA sequencing from tissue sections to create a 3D map of part of the brain.

"To our knowledge, these three techniques have not been combined previously in aged and Alzheimer's disease mouse models," the team noted.

They are looking at RNA, proteins and peptides, lipids, and small metabolites, for molecular changes that may be associated with Alzheimer's or aging. And they are trying to determine if spatial and abnormal distribution of biomolecules play a role in Alzheimer's development.

Their findings could lead to more targeted diagnosis and treatment.

The team plans to apply for a National Institute on Aging grant for ongoing Alzheimer's research this fall and then pursue a second NIH grant for a project combining their Alzheimer's research with Crouch's studies on the impact of aging on the cardiovascular system.

StART Awardee

Doowon Kim

ELECTRICAL ENGINEERING & COMPUTER SCIENCE

Doowon Kim, an assistant professor in UT's Min H. Kao Department of Electrical Engineering and Computer Science, is trying to improve the security of connected and automated vehicles (CAVs).

The goal of CAV technology is to allow safe, fuel-efficient, driverless transportation through communications among vehicles or between vehicles and roadside infrastructures, such as traffic signals.

"Despite these advantages, security has not been the first priority in the CAVs' ecosystem," Kim explained in his StART proposal. "Adversaries can send forged, malicious information to nearby vehicles and infrastructures and inject malicious payloads to abuse the CAVs' ecosystem, resulting in wrong decisions and safety issues such as car accidents. Our research interest lies in solving security and safety problems in the CAVs' ecosystem."

Kim is working with Jinghui Yuan, a research and development associate in ORNL's Vehicle Systems Integration Research Group. They have three goals: develop a public key infrastructure (PKI), employ continuous verification systems using federated learning to detect malicious activities, and design a new secure firmware updating mechanism to prevent malicious firmware injection attacks.

"PKI is widely used in other fields (such as 5G and Transport Layer Security, or TLS) and is believed to provide the most secure authentication mechanism. However, the PKI is never considered in CAVs," Kim said. "Applying this mechanism to CAVs would be significantly challenging as CAVs do not have powerful computation powers. Therefore, we need to modify the PKI to be more efficient for CAVs."

To identify and remove malicious entities, "we plan to design and develop a system that logs activity and a machine learning model that actively and continuously verifies these activities," Kim said. Since traditional centralized machine learning is too slow to provide a real-time fix, they plan to use federated learning.

"This approach enables multiple entities to build a robust, efficient machine learning model without sharing data among all entities. Specifically, in each certain communication group, a representative entity is temporarily selected to collect logs from neighbor entities and build a federated learning model without introducing a delay for decision making."

Finally, they plan to design a new firmware updating mechanism based on the code-signing technique that uses the digital signature.

Kim and his team have already submitted additional funding proposals to the National Science Foundation and the Department of Energy. They also are seeking collaborations with various automotive companies.

StART Awardee

Eric Lass

MATERIALS SCIENCE & ENGINEERING

Aluminum-cerium (Al-Ce) eutectic alloys are very strong materials that are able to withstand high temperatures tolerated by heavier and more expensive materials, like stainless steel or titanium.

But Al-Ce alloys are so brittle that their commercial uses are limited.

Eric Lass, an assistant professor of materials science and engineering, is leading a StART project to learn how to make these strong, heat-resistant—and cheaper—materials more pliable so they can be more widely used in manufacturing.

Lass said Al-Ce alloys contain a mixture of relatively soft metallic aluminum and a much harder ceramic-like material, called an intermetallic, that contains aluminum and cerium.

"Al-Ce eutectic alloys exhibit very high strengths compared to conventional aluminum alloys," he said. "Further, they retain their strength up to about 450 degrees Celsius, whereas any other aluminum alloys lose all of its strength above about 200 degrees Celsius.

"But, because they contain a ceramic-like intermetallic, Al-Ce alloys tend to be brittle, and are not ductile," he said. "This means that they are difficult to bend or machine into useful geometries for commercial applications."

Lass and his team hope to engineer more ductile versions of the alloys which can be made into plates, sheets, bars, rods, wires, or other shapes.

"Many components in aerospace and space exploration must be made of steel or titanium due to the temperatures they experience. The successful development of an Al-Ce alloy that could be formed into a sheet for an aircraft skin, structural beam, or similar structure would decrease overall vehicle weight, increase cargo capacity or fuel efficiency, and at the same time reduce cost."

Lass is working with researchers at ORNL's Manufacturing Demonstration Facility.

"They are interested in understanding deformation behavior in Al-Ce to help them understand the mechanical properties they see in powder-based additive manufacturing (3-D printing) of Al-Ce alloys, as well as a potential means for producing wire material to use as feedstock for other additive manufacturing technologies," Lass said.

He will be working with NASA's Marshall Space Flight Center through the Materials and Manufacturing Joining Innovation Center, an Industry-University Cooperative Research Center supported by the National Science Foundation. Led by Ohio State University with UT Knoxville as a partner site, the project seeks to develop Al-Ce alloys that can be made in wire form for welding and additive manufacturing applications.

"We also recently submitted a proposal to the DOE Advanced Manufacturing Office with Lawrence Livermore National Laboratory and multiple industrial partners to look at developing wrought Al-Ce alloys (alloys produced through thermo-mechanical processing) for aerospace applications," he said.

Another proposal for an externally funded research project is forthcoming.

In addition, one of Lass's graduate students presented a poster at The Materials Society's 2022 annual meeting, and the team is producing its first paper.

StART Awardee

Joon Sue Lee

PHYSICS & ASTRONOMY

Joon Sue Lee, a UT assistant professor of physics and astronomy, is using StART funding to further his research on developing topological quantum materials—materials with nontrivial topology in the aspects of electronic wavefunctions. These materials could be the building blocks for future device applications, such as next-generation computer chips and quantum bits.

Lee is collaborating with ORNL staff scientist Matthew Brahlek on the project.

Sharing the expertise and technology available at UT and ORNL "will synergistically fill the gap of capabilities at each institution and enable faster turnaround time of planned experiments and deeper studies on the research topics," Lee said.

The project itself is intended to fill gaps in emerging science.

"Discovering novel features and emerging quantum phenomena has been of great interest in the research field of quantum materials. In addition, new functionalities of topological materials, leading to better electronics and computing devices such as spintronics and quantum computing, have been widely pursued by communities in science and engineering," Lee said. "In this project, we focus on the synthesis of high-quality topological materials with varying dimensions and lattice parameters to induce the novel quantum-mechanical features."

The researchers are synthesizing thin films and nanocrystals prepared by molecular beam epitaxy (an ultra-high vacuum technique for the layer-by-layer construction of thin films) with precise control over stoichiometry (studying the relationship between quantities of reactants and the products that exist before, during, and following chemical reactions) and doping (varying the number of electrons and holes for changing material properties).

"We will evidence the topological phase transitions and associated topological bound states, which are expected to be dissipation-less and can be used for energy-efficient device applications. This work will bridge the current gap between basic physics and applications for building new technologies," Lee said. "Various expertise of materials synthesis, characterization, device fabrication, and transport measurements will be combined in this project and future directions, which are essential for studies of quantum materials and emerging quantum phenomena."

The team plans to apply for future funding from the National Science Foundation and the Department of Energy.

StART Awardee

Rachel Patton McCord

BIOCHEMISTRY & CELLULAR & MOLECULAR BIOLOGY

Rachel Patton McCord, associate professor in UT's Department of Biochemistry & Cellular and Molecular Biology, is involved in a StART project looking at how chromosomes are folded into cells and how that configuration impacts the effect of radiation. The results could help improve radiation therapy to make it more effective in killing cancer cells while preserving healthy cells.

"A cell's sensitivity to radiation is in part affected by how the DNA is arranged in 3D inside the nucleus. To develop therapeutics that destroy cancer while minimizing damage to surrounding tissues, it is critical to understand, and even manipulate, how different cell types respond to radiation," McCord said in her StART proposal.

McCord's lab is the region's foremost expert in 3D genome structure, studying how two-meter-long chromosomes are packaged into 10-micron nuclei, and how that configuration affects cells, health, and disease. This StART project melds her work with ORNL's strength in radiotherapeutics and computational modeling.

McCord's ORNL partners on the StART project are Sandra Davern, head of radioisotope research and development; Greeshma Agasthya, a research scientist in artificial intelligence (AI) for health care; Anuj Kapadia, head of advanced computing in health sciences; and Debsindhu Bhowmik, a computational scientist and AI specialist. UT graduate student Heng Li is assisting with many of the experiments in McCord's lab.

During this project, McCord's team uses various techniques to change DNA folding and then test the impact of those manipulations. Using that initial data, the ORNL team then simulates radiation on the modified cells to predict impact. Subsequent work in McCord's lab looks at whether that predicted impact actually occurs.

The team started with skin cells and blood cells. Next, they'll use breast cancer cells and healthy breast cells.

"Through iterative prediction and experiment, we will reveal the relationship between 3D genome structure and cell radiosensitivity and identify structure manipulations that increase cancer susceptibility to radiation therapies," McCord said.

Their work may also help identify pre-treatments that sensitize the genome to radiation damage. It will also help scientists develop and improve predictive computational simulation models.

"We are poised to make an impact in understanding and manipulating cellular radiosensitivity," McCord said.

A paper about the ORNL computational work is forthcoming and the team is exploring opportunities to apply for additional funding from the National Institute of Health.

StART Awardee

Gila Stein

CHEMICAL & BIOMOLECULAR ENGINEERING

Gila Stein, Prados Professor and associate head of the Department of Chemical and Biomolecular Engineering, is looking for ways to make better, safer electrolytes.

Stein, an expert in X-ray scattering techniques for polymer characterization, is collaborating on this StART project with Yangyang Wang, from ORNL's Center for Nanophase Materials Sciences. Wang is an expert in broadband dielectric spectroscopy (BDS) and its applications in materials science.

"The rising energy needs of our society cannot be met without high-performing batteries," Stein wrote in her StART proposal. "These devices use electrolytes to transport ions between the electrodes. However, the organic electrolytes used in rechargeable lithium ion batteries are volatile and flammable, and the associated safety issues are an ongoing challenge for both consumer products and large-scale applications such as transportation."

Stein said polymerized ionic liquids (PILs) are an emerging class of non-volatile, non-flammable ion conductors that show promise as electrolytes for rechargeable batteries. The challenge with PILs is that there is a tradeoff between ionic conductivity and mechanical properties. An ideal electrolyte for lithium ion batteries should offer both high ionic conductivity to maximize electrochemical performance and also have high stiffness or strength.

One approach to "decoupling" ionic conductivity from mechanical properties is the synthesis of self-assembling "block copolymers" where PIL chains are linked to stiff thermoplastics chains. The resulting material could offer high ionic conductivity with good mechanical integrity.

"Block copolymers comprised of a polymeric ionic liquid linked to a non-ionic polymer are a class of 'safe' electrolytes with tunable mechanical properties," Stein said. However, recent work done by Stein's laboratory showed that ionic conductivity in these materials is significantly depressed relative to predicted values, posing a challenge for applications in energy storage.

"We hypothesize that this depression is a result of mesoscale defects that inhibit ion transport, local effects associated with molecular design, or a combination of these factors. We will implement systematic structure-function studies that provide a foundation to improve ionic conductivity through materials processing and/or molecular design."

Stein said that the simple objectives of this project will provide valuable foundational data for further grant applications.

The National Science Foundation, the Department of Energy, and the Army Research Office are among the agencies where the team could seek future funding.

"There are several potential funding mechanisms for this work, although which program we target will depend on the outcomes of preliminary studies," Stein said.

StART Awardee

Himanshu Thapliyal

ELECTRICAL ENGINEERING & COMPUTER SCIENCE

Himanshu Thapliyal, an associate professor in UT's Min H. Kao Department of Electrical Engineering and Computer Science, is using StART funding to work on ways to improve quantum computing.

Quantum computing uses quantum theory principles – employing modern physics to explain the way matter and energy behave at the atomic and subatomic levels – to solve problems too complex for classical computers. Quantum computing can be used for many complex tasks, such as drug design and development, cybersecurity, financial modeling, weather forecasting, and improving industrial logistics.

While scientists believe this evolving technology could revolutionize the way data is processed and stored, quantum computing is not without its challenges.

Quantum computers are very sensitive to "noise," environmental interactions that can erode the accuracy of the calculations. Much research is devoted to developing ways to lessen or correct this problem.

"Fully fault-tolerant quantum computation will take a significant amount of resources," Thapliyal said. "Therefore, one of the current focuses in quantum computation is to establish the utility of small scale, error-prone, or 'noisy intermediate-scale quantum' (NISQ), machines."

Through this StART project, Thapliyal is looking at the hybridization of quantum computing and "approximate computing," technology that is less accurate in computation, storage, and communication but offers better performance and energy efficiency. Such hybridization could make NISQ computers more resilient to factors that trigger errors.

"By using approximate computing, we can reduce the logical gates at the circuit level, or computational blocks at the algorithmic level, which are more prone to machine noise in quantum computing," Thapliyal said.

Thapliyal is collaborating with Travis S. Humble, director at the Department of Energy's Quantum Science Center, a Distinguished Scientist at ORNL, and director of the lab's Quantum Computing Institute.

The two met in 2017 at a colloquium lecture series at the University of Kentucky, where Thapliyal worked prior to coming to UT.

Thapliyal joined the faculty at UT in Fall 2021, creating "a serendipitous opportunity to formalize our collaboration and to establish a research program formally funded by a federal agency," Humble wrote in a letter included with the StART proposal.

Thapliyal and Humble said their collaboration could lead to joint funding opportunities through agencies such as the Defense Advanced Research Projects Agency (DARPA), the Army and Air Force, NASA, the National Science Foundation, and the Department of Energy. Thapliyal said the work also will help strengthen UT's quantum computing programs.

PACT AWARDEES

The Science Alliance was formed to build and enhance relationships between University of Tennessee, Knoxville (UTK) faculty and Oak Ridge National Laboratory (ORNL) scientists and engineers. In keeping with this rich history, the Science Alliance implemented the Program for Advancing Collaborative Teams (PACT) program to provide support for collaborative research endeavors aimed at securing large extramural funding, such as NSF Materials Research Science and Engineering Centers (MRSEC) or NIH RM1 grants.

Photo Courtesy of ORNL, Genevieve Martin

Wesley Hines & Khalid Hattar

NUCLEAR ENGINEERING

With help from PACT funding, UT is creating a world-class facility for ion-beam modification.

J. Wesley Hines, Postelle Professor, Chancellor's Professor, and head of the Department of Nuclear Engineering, and Khalid Hattar, director of the Tennessee Ion Beam Materials Laboratory (TIBML), are overseeing expansion of the lab. The PACT grant was used to buy a 300 kV ion implanter, which will arrive in 2024.

TIBML was built in 2012, but facility funding and leadership changes led to its closure in 2021. A committee was established to evaluate options for the lab's future.

"It was decided that there is both a local and national need for a facility with expanded capabilities. … University leadership is investing $2.5 million in a new director, operations manager, and commitments for a second beam line and advanced in-situ microscopy capabilities," Hines and Hattar wrote in the PACT proposal. "The requested investment from this proposal is to add a third accelerator (200-300 kV implanter), which opens up the range of ion species and energies that can be explored."

The end result will be a lab "that can compete with world-class facilities in ion beam modification with greater flexibility and the ability to accommodate more than one user at a time."

Hattar, formerly a research scientist at Sandia National Laboratories, was hired as the TIBML's director in January.

"Dr. Hattar presented a vision for the center to expand its capabilities and make TIBML one of the best and impactful facilities in the world competing with the Michigan Ion Beam Laboratory at the University of Michigan, Ion Beam Materials Laboratory at Los Alamos National Lab, the Ion Bean Laboratory at Sandia National Labs, and the Joint Accelerators for Nanosciences and Nuclear Simulation (JANNuS) facility at the University of Paris, Orsay, France," Hines said.

TIBML is already equipped with a 3 MV tandem accelerator, two ion sources, three beamlines, and four endstations that provide state-of-the-art capabilities for ion beam analysis, materials modification, fundamental research on ion-solid interactions, and applied research on radiation effects in materials for nuclear and space applications.

The implanter will be used for ion modification of materials. It strips electrons from ions and accelerates the remaining part of the atom through the surface of a material, implanting the atom into an exact region of the material. This allows scientists to tailor materials' internal structures at the nanometer level to create microelectronics used in devices such as cell phones, computers, and antennae. It also allows scientists to replicate and study radiation effects in materials for nuclear and space applications.

Lab use is available for a fee to UT and Oak Ridge National Laboratory researchers, as well as those from other universities, private industry, and other national labs. Users from at least 10 states are currently in the queue.

With TIBML enhancements like the implanter, "when it comes to tailoring materials or studying materials in extreme environments, UT is going to be one of the go-to places in the United States," Hattar said.

PACT Awardee

Nicole McFarlane

ELECTRICAL ENGINEERING & COMPUTER SCIENCE

Imagine if cells and computers could talk.

That might allow doctors to implant patients with a single programmed cell capable of measuring health data, such as blood sugar or hormone levels, and communicating those results in real-time. With no delay for tests or lab work, intervention could be immediate.

Nicole McFarlane, an associate professor of electrical engineering in the Min H. Kao Department of Electrical Engineering and Computer Science, is working on a Program for Advancing Collaborative Teams (PACT) program called "Towards Hybrid Biomicroelectronic Systems" that melds electronics and biology to create biological or environmental sensors that can measure, transmit, and receive information.

"These electronics give you the ability to communicate with the rest of the digital world," McFarlane said.

Biologists provide the precision: "Biology is way more efficient than anything electronic, so we're trying to harness the power of biology" by modifying cells so that they can monitor for specific stimuli, communicate information, and receive direction.

"Instead of replicating biology, we want to use it—and talk to it."

McFarlane is working with other scientists to devise this multi-layered technology.

"I am a circuit designer, not a biologist," she said.

Her collaborators include Steven Ripp, a research professor in the UT-ORII Genome Science and Technology program, who is creating cells that communicate via bioluminescence; and Staff Scientist Nickolay Lavrik and Distinguished Research Staff Scientist Scott Retterer, both with ORNL's Center for Nanophase Materials Science, who are working on nano-size electrodes that will provide the interface between the cells and the electronic circuits that McFarlane is designing.

First, the team is focusing on the science—creating cells that emit light when they encounter a certain stimulus (they're starting with a thyroid hormone) and outfitting the cells with circuits and electrodes to communicate that information to computers.

After that, the work will expand to other stimuli. And once the science is in place, they'll focus on wearable and implantable applications.

McFarlane said the team will try to secure external funding from the Department of Defense because military uses are possible and likely to come first. Medical applications, because they require extensive clinical trials and FDA approvals, are likely to take longer.

McFarlane was raised in Trinidad and came to America to attend college. She has a doctorate from the University of Maryland, College Park, and bachelor's and master's degrees from Howard University. She has been on the faculty at UT since 2010.

PACT Awardee

Dayakar Penumadu

CIVIL & ENVIRONMENTAL ENGINEERING

Hypersonic weapons – a new class of vehicles and missiles that are being developed to travel 5 to 25 times the speed of soundmust be built with materials that can withstand extreme environments and conditions.

Dayakar Penumadu, the Fred N. Peebles Professor and Institute for Advanced Materials and Manufacturing Chair of Excellence at UT, is using PACT funding for research into developing such materials.

"Hypersonic weapons achieve speeds in excess of Mach 5 during operation, resulting in extreme temperatures along the aeroshell. In some cases, these temperatures are sufficiently high to cause dissociation of airborne molecules into plasma, emphasizing the need for improved thermal management systems," Penumadu explained in his PACT proposal. "There is an urgent need to develop a new class of materials to withstand this extreme environment."

While many material solutions have been developed for hypersonic spacecraft, these vehicles spend significantly less time at hypersonic speeds in atmospheric conditions than is required for air-breathing guided hypersonic missile systems.

Penumadu's team plans to develop carbon/carbon face sheets with lightweight carbon or graphite foam core material, capable of insulating sensitive components while offering sufficient strength to handle extreme loading conditions without degrading.

"A concept using graphite and carbon foam core material in sandwich structures format will be developed and evaluated using appropriate high-temperature interface joining solutions. We also plan to explore through-thickness stitching using non-crimped fabrics for much-improved delamination properties, a critical need for mechanical applications, in addition to superior in-plane properties," he said.

Penumadu and Professor Uday Vaidya, the UT-ORNL Governor's Chair in Advanced Composites Manufacturing, are working with ORNL researchers who are developing new materials and technologies. They are also collaborating with industries, such as aerospace technology giant Lockheed Martin.

"We expect that this PACT grant will provide seed funding for much-needed basic materials and manufacturing innovation concept development in parallel for clients such as the Army," Penumadu said. "There is a very high interest at the national level in substantially augmenting this research capability, and the UT and UT-ORII ecosystem is uniquely positioned to respond to this national need."

DISTINGUISHED SCIENTISTS

The Science Alliance Distinguished Scientist Program supports high-profile joint leadership in research areas where UT and ORNL share complementary strengths. It has been the anchor program of the Science Alliance since 1984.

Distinguished Scientists hold tenured professorship at UT; most also hold a Distinguished Scientist appointment at ORNL, nominally half time at each institution. Appointments include an ongoing discretionary research fund equal to 12 months' salary.

Photo Courtesy of ORNL, Carlos Jones

Elbio Dagotto

Elbio Dagotto is a UT-ORNL Distinguished Professor of physics at UT and a Distinguished Scientist at Oak Ridge National Laboratory. He is a condensed matter theorist whose research primarily involves studies of the electronic properties of metals and ceramics, often employing numerical methods to explain the quantum mechanics of many particles. His work has impacted the quantum theory of solids and nanoparticles, especially regarding magnetic and conducting properties.

He is the principal investigator on "Theoretical Studies of Complex Collective Phenomena," a multimillion-dollar grant from the Department of Energy (DOE) Office of Science, Basic Energy Sciences, Materials Sciences and Engineering Division.

"Correlated electrons do things all together in states that are called 'collective,'" Dagotto explained. His theoretical work often leads to the discovery of unexpected states of matter where complex collective behavior emerges out of seemingly simple and natural interactions among electronic constituents.

Dagotto received the 2023 David Adler Lectureship Award in the Field of Materials Physics from the American Physical Society for "pioneering work on the theoretical framework of correlated electron systems and describing their importance through elegant written and oral communications." He also received the 2023 Alexander Prize from UT in recognition of superior teaching and scholarship.

Dagotto and his wife, Adriana Moreo, also a UT-ORNL joint faculty professor in theoretical condensed matter physics, run ORNL's Correlated Electrons Group. At present, Dagotto's group includes six postdoctoral fellows: Ling-Fang Lin, Yang Zhang, Nitin Kaushal, Pontus Laurell, Arnob Mukherjee, and Bradraj Pandey.

Takeshi Egami

Takeshi Egami, a UT-ORNL Distinguished Scientist/Professor in UT's Department of Material Sciences and Engineering with an adjunct appointment in the Department of Physics and Astronomy, explores new science involving liquids and gases. His work involves neutron and synchrotron X-ray scattering experiments using national facilities, including the Spallation Neutron Source at ORNL, and computer simulation with quantum mechanical calculations.

Some of Egami's recent work involves developing a new technique to observe atomic dynamics in real space and time using inelastic X-ray and neutron scattering. He is using this technique to determine the microscopic mechanism of ionic motion in water, electrolytes, and other liquids. His team is also developing a new theory of liquid and gas, based on simulation and experiment.

Egami continues to work on research funded by a Basic Energy Sciences grant from the Department of Energy that was renewed in 2021 for an additional three years, as well as by the National Science Foundation. Egami's team – which includes graduate students Leo Zella, Rudra Bahadur Bista, and Mariah Wakefield – is using the new X-ray and neutron scattering technique to help develop electrolytes with high ionic mobility for battery application.

Egami's research group also includes Research Associate Professor Wojciech Dmowski; ORNL staff members Yuya Shinohara, Eva Zarkadoula, and Chengyun Hua; and Jaeyun Moon, an ORNL postdoctoral fellow.

Expenditures from External Funding

PRINCIPLE INVESTIGATOR	PROJECT TITLE	FY 23 EXPENDITURES
Egami	DMREF: Collaborative Research	**$71,094**
Egami	Atomistic Study of Bulk Metallic Glasses	**$86,089**
Egami	CTR OF EXC-DIST SCI-EGAMI	**$354,455**

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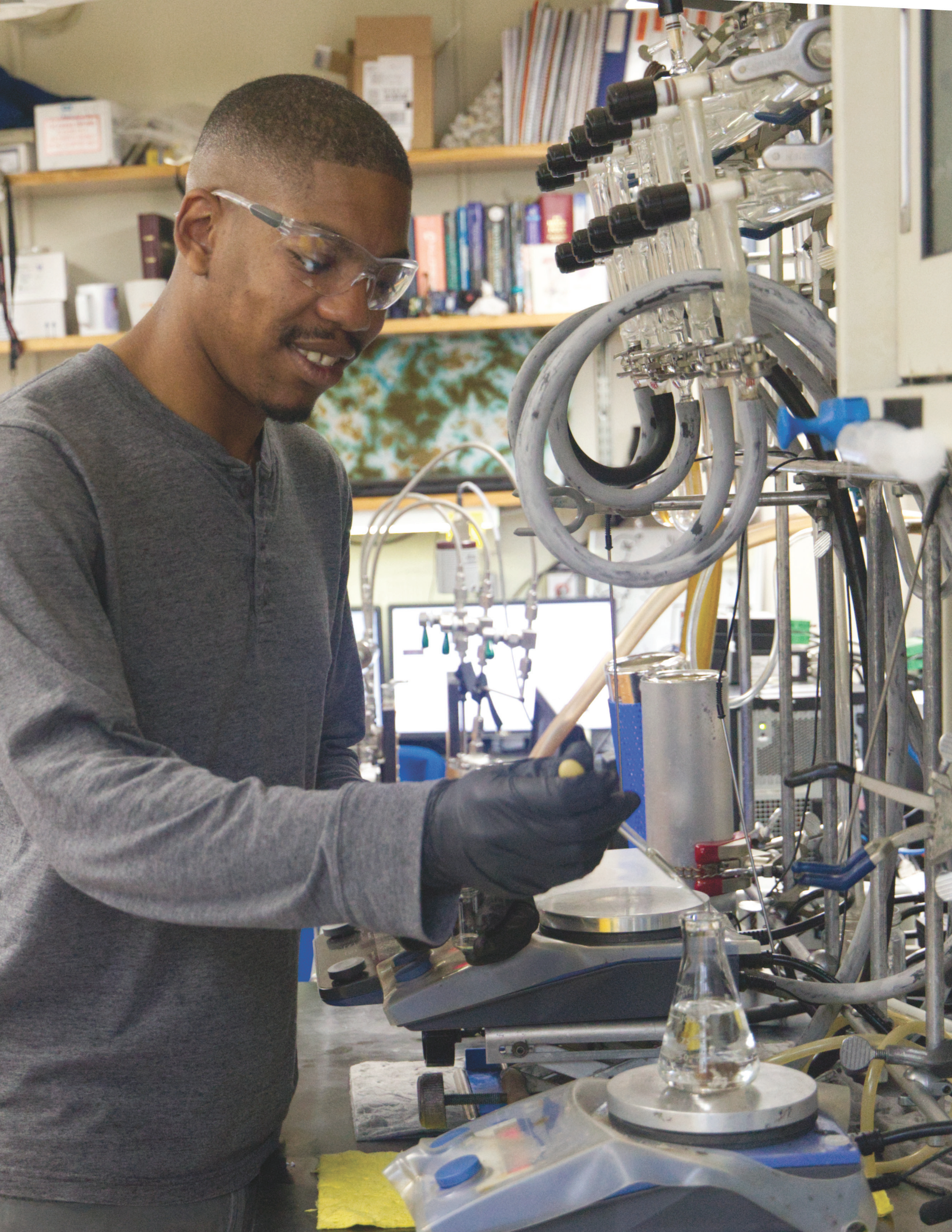

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