2018-2019 SCIENCE ALLIANCE ANNUAL REPORT

THE UNIVERSITY OF TENNESSEE KNOXVILLE
SCIENCE ALLIANCE

THEC State Appropriations Request 2018-2019

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EXECUTIVE SUMMARY

Shawn Campagna
Faculty Fellow for Research Development and Professor and Associate Head of Chemistry

The Science Alliance continues to be a critical component in the continued growth of the partnership between the University of Tennessee, Knoxville, and Oak Ridge National Laboratory. Our researchers are collaborating on large initiatives in materials science, biomedical sciences, high-performance computing, and bioenergy science, to name a few.

This year Steven Wilhelm, Kenneth and Blaire Mossman Professor of Microbiology and Joint Directed Research Development Fellow, was awarded a portion of a $3 million grant from the US Department of Energy. The grant was shared by Wilhelm and his colleagues at Duke University and ORNL and will facilitate the study of peat moss's ability to store carbon and the subsequent potential implications for the environment. This is in keeping with Wilhelm's work in the JDRD program.

In 2019, five faculty members with previous or current Science Alliance funding earned National Science Foundation CAREER awards, highlighting the importance of internal awards, like the JDRD program and others you will read about in this document, in the development of successful research on this campus.

Successes like these attract competitive faculty members, researchers, and the highest-caliber students to our university. In the past year Science Alliance programs supported more than 130 graduate students and 22 undergraduate students. Many of them authored publications, presented their research at meetings or conferences, or worked on sponsored projects. These students are working in the nation's leading scientific laboratories and learning how to apply for funding, putting them ahead of their peers.

To ensure the success of future scientists and researchers, we must reach out to students earlier in their educational careers. That is why the Science Alliance supports FIRST Robotics. The values espoused by FIRST support collaborative research, increased enrollment in higher education, and participation in STEM fields. The Smoky Mountain Regional competition is an opportunity for Tennessee's high school students to not only learn more about robotics, but experience collaborations in a competitive setting, preparing them for a future of collaborative work. This is the fourth year Science Alliance has provided support for this program.

This report is not only a summary of the past year's effort by our Distinguished Scientists, Joint Directed Research Development Fellows, project leaders, and team members to advance the research enterprise here at UT and with our partners at ORNL, but also a glimpse into the future of innovation in the state of Tennessee and across the nation.

SCIENCE ALLIANCE OVERVIEW

The Science Alliance is a Tennessee Center of Excellence, established in 1984, and supported annually by the Tennessee General Assembly.

The mission of the Science Alliance is to:

- Hire and support joint distinguished scientists of national note
- Create and support joint institutes
- Share resources
- Bring the University of Tennessee and Oak Ridge National Laboratory together to support technology transfer
- Build areas of common strength
- Provide incentives to attract and retain the highest quality faculty and students
- Strengthen educational opportunities
- Grow government and industrial support of the shared research enterprise

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.

Much of our current collaborative research emphasizes strategic areas of importance to both organizations. Advanced manufacturing, advanced materials and materials science, neutron science, computational science, big data and data science, and bioinformatics are currently among the most prominent UT-ORNL collaborative areas receiving support.

The investment made by the state each year in this important collaboration is greatly appreciated and is instrumental in allowing the Science Alliance to provide a variety of opportunities for innovative and groundbreaking collaborations between people. Great science and discovery come when people-to-people interactions are optimized, not unlike a chemical reaction. A reaction progresses because of interactions, and these funds support those interactions. They hold a decisive role in leveraging the federal investments made at ORNL and UT in our areas of collaborative research and development.

DID YOU KNOW?

Since 2015, the Science Alliance has provided support to **42** Joint Directed Research Development projects, **7** Distinguished Scientists, and more than **700** graduate student appointments.

GOALS AND FUTURE PLANS

The primary mission of the Science Alliance has always been to develop and support collaborations between the University of Tennessee and Oak Ridge National Laboratory.

With a solid foundation of decades spent working toward that end, the Science Alliance seeks to amplify that relationship with greater development and educational opportunities. Last year Professor and Associate Department Head of Chemistry Shawn Campagna joined the Science Alliance as the faculty fellow for research development, Science Alliance. The creation of this position has provided an opportunity to grow Science Alliance programmatic activities, increasing internal opportunities for both faculty and student research.

In keeping with the Science Alliance goal of creating educational opportunities for students, **the Student Mentoring and Research Training (SMaRT)** program was implemented in summer 2019. The SMaRT program is designed to bring together both graduate and undergraduate students for professional development and hands-on research training. Graduate students serve as mentors to undergraduate students for one year. During this mentorship, undergraduate students spend the summer working with UT researchers with ORNL affiliations. In faculty labs, students will gain skills and experience that prepare them for future research opportunities and careers.

The Science Alliance has a long history of supporting graduate students through 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 current students and will help recruit the next generation of scientists moving forward.

The Science Alliance strategic plan also includes a number of new programs designed to encourage and deepen collaborations between faculty and ORNL researchers, with an increased focus on outcomes and pursuit of external funding opportunities.

Given the success of existing collaborations between university and ORNL scientists, the Science Alliance will implement a new **Faculty Fellows** program. This program is designed to reward faculty by providing some of the benefits that are enjoyed by Distinguished Scientists through up to five fellowships.

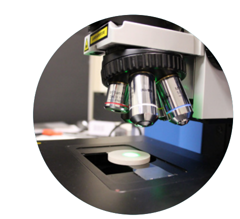
The Support for Affiliated Research Teams (StART) program will provide faculty funding for up to two years to explore first and new collaborations with ORNL researchers. Funded projects are expected to produce an external proposal in order to be eligible for second year funding.

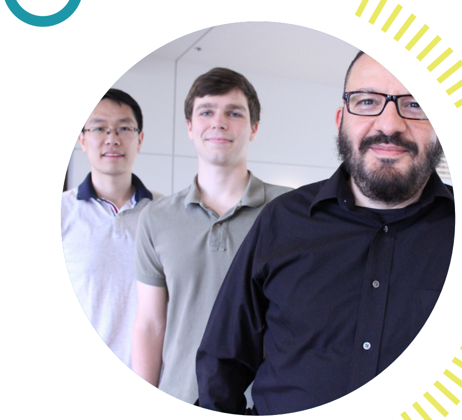
The **Joint Directed Research Development (JDRD) program**, one of the Science Alliance's long standing initiatives, will undergo a shift in focus for the next year. Historically the program has provided funding opportunities for university faculty members working collaboratively with ORNL scientists supported by the Laboratory Directed Research Development (LDRD) program.

Moving forward, the program will take a narrowed approach, focusing on a list of research areas that facilitate the strategic goals of both the university and the lab. Awards will support scientists for up to two years, pending a review process at the conclusion of the first year. The results of supported projects will continue to be presented to a university and ORNL audience at an annual JDRD Symposium event.

In addition to these initiatives, the Science Alliance will also implement a program designed to develop research communities that will foster greater interactions between UT and ORNL and lead to increased meritorious research. The **Partnership and Collaborative Teams (PACT)** program will fund joint activities such as seminar series, poster sessions, and novel pilot projects for up to three years.

Over the next year, the Science Alliance will implement these programs to better serve university faculty and students and to integrate with the efforts of the Oak Ridge Institute (ORI). These initiatives will translate into global scientific and economic impacts, intellectual capacity development, and a prepared future workforce for Tennessee, while deepening the ties between the university and ORNL through new and well-developed collaborations. These partnerships will aid the university in the joint development and acquisition of talented scientists and engineers as well as continuing to provide consistent graduate student support in arenas of global interest.



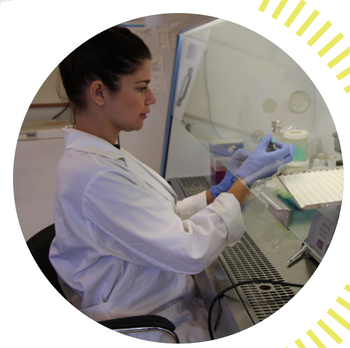


MISSION STATEMENT

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.
Science Alliance objectives:

- Create a strong formal bond between UT and ORNL
- Hire joint UT-ORNL distinguished scientists
- Create joint UT-ORNL institutions
- Share resources and build areas of common strength at UT and ORNL as well as with industry and other institutions
- Contribute to technology transfer
- Provide incentives to attract and retain high-quality faculty
- Strengthen graduate and undergraduate opportunities
- Increase public and professional awareness of UT-ORNL partnerships

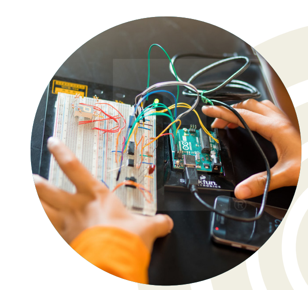


DISTINGUISHED SCIENTISTS

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.

In the future, we intend to explore Distinguished Scientist positions that are co-supported by endowments from our corporate research and development partners. This structure may allow us to amplify the investments made by the state and ORNL in areas of interest to our key industrial research and development partners.



ELBIO DAGOTTO

Elbio Dagotto, a Distinguished Scientist in UT's Department of Physics and Astronomy and ORNL's Division of Materials Science and Technology, primarily uses computational techniques to study transition metal oxides, oxide interfaces, and the recently discovered iron-based high-temperature superconductors. These materials and others studied by his group show promise for both technological applications and advancing fundamental concepts in condensed matter physics.

Dagotto has several active collaborations with ORNL scientists working with materials from manganese oxides to iron-based high-temperature superconductors. Additionally, he serves as principal investigator of a US Department of Energy field work proposal, *Theoretical Stidies of Complex Collective Phenomena*, which secured a grant from the DOE that awarded $2 million over 18 months to ORNL.

TAKESHI EGAMI

Takeshi Egami, director of the UT-ORNL Joint Institute for Neutron Sciences and a Distinguished Professor in UT's Deptartment of Material Sciences and Engineering, explores new science involving liquids and gases. His work involves computer simulation (including quantum mechanical calculations) and neutron and synchrotron X-ray scattering experiments.

Egami is currently participating in a number of active collaborations with ORNL scientists, including DOE projects whose annual budgets total more than $2.7 million. His work has been repeatedly highlighted by the DOE in the past year.

Egami was recently named an Aris Phillips Lecturer, the most prestigions award given by the Department of Mechanical Engineering at Yale University. He serves as editor of *Advances in Physics* (a position he has held since 2011) and editor in condensed matter physics for *Physical Reciew Letters*.

CLAYTON WEBSTER

Clayton Webster's research interests include approximation theory, numerical and functional analysis, and high-performing algorithms, with particular focus on large-scale applications. Webster is head of the Department of Computation and Applied Mathematics at ORNL and a Distinguished Professor in UT's Department of Mathematics. He also holds a joint appointment in the UT-ORNL Bredesen Center for Interdisciplinary Research and Graduate Education. He was previously the director of quantitative analysis and trading at NextEra Energy Power Trading LLC.

Webster was awarded the John von Neumann Fellowship by Sandia National Laboratories in 2007, and the National Academy of Sciences named him a Frontiers of Science Fellow in 2014.

EXTERNAL FUNDING

Prin Inv	Project Title	FY19 Expenditures
Dagotto	Study of Multiorbital Hubbard Models for Iron-Based Superconductors and Spin-Orbit Coupled Transition Metal Oxides Using the Density Matrix Renormalization Group Technique	$80,679
Egami	Dynamics of Biologically Relevant Model Membrane Systems	$116,889
Egami	Neutron Scattering Study of Disordered Materials under Pressure	$51,611
Egami	Atomistic Study of Metallic Glasses	$408,050
Egami	Fluid Interface Reactions, Structures and Transport (FIRST): Energy Frontier Research Center	$54,237
Webster	Collaborative research: Mathematical Methods for Approximation and Control of Multidimensional Parameterized Systems	$17,670

DID YOU KNOW?

75% of funded JDRD researchers used their work as the basis for external proposals. **80%** of those researchers received funding for these proposals.

JOINT DIRECTED RESEARCH DEVELOPMENT

The Joint Directed Research Development (JDRD) program offers an opportunity for collaborative research with ORNL.

A dual UT and ORNL venture, JDRD complements the Laboratory Directed Research Development (LDRD) program and ORNL Seed Money Fund. The LDRD is a US Department of Energy program that encourages multi-program DOE laboratories such as ORNL to select a limited number of projects with the potential to position the lab for scientific and technical leadership in future national initiatives.

The ORNL Seed Money Fund provides a source of funding for innovative ideas that have the potential to enhance the laboratory's core scientific and technical competencies and provide a path for funding new approaches that fall within the distinctive capabilities of ORNL but outside the more focused research priorities of the existing major initiatives. The JDRD program identifies and supports corresponding areas of research at UT, and projects approved for the program have both a UT and ORNL component.

JDRD awards run for up to two calendar years. A progressive assessment at the end of year one determines if second year funding will be awarded, based on the partnership development research progress thus far.

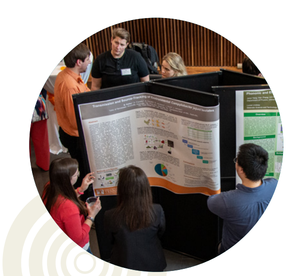
JOINT DIRECTED RESEARCH DEVELOPMENT SYMPOSIUM

In February 2019, the Science Alliance hosted its first-ever Joint Directed Research and Development Symposium. The symposium brought university researchers together with ORNL collaborators to create an outcomes-driven event showcasing the work of the JDRD cohort.

Held in the Ken and Blaire Mossman Building, a new facility on campus designed as a collaborative space for researchers, the event began with a one-hour poster session. The building lobby hosted 10 poster presentations describing first-year JDRD projects, many of them done by students affiliated with the projects.

In the second hour of the event, three faculty members with second-year projects worked in conjunction with their ORNL collaborators to present the results of their research. These included Jeremiah Johnson, assistant professor of microbiology; Maik Lang, associate professor of nuclear engineering and Pietro F. Pasqua Fellow; and Seungha Shin, assistant professor of mechanical, aerospace, and biomedical engineering.

Attendees included university faculty, staff, students, and administrators, as well as researchers and administrators from ORNL. Science Alliance plans to continue hosting an annual JDRD Symposium to bring greater attention to the accomplishments of JDRD PIs, collaborators, and students. Future events may expand to provide information about upcoming calls to prospective proposers.



BARRY BRUCE

Breakthroughs in technology can come from unexpected places. In some instances discoveries are made accidentally, as in the case of penicillin. Sometimes new developments in a field are the result of trying something new or imagining a new application for an established process or technology. In the case of the JDRD work being done by Barry Bruce, professor of biochemistry and cellular and molecular biology, it is both of these.

Bruce's work focuses on photosynthetic protein complexes—most recently on purifying these large membrane proteins by removing them with an industrial polymer, which has proven effective at a significantly reduced cost from previous methods of protein isolation. Bruce realized that this new method of protein extraction could be applied to another area of his research: solar energy.

"We started to extract these protein complexes. We used an expensive detergent and a mild metallization protocol and realized if we shone a light on isolated complexes we could make hydrogen, and the hydrogen would accumulate as long as you were shining the light on them," said Bruce. He wondered if the same protein complexes could be integrated into biohybrid solar cells—solar cells composed of elements of both biology and materials science. Traditional solar cells are built using minerals such as ruthenium and cadmium that are not abundant in nature. Bruce hopes the photosynthetic properties of plants can be harnessed to create cheaper, more efficient cells.

"Photosynthesis is really the energy driving metabolism for our plant. Most of the work in biofuels is really still photosynthesis," he said.

The project's first year has led to the publication of two papers, with a third currently under revision and a fourth in the final stages of preparation.

Moving forward, Bruce hopes to use neutron reflectometry at the Spallation Neutron Source at ORNL to further characterize how these polymers interact with biological membranes. Additionally, he and another faculty member, Associate Professor of Chemistry Brian Long, are working on a joint external proposal building on Bruce's JDRD work and Long's polymer expertise.

JAMIE COBLE

In 2011, when Japan experienced a massive tsunami and subsequent meltdown at the Fukushima Daiichi nuclear plant, renewed attention to nuclear safety swept the globe. There are more than 450 nuclear reactors on the planet—many of them built more than 40 years ago, before the discovery of some of the potential environmental dangers that are known today. Many of Japan's nuclear reactors, for example, were built in the 1970s and are perched on the coast.

With an increased focus on nuclear safety, research has turned toward the development of accident-tolerant nuclear fuels. Testing these fuels, however, is difficult. Current methods put a fuel into a test reactor, irradiate it for a period of time, take it out, and evaluate it, providing a limited amount of data exclusively from the end points of the experiment.

Jamie Coble, associate professor of nuclear engineering and Southern Company Faculty Fellow, hopes to change this. Her JDRD work is currently focused on building a sensor to collect data on nuclear fuels while they are in the reactor, providing a much clearer picture of what is happening in the experiment.

"This is very challenging to do for a number of reasons. It's a high-radiation, high-temperature environment. It's also very tight, so there's not a lot of space to put in a big, bulky sensor," said Coble.

To address these limitations, Coble's team worked to develop a sensor that was capable of surviving the extreme conditions inside the reactor and small enough to fit inside the available space. The completed sensor fits around a fuel rod like a ring or cuff and measures any dimensional changes taking place as a result of the irradiation.

In the first year of Coble's JDRD work, her team identified appropriate materials from which to construct the device, conducted modeling and simulation, and designed and built both the sensor and a testing apparatus to conduct initial experiments.

"Our initial results look really good. We're getting different enough measurements that we can actually differentiate some changes in the material," said Coble. "In the first year I feel like we got pretty good agreement between our simulations and our experimental results."

Coble plans to take her sensor to ORNL for testing with collaborators there, which may require some alterations to accommodate a different experimental system. She hopes to present the team's progress at an upcoming meeting of the American Nuclear Society.

MARK DEAN

As long as there have been computers, they have been compared to the human brain. The brain has enormous computational power, with some estimates suggesting the equivalent of billions of calculations per second.

Modern high-performance computing systems—often called supercomputers—have caught up to the brain in terms of speed and storage capacity. However, the brain remains a more efficient machine, with very little energy cost to the body, while high-performance computing systems require a tremendous amount of energy to operate. The brain also maintains an edge in terms of flexibility and the ability to learn. Enter neuromorphic computing.

"Neuromorphic computing uses the model of the brain to build systems," said Mark Dean, John Fisher Distinguished Professor in the Min H. Kao Department of Electrical Engineering and Computer Science. "It uses neurons and synapses, which are common in biological systems, to do computation and transfer information."

According to Dean, neuromorphic computing has the potential to significantly reduce power consumption and take on more complex functions—and even to increase the complexity of problems a computer can manage.

"Our goal is not to replicate the brain but to learn from what we know and build a computer that is much more efficient, has much more scalability, and can solve problems that are difficult for computers to solve—like watching a video and identifying a person in that video. Humans can do that, but computers have a hard time with those kinds of applications," said Dean.

In its first year, Dean's JDRD team worked to develop a scalable neural network structure using a neuromorphic array communications controller and a second-generation dynamic adaptive neural network array applied to an autonomous robot. Graduate student Aaron Young has demonstrated the scalability and flexibility of this structure and plans to submit a publication on his findings in the next year.

By the end of this funding year, Dean hopes to have created a neural network with the ability to scale up from small applications to large systems like high-performance computers.

SEDDIK DJOUADI

Renewable energy has been an expanding area of research for decades now, but relatively little energy from renewable sources is in use today. New energy sources require new infrastructure with enormous up-front expenses, presenting a significant barrier to their adoption. One way to circumvent this expensive setup is to integrate new energy sources into the existing infrastructure, but doing so requires some innovative problem solving.

A good example is the power grid itself. As it stands, the grid is not equipped to effectively deal with the difference between existing energy sources, such as that between fossil fuels and renewables. This is where the work of Professor of Electrical Engineering and Computer Science Seddik Djouadi becomes important.

"This project is about improving the performance and stability of the future power grid," said Djouadi. To integrate renewable energy sources into an existing grid, he explains, power electric converters must be used to manage variability between energy sources.

There are systems in place doing this already, but Djouadi thinks they could be better. His JDRD project is focused on designing more effective controllers for these power converters. In its second year, the work is focusing on computational features to help ensure the stability and safety of the future power grid.

"These power converters introduce what's called discrete dynamics—they switch between different modes of operation—but the grid is working in a continuous mode. When it is combined with power converters there is also switching, and this creates a lot of problems in integration as far as stability and performance are concerned," said Djouadi.

Djouadi likens this to driving a car with a manual transmission: a driver shifts gears while driving to speed up and slow down. This shift from one mode to the next is essentially discrete dynamics. In a power grid, shifting between energy sources disrupts the way the existing system works, introducing potential issues.

As more renewable energy sources are integrated into the existing power grid, Djouadi's work has the potential to provide tremendous benefits.

"Five to 10 years from now I would say we'll have high penetration of renewable energy resources, and the benefit is obvious. It impacts everyone," said Djouadi.

SARAH LEBEIS

As technology and modern medicine continue to advance, the human microbiome is becoming less mysterious. Most people now understand that their bodies are populated by a variety of different bacteria, many of which support bodily functions like digestion. In recent years this microbiome has been linked to any number of conditions, including arthritis and obesity. Attempts at managing the microbiome, including the use of probiotic supplements, have also increased despite an incomplete understanding of how they work or whether they are effective.

Like humans, plants play host to a microbial community that is believed to affect their health in any number of ways. Some agriculture companies have begun producing and selling products designed to encourage the growth of so-called good microbes in plants. These products, however, are not always effective.

Sarah Lebeis, assistant professor of microbiology, believes the missing piece of this puzzle relates to the effect of certain bacteria on plant microbiomes. Her work has the potential to explain why some products designed to help plants grow are ineffective, and it may even illuminate a path toward more consistent success with these products.

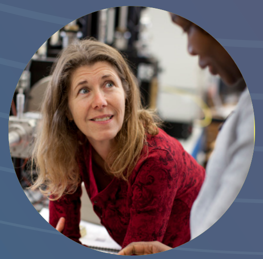
"What we'd like to do is define if these particular bacteria play a role that might prevent good bacteria from coming in. They'll prevent the pathogens from coming in, but do they also prevent the good bacteria from coming in, and can we figure out ways to make the good bacteria compatible?" said Lebeis.

In the first year of her project, Lebeis's JDRD team focused on *Streptomyces*, a particularly large genus of bacteria, and how it may be affecting the microbes allowed into a plant. For the second year, the project is shifting focus to a different genus, *Pantoea*.

"We're really interested in how microbes can help plants to grow. So what's cool about having these two subsequent JDRD years is it's allowing us to look at different types of bacteria that can colonize plants and then also shape what communities become," said Lebeis.

Her team has already experienced several positive outcomes from the work, including a Community Science Project grant from the Joint Genome Institute in the US Department of Energy. One of the students working on the project received a National Science Foundation Graduate Research Fellowship Program award, making room for Lebeis to support another student to join her team.

Lebeis plans to use her JDRD results as proof of concept to pursue continued funding for the work.



CLAUDIA RAWN

Experimental research is dynamic. Sometimes everything happens just as it was modeled or predicted. Sometimes experiments have surprising outcomes or complications—but these complications can lead to new competencies and stronger outcomes.

Claudia Rawn, associate professor of materials science and director of the Center for Materials Processing, encountered one such issue while working on her current JDRD project. Rawn's project investigates the impact of molten salts on chromium-containing alloys, work that requires a controlled environment.

"When I wrote the proposal, I had no appreciation for how much water some of the materials take out of the air," said Rawn. "We're taking a lot of care to keep water out of our system, so that requires a glove box and sealed ampules—starting materials that have been handled very carefully."

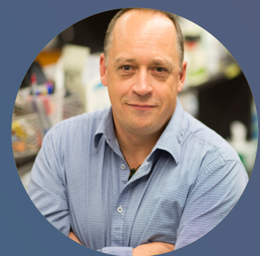
Because of this unexpected complication, Rawn's research has branched out from her original plan to include measuring how much water is actually taken in by some of the compounds she's working with. This new direction has led to additional training and competencies for the students working with Rawn on the project.

"The students that worked for me previously didn't have experience using a glove box or having to carefully control everything. Everything they made they could just make in air. They've really gained expertise and they can now do this kind of detailed synthesis where exposure to the atmosphere can cause differences," said Rawn.

Rawn's JDRD work has supported the efforts of her ORNL collaborator, Stephen Raiman, a research associate in corrosion science. Raiman is investigating chromium in structural materials that come into contact with molten salts in places like nuclear and concentrated solar reactors.

"The molten salt is in contact with different structural components, and there is concern about the chromium leaching out into the salt," says Rawn. While Raiman's team has been investigating the interactions between molten salts and these structural alloys, Rawn's team has focused on the salts themselves.

To study the salts, Rawn and her team have made use of the diffraction facility at the UT-ORNL Joint Institute for Advanced Materials. The team has also consulted with researchers at the Simulator Materials Research Center at ORNL on the water issue. Rawn hopes the project will conclude with a strong external proposal and the opportunity for further investigation.



STEVE WILHELM

Microbiology, or the study of microorganisms, has been a growing field since microscopes revealed the existence of these tiny organisms. Microbes have been shown to have far-reaching impacts that affect a number of functions of the human body, plant and animal waste decomposition, and more. They are now widely recognized as an important element of life on earth.

Steven Wilhelm, Kenneth and Blaire Mossman Professor of Microbiology, believes there may be another community that plays an important role on the planet but is overlooked as microbes once were: viruses.

"We've known for 25 to 30 years that there are literally hundreds of thousands of viruses in every drop of water, be it ocean water, river water, or puddles that form after rainstorms," he said.

Despite this abundance of viruses, Wilhelm says, they are quite fragile and must reproduce quickly to maintain their large population. The way viruses do this is typically by killing things and making new viruses. Wilhelm believes viruses are doing this in microbial communities, impacting the health and size of those communities.

"We became engaged because we were curious about what types of processes could be controlling microbes other than chemistry, and in my lab that's usually viruses. Our goal is to begin to understand the effect these viruses are having on the microbial community. Are they controlling some members of the community? All members of the community? Are they doing nothing at all? We are really trying to quantify and understand what may be happening in terms of the biology," said Wilhelm.

In the first year of Wilhelm's JDRD project, his team gathered enough preliminary data to generate a publication in the *Journal of Applied Environmental Microbiology*. He describes the results of this data analysis as exciting, as they not only confirm the presence of a great deal of viral activity but also point toward the potential importance of viruses infecting single-cell organisms.

"We typically look at viruses that infect the dominant species, but we started to notice that there were these other viruses that were very abundant, but they should be infecting the much less dominant species," said Wilhelm. "It made us start to think that what these viruses are doing is repressing these organisms that would otherwise take over."

A team including Wilhelm, his collaborators Dale Pelletier and David Weston, senior staff scientists in ORNL's Bioscience Division, and two colleagues from Duke University—Assistant Professor of Biology Jean Philippe Gilbert and Professor of Biology Jonathan Shaw—was recently awarded $3.1 million by the US Department of Energy. They plan to leverage the unique skill set of each partner to further investigate the impact of viruses on the microbial community. Wilhelm credits the work on his JDRD project for his contribution to this proposal.

STUDENT SUPPORT

STUDENT MENTORING AND RESEARCH TRANING

In an effort to deepen Science Alliance's existing commitment to student support, this year saw the implementation of a new program for both undergraduate and graduate students. The Student Mentoring and Research Training program (SMaRT) provides opportunities for undergraduate students to engage in a year-long mentored research experience that includes an intensive 10-week summer research internship performing a collaborative project with UT and ORNL faculty and staff.

Beginning in spring 2020, undergraduate students participating in SMaRT will receive mentorship from graduate students supported by the program to both prepare them for the summer and help with dissemination of the work afterward. Presented in partnership with Tennessee Louis Stokes Alliance for Minority Participation, Student Support Services, and the Office of Undergraduate Research, SMaRT serves to provide hands-on experience to undergraduate students in a national laboratory setting.

SMaRT UNDERGRADUATE SUPPORT

Department	Total Support	# of Students
Biochemistry & Cellular and Molecular Biology	$10,632	2
Mechanical, Aerospace & Biomedical Engineering	$10,549	2
Electrical Engineering & Computer Sciences	$4,746	1
Nuclear Engineering	$15,697	3
Chemical & Biomolecular Engineering	$10,549	2
Physics	$16,040	3
Neuroscience	$5,275	1

FIRST ROBOTICS

For Inspiration and Recognition of Science and Technology, or FIRST, was founded in 1989 as a non-profit organization devoted to encouraging young people to participate in science and technology.

FIRST's programmatic activities include Lego League, Lego League Jr, and Tech Challenge, but the organization is most readily recognized for its international Robotics Competition.

As in previous years, this year's participants were required to form alliances consisting of three teams. Entitled "Destination: Deep Space," the 2019 competition required teams to design and construct robots capable of performing specific mechanical tasks. Robots were required to operate autonomously from a set of pre-programmed instructions for the first 15 seconds of the competition, leaving two minutes and 15 seconds for operator controlled activity.

The robotics competition held in Knoxville is a perfect model of FIRST's core value of "gracious professionalism." Gracious professionalism is the notion that students can learn and compete with one another fiercely, while still treating one another with respect. In addition to nurturing the next generation of scientists, FIRST's practices and values engender the characteristics that make good collaborators.

Collaboration between researchers is the bedrock of the Science Alliance's programmatic activities. For the last three years the Science Alliance has provided support to the Smoky Mountain Regional FIRST Robotics Competition as a means to foster the future of collaboration in East Tennessee and encourage student participation in STEM fields. In fact, approximately 75% of FIRST Robotics alumni are either students or professionals in a STEM field.

FIRST ROBOTICS CONT.

This year's winning alliance consisted of one team from Tennessee, the Secret City Wildbots from Oak Ridge, one of 2018's winning teams, a team from West Virginia and a team from Florida. Of the 28 additional awards given to teams, 12 of them were secured by Tennessee teams, most of which were from the greater Knoxville area. Six teams from Tennessee advanced to the world championships held in Houston, TX.

This year's competition also saw the inclusion of a submission from a FIRST Robotics alumni team from the University of Tennessee, Knoxville; Big Orange Robotics. Big Orange Robotics, as a team composed of college students, participated as a Robot in 3 Days (Ri3D) team. Ri3D teams build robots to the same specifications as other regional teams. However, they complete their robot from start to finish in 72 hours.

The impact of the FIRST Robotics program is undeniable, with research showing 88% of participants are more interested in doing well in school. The Science Alliance's activities encourage collaboration as a model for future innovation in research. The work of FIRST and the FIRST Robotics Competition, by laying the groundwork for a future generation of collaborators, is a natural step toward that model for innovation. Providing support to the FIRST organization helps offer a wealth of opportunities to young students in the state of Tennessee and contributes directly to the future of innovation and research.

DID YOU KNOW?

Science Alliance funded graduate students helped generate more than **50** publications in the last year across a range of disciplines including chemistry, physics, and electrical engineering.

GRADUATE STUDENT SUPPORT

Integral to the charter of the Science Alliance is this principle: Science Alliance funding will be used to "provide incentives to attract and retain the highest quality students and strengthen the educational opportunities for both UT and ORNL." Consequently, each year a portion of the Science Alliance's funding is distributed directly to two colleges within the university with the express purpose of supporting graduate education and research. As a result, many students have had occasion to add significantly to the foundation of their future careers through direct support provided by Science Alliance programs.

Tyler Naughton, master's student working with Jamie Coble, has not only been first author on a publication, but also had the opportunity to present his work with Coble at the 2019 International Conference on Nuclear Plant Instrumentation and Control and Human-Machine Interface Technology (NPIC-HMIT) in Orlando.

Mark Dean's student, **Aaron Young**, continued his work with the JDRD program for Dean's second year of funding. This allowed Young to successfully simulate a multi-arry neuromorphic computing system, providing him a level of proficiency in an emerging research area.

Bridget O'Banion is a PhD candidate working with JDRD supported researcher Sarah Lebeis. O'Banion's work on the JDRD gave her experience with a number of experimental techniques. She was selected to speak at two international conferences and was a awarded a prestigious National Science Foundation Graduate Research Fellowship. Her work and experience with the JDRD program will serve as the foundation for her research for the fellowship.

Barry Bruce's JDRD project supported several graduate students. One student, **Nathan Brady**, was recognized at the international Styrene Maleic Acid Lipid Particles (SMALP) conference for the top student talk and is currently completing three papers based on his work with the JDRD project.

Alex Teodor, another of Bruce's graduate students, was selected for the top graduate student presentation at the 70th International Society of Electrochemistry. He, along with Brady, received training in robust control methods, model reduction techniques, and simulation generation with Matlab and Simulink software.

Many Science Alliance funded graduate students are actively collaborating with ORNL scientists. They have earned additional funding for their work from a variety of sources, including the National Science Foundation, the Department of Energy, and NASA. Many of them also serve as mentors to the undergraduate students on their teams. The contributions made by these scholars not only prepare them for future careers, but also serve to ensure a foothold for the University of Tennessee, and the State of Tennessee, in the future of the nation's scientific community.

GRADUATE STUDENT SUPPORT BY DEPARTMENT

Department	Total	# of Students	Highlights
Biology	$303,269	33	Supported students co-authored 12 publications and made more than 10 conference presentations. More than 80 percent of students developed or maintained an ORNL affiliation; of those, two worked with the National Institute for Computer Sciences and one at the Spallation Neutron Source. Awards include the Rockefeller University Travel Award, the Ecological, Evolutionary and Conservation Genomics Award from the American Genomics Society, and others.
Chemistry	$156,119	32	Chemistry students supported by Science Alliance had multiple ORNL and governmental affiliations, including with DOE, NSF, and NIH. They co-authored more than 15 publications; one student received the Excellence in Polymer Graduate Research Award at the American Chemical Society national meeting.
Earth & Planetary Sciences	$37,548	7	Funded students co-authored three publications and made five meeting or conference presentations. All students have external affiliations or funding sources including ORNL, NSF, DOE, NASA, and the US Army. One student was awarded the Grant A. Harris Fellowship by METER Group USA in the amount of $10,000 for research instrumentation.
Electrical Engineering & Computer Sciences	$93,396	14	Supported students maintained both governmental affiliations, such as with DOD, NSF, and USDA, and industry affiliations with Applied Research LLC, Intel Corp, and Cree Fayetville Inc. These students co-authored eight publications and one poster. One contributed to a US patent.
Mathematics	$97,795	18	All funded mathematics students engaged in an ORNL affiliation. This group of students helped generate four publications and seven conference or meeting presentations.
Physics	$222,500	25	Supported students co-authored eight publications and made seven conference or meeting presentations. Additional students attended professional conferences. All but the first-year students engaged in relationships with ORNL or a UT-ORNL joint institute. One student received the NSF Nanoscholar II Scholarship.
Psychology	$10,022	1	The single supported student co-authored three publications and was awarded the Chancellor's Citation for Extraordinary Professional Promise. The student also served as a NeuroNet Brown Bag Spring Seminar Series lecturer.

UT-ORNL JOINT INSTITUTES

UT-ORNL JOINT INSTITUTE FOR ADVANCED MATERIALS

The Joint Institute for Advanced Materials promotes interdisciplinary research and education related to developing new materials with superior properties, such as greater toughness and high-temperature strength, or those that can be tailored to support new technologies, such as pocket-sized supercomputers.

UT-ORNL JOINT INSTITUTE FOR BIOLOGICAL SCIENCES

The Joint Institute for Biological Sciences supports interdisciplinary, crosscutting research that accelerates progress in complex bioenergy and bioenvironmental systems. It also aids access by UT-ORNL faculty, staff, and students to state-of-the-art capability in genomic, transcriptomic, proteomic, and metabolomic analysis of biological and environmental systems.

UT-ORNL JOINT INSTITUTE FOR COMPUTATIONAL SCIENCES

The Joint Institute for Computations Sciences (JICS) advances scientific discovery and state-of-the-art engineering and computational modeling and simulation. JICS takes full advantage of the petascale and beyond computers in the DOE National Center for Computational Sciences and UT's National Institute for Computational Sciences.

UT-ORNL JOINT INSTITUTE FOR NUCLEAR PHYSICS AND APPLICATIONS

The Joint Institute of Nuclear Physics and Applications links UT, ORNL, and Vanderbilt University research to promote and support basic nuclear physics research and nuclear and radiological applications of common interest to the participants.

UR-ORNL SHULL WOLLAN CENTER, A JOINT INSTITUTE FOR NEUTRON SCIENCES

The Shull Wollan Center promotes worldwide neutron scattering collaboration among researchers in biological and life sciences, energy sciences, polymer science, condensed matter physics, and computational sciences.

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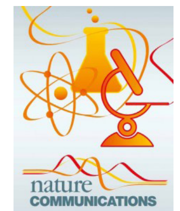

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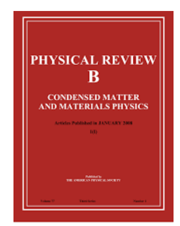

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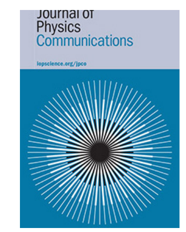

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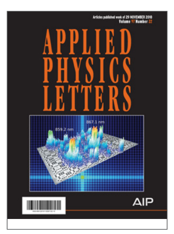

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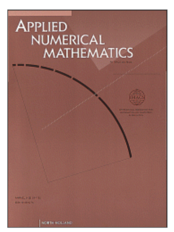

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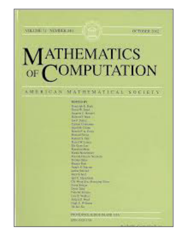

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