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National Science Foundation will continue funding

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NEURON

West Virginia's Journal of Science and Research

SUMMER 2019

WEST VIRGINIA UNIVERSITY

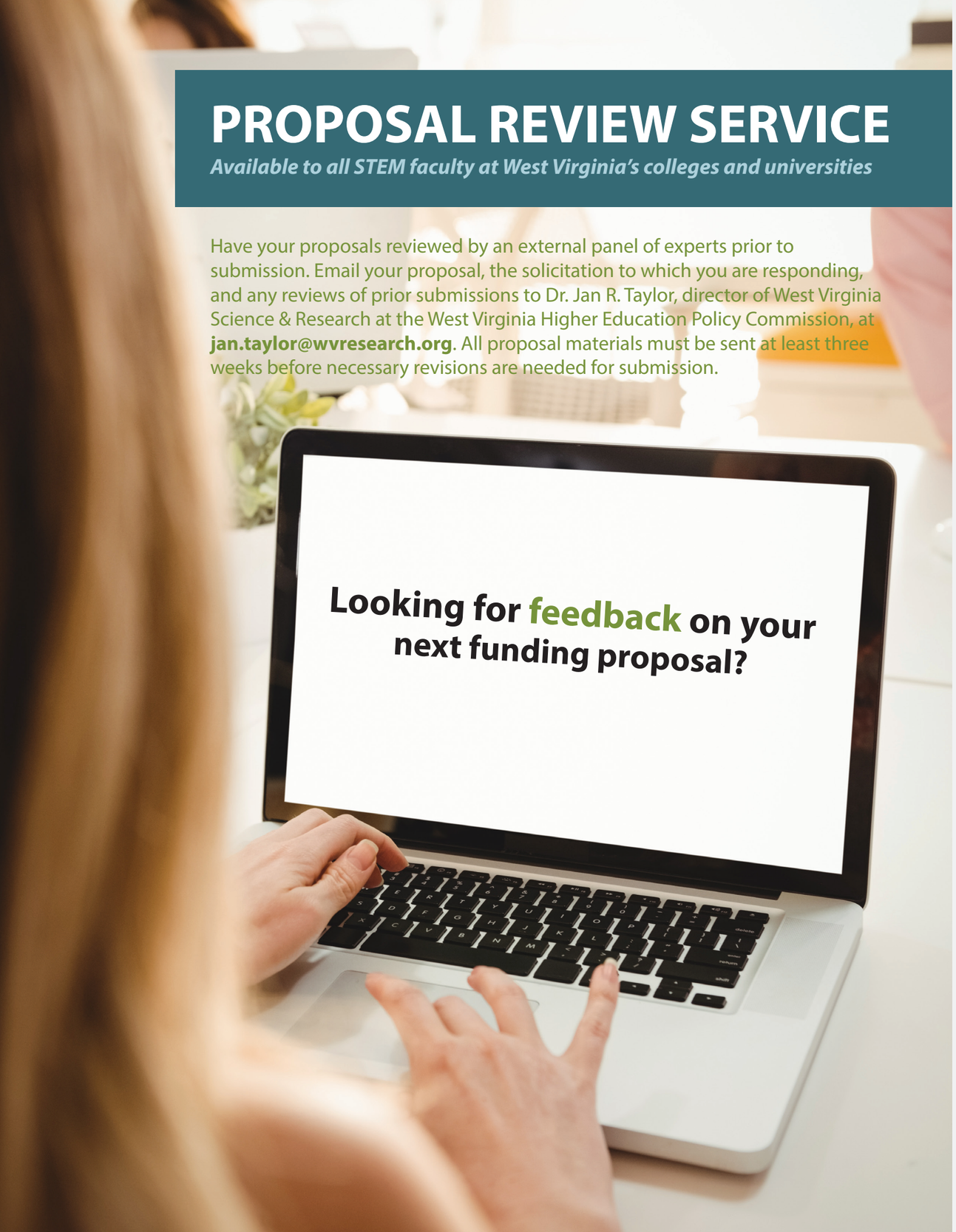
Jason Hubbart

WVU hydrologist seeks solutions to water quality issues while leading a team of researchers

PROPOSAL REVIEW SERVICE

Available to all STEM faculty at West Virginia's colleges and universities

Have your proposals reviewed by an external panel of experts prior to submission. Email your proposal, the solicitation to which you are responding, and any reviews of prior submissions to Dr. Jan R. Taylor, director of West Virginia Science & Research at the West Virginia Higher Education Policy Commission, at **jan.taylor@wvresearch.org**. All proposal materials must be sent at least three weeks before necessary revisions are needed for submission.



West Virginia Science & Research

SUMMER 2019

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ABOUT
West Virginia Science & Research, a division of the West Virginia Higher Education Policy Commission, provides strategic leadership for the development of competitive academic research opportunities in science, technology, engineering and mathematics. The office directs the National Science Foundation's Established Program to Stimulate Competitive Research (EPSCoR) in West Virginia, coordinates scientific research grants to academic institutions from federal and state agencies, and conducts outreach activities to broaden the public's understanding of science.

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Photo: Alex Wilson

Jason Hubbart, professor of hydrology and water quality at West Virginia University, uses a laser level to measure stream geomorphological changes due to land-use practices

INSIDE THIS ISSUE

News briefings

Alderson Broaddus professor guest lectures abroad

One Alderson Broaddus University professor shared his knowledge and expertise with students across the globe. Igor Woiciechowski, associate professor of mathematics in the College of Health, Science, Technology, and Mathematics spent nearly a week in May lecturing at Urgench State University in Uzbekistan on topics from mathematics to molecular physics.

During his visit, Woiciechowski taught a class of approximately 60 students and marveled at the opportunity. "I met many young people who were interested in science, specifically in physics," Woiciechowski said. "I saw their genuine interest in my presentations, and it was very encouraging as an educator and scientist."

Specifically, Woiciechowski shared his expertise on emission electronics, foundations of secondary ion mass spectrometry (SIMS), cluster ion sources in SIMS, fundamentals of molecular dynamics simulations, fundamentals of Monte Carlo simulations, and also reviewed his works on ion emission in SIMS.

Hands-on learning great experience for Fairmont State professor, student

Fairmont State University's Kristy Henson, assistant professor of forensic science, and sophomore, Alexandra Knighten, were chosen to participate in a bioarchaeology excavation with the Institute for Research and Learning of Archaeology and Bioarchaeology (IRLAB) in May.

Henson said this is an extremely competitive program available to students and faculty from all over the world and for this program they only accepted 20 people. They worked in the Historic Harrison Township Cholera Cemetery just south of Columbus, Ohio, for a month.

Bluefield State students and faculty deliver presentations at Cytoscape Workshop

Bluefield State College faculty and students are utilizing Cytoscape, a social network of open source software to visualize molecular interaction networks and biological pathways, to process mountains of data to identify relevant research then incorporate it into their work.

Four students and two faculty took part in a recent two-day workshop at Marshall University where groups collaborated and then presented their molecular biology work. This workshop was sponsored by West Virginia IDeA Network of Biomedical Research Excellence (WV-INBRE).

WVU invites entrepreneurs to participate in NSF I-Corps training program

West Virginia University invites all entrepreneurs, researchers and students from across West Virginia to participate in the National Science Foundation Innovation Corps (I-Corps) training program, which will help prepare participants to accelerate their cutting-edge technologies and products into the marketplace.

"As WVU remains committed to building a robust, statewide ecosystem of entrepreneurs and innovators, we encourage not only WVU faculty and staff to take advantage of this training, but all West Virginia entrepreneurs, innovators, researchers and tech experts to learn the process of commercializing their advanced technologies, discoveries and innovations," said Randy Quinn, an I-Corps instructor in the WVU Office of Technology Transfer. "This training will serve as an entrepreneurial boot camp for participants to discover what it's like to take a product to market."

The third cohort training will take place September 20 through October 5, 2019. Those interested in applying should reach out to Randy Quinn at randolph.quinn@mail.wvu.edu. as the deadline to apply is approaching fast.

Photo courtesy of Alderson Broaddus University

FROM THE DIRECTOR: Jan R. Taylor

Thank you, National Science Foundation: the Green Bank Telescope is here to stay


Taylor

Prior to 1957, the area of Pocahontas County named Green Bank was merely another secluded, rural community like so many others across Appalachia. While still secluded and still rural, much changed with the construction of telescopes and the establishment of the National Radio Quiet Zone. While we often read about the uniqueness that is Green Bank - no WiFi, no cell service - it is the science that makes it all happen, bringing researchers the world over to utilize its resources.

Operating Green Bank Telescope (GBT) - the world's largest steerable, single-dish radio telescope built in 2001- has not been without challenges. In 2012, the National Science Foundation (NSF) released a report recommending the reallocation of funding used for GBT because it was said many of the telescope's capabilities were duplicated by the stationary Arecibo Telescope in Puerto Rico. In 2016, NSF's National Radio Astronomy Observatory cut ties with GBT, leaving its future uncertain as it continued on in a standalone capacity. That's why the recent Record of Decision released from the National Science Foundation in July was so monumental.

According to the release, "after careful consideration of a variety of important factors … NSF now issues this Record of Decision (ROD) selecting Alternative A: Collaboration with interested parties for continued science-and education-focused operations with reduced NSF funding for implementation." The statement also highlights that the "scientific value of GBO remains high" and "hundreds of scientists use the GBT each year for research that spans virtually every field of modern astrophysics." This is good news for West Virginia. The accessibility of such a valuable tool will benefit many astrophysicists and astronomers for years to come.

Jan R. Taylor
West Virginia Science & Research Director and NSF EPSCoR Project Director
West Virginia Higher Education Policy Commission

The Science & Research Council was established by the West Virginia Legislature in 2009. The goal of the Science and Research Council is to increase the capacity of the state and its colleges and universities to attract, implement and use cutting-edge, competitive research funds and infrastructure. Members provide expertise and policy guidance regarding federal and state programs including EPSCoR, the Research Challenge Fund, and the former Research Trust Fund. Representatives of government, industry, business and academia make up the council.

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HYDROLOGY

WVU hydrologist seeks solutions to water quality issues while leading a team of researchers

Written by **Angela Sundstrom**
Photos by **Alex Wilson**

Andrew Carnegie once said, "No man will make a great leader who wants to do it all himself, or to get all the credit for doing it." Jason Hubbart knows this and demonstrates so in his leadership style.

Hubbart, professor of hydrology and water quality at West Virginia University (WVU) and director of the Institute of Water Security and Science, is quick to empower those around him. Within months of beginning his tenure at WVU in 2016, Hubbart assumed the institution's technical leadership role for the Appalachian Freshwater Initiative, a multidisciplinary project focusing on water quality funded through the National Science Foundation's Established Program to Stimulate Competitive Research (EPSCoR). By 2018, Hubbart would be the overall technical lead for all five academic institutions involved. That means in addition to research, there was quarterly reporting and ensuring participants were meeting objectives. At the time, Hubbart admits things felt disconnected, but he credits his colleagues Charles Somerville at Marshall University and Ulises Toledo of West Virginia State University for working with him on the turnaround.

Photo: Alex Wilson

Hubbart

"There are literally hundreds of tasks," Hubbart said. "I think we are now five behind. That's an incredible, incredible catch-up from the way things were in 2016. I'm really pleased about that and, of course, pleased to have worked with so many scientists at Marshall, West Virginia State and West Virginia University. There's a lot of really good people that work at those institutions. Really bright, really capable, and progressive thinkers. It's been so much fun to work with them."

In addition to administrative duties, Hubbart still flexes his research muscles by studying pathogens, specifically *Escherichia coli (E. coli)*. Wildlife and cattle contribute fecal matter to storm water runoff that can pollute watersheds used for food production, drinking water and recreation. Without proper management, such pollution leads to disease outbreaks. As a hydrologist, Hubbart believes in focusing on the pollutants' transport.

"It's impossible to estimate pollutant loading unless you know how much water is moving because it's the water that carries along the pollutants."

Hydrology is a climate-driven process. When it rains, movement occurs in surface runoff and ground water. To study the effects of pathogens, Hubbart utilized the EPSCoR program to develop West Run Watershed, a teaching and research mixed-land-use experimental watershed study in Morgantown. West Run is one of the most rapidly developing areas of both Monongalia County and West Virginia, characterized by increasingly widespread urbanization plus agricultural, industrial and mining land uses that have contributed to land and water resource degradation. One of the most intriguing discoveries is that acid mine drainage (AMD) reduces the presence of *E. coli*.

"AMD is useful to combat *E. coli*, but as much as it kills *E. coli,* it kills most everything else biological," Hubbart said. However, he and his team believe there may be other metal or chemical thresholds worth researching. AMD changes the pH enough to kill *E. coli*. because of geochemical attributes like heavy metals in the water. Reviewing the

"It's impossible to estimate pollutant loading unless you know how much water is moving because it's the water that carries along the pollutants."

- Jason Hubbart

Photo: Alex Wilson

Hubbart communicates with a climate station that monitors local weather conditions impacted by land-use practices

Above: Hubbart measures current water quality using a water quality multi-parameter sonde in the West Run Watershed in Morgantown

Photo: Alex Wilson

biogeochemistry of the water and its relationship with *E. coli* could lead to breakthroughs regarding how specific metal or chemical constituents might kill off the pathogen and possibly remediate other pollutants.

"Sometimes the most difficult questions in life are the easiest. We just need to quit trying so hard and look at what's right in front of us."

Reaching underrepresented populations is also one of Hubbart's passions. He especially hopes to create West Virginia Mesonet, a climate network monitoring weather and environmental changes. The idea involves more than 100 spatially distributed climate stations throughout the state, providing current weather conditions, ideal times to plant or harvest crops and the current soil and water conditions.

Hubbart earned his bachelor's and master's degrees from California State University and his doctorate degree from University of Idaho – Moscow. Yet, Hubbart is the first to concede it took time to find his niche.

"My mentors told me to focus at certain times, but I couldn't. I wanted to know how everything worked and I realized everything is connected. Surround yourself with people you want to be like, with people who think like you do and appreciate what you are doing and then just go for it. Don't worry about the rest."

Hubbart eventually realized his appreciation for environmental stewardship could lead to a career. He often cites one particular moment where, as a young boy on his family's dairy farm outside of Spokane, Washington, Hubbart decided to go fishing, but was so mesmerized by the shimmering stream he just sat there in awe admiring the beauty and physics of moving water. He also gained an appreciation for the livelihood of fish. That stream was its home and he realized all creatures deserved clean resources that supported life.

"Sometimes the most difficult questions in life are the easiest. We just need to quit trying so hard and look at what's right in front of us."

WVU Tech student aims to turn distracting phones into valuable teaching tools

By **Zac Carrier**

On the desk in front of Nima ShahabShamir was a piece of paper with a small pattern. He loaded an app and popped his phone into the goggles. He flipped up the visor and looked around. Everything the phone was projecting was the real world.

Then, he looked down.

Suddenly, the pattern turned into a playing video. ShahabShamir picked up the paper and moved it back and forth across his line of sight. The video kept playing, and the app kept tracking it. It was ShahabShamir's first breakthrough in his app development and the first of many steps in a plan to create an augmented reality app for the modern classroom.

ShahabShamir came up with his idea for an app to use as an educational tool. He took this idea to the NASA West Virginia Space Grant Consortium, which awarded him a grant for development.

He calls the app "Project AR," and it's designed to allow students to experience augmented reality as a component of their day-to-day coursework.

Though similar fields, there is a big difference between augmented reality and virtual reality.

"Virtual reality is when you put the goggles on and you can view 360 video or a three-dimensional space, but it's a space that someone designed for you," ShahabShahmir said. "In augmented reality, you still see what you see right now, but you get to add objects into your reality. You're enhancing your reality. If you have a wall, you can turn it into your browser, for example," he said.

ShahabShahmir

ShahabShahmir has also been working with the WVU Tech LaunchLab to garner support for the project.

"Augmented reality. Virtual reality. Artificial intelligence. It's all going to play a role in the classroom in the next few decades. If this can help students better grasp STEM lessons in a cost-effective way for teachers, then I'm going to do what I can to make it work."

Photo courtesy of West Virginia University Institute of Technology

First2 Network expands program for undergraduate summer research experiences

By **Angela Sundstrom**

Select undergraduate students spent their summers gaining useful laboratory skills while experiencing hands-on research, some for the first time.

First2 Network (First2), a grassroots alliance aiming to improve college readiness and the success of first-generation students in West Virginia, piloted the internship program in 2016 at Fairmont State University and Green Bank Observatory. With additional funding awarded from a National Science Foundation INCLUDES grant, the internships expanded in 2019 to Fairmont State, Chemours, Marshall University, West Virginia University and West Virginia State University with 30 interns and nine mentors.

The First2 immersion program is unique in that it offers short, two week experiences. Rising freshman are also mentored by older students with at least one year of studies complete. This allows participants early involvement in research while emphasizing student engagement and academic support.

"The Summer Immersion Program is an incredible experience," said Michael Fultz, associate professor of chemistry at West Virginia State University and one of the internship site leaders. "As a first-generation college student myself I find it inspiring to see students who want to succeed."

Shepherd nursing receives $2.7 million grant to help fight opioid problem

By **Shepherd University Communications**

Shepherd University's School of Nursing has received a four-year, $2.7 million Advanced Nursing Education Workforce Grant from the U.S. Health Resources and Services Administration. The grant will be used for an Innovative Modalities for Rural Nurse Practitioner Education and Collaboration to Transcend Health Disparities (IMPACT) program designed to encourage advanced practice nurses to work in rural West Virginia communities helping underserved populations and to promote the use of treatment such as photobiomodulation (PBM) light therapy to manage pain to help reduce opioid use.

Shepherd has partnered with four federally qualified health centers - Shenandoah Valley Medical Systems; Tri-State Community Health Center; E.A. Hawse Health Center; and Mountaineer Community Health Center in Paw Paw - where Shepherd's Doctor of Nursing Practice (D.N.P.) students will gain practical experience.

"We're thrilled to be partners with these health centers," said Sharon Mailey, dean of the College of Nursing, Education, and Health Sciences and director of the School of Nursing. "Students will have an immersion experience in rural health primary care at these clinics and this will foster retention in the region helping impact the health of our most vulnerable."

Above: (L-R) Students Colton Ring, Janeeva Jenkins, Daniel Reid and Kayla Hall in Panama while conducting research this summer with Professor Jeremy Keene. Their research centered on predation of the coral reef, epiphyte diversity in trees and habitat requirements for dart frogs.

Glenville State College students conduct research in Panama

By **Dustin Crutchfield**

Earlier this summer, a group of students from Glenville State College (GSC) traveled to Panama with Assistant Professor of Biology Jeremy Keene for an embedded Tropical Ecology research experience. The eight students – Kayla Hall, Logan Hays, AJ Howard, Janeeva Jenkins, Autumn Jones, Daniel Reid, Colton Ring and Justin Woods – conducted independent research projects looking at predation on the coral reef, epiphyte diversity in the trees on Isla Colon and habitat requirements of poisonous dart frogs.

The Glenville State students were also able to include a group of fifth graders in their research projects; the younger students were visiting the field station in Panama at the same time. "The timing of the visits of our two groups allowed our students and the fifth graders the opportunity to understand how research progresses and how to teach that research to others," Keene said.

During the trip, Keene was able to continue his work focusing on the diversity of *gesneriads,* part of the African violet family, on Isla Colon. A similar education abroad program took Keene and several GSC students to Panama in 2018.

Photo courtesy of Glenville State College

WVU researchers map crystals to advance treatments for stroke, diabetes, dementia

By **Cassie Thomas**

Medications attach to the proteins in our bodies the way spacecrafts dock into the International Space Station. Describing that process in detail can reveal a lot about how the medications work - and what form new medications should take.

Geldenhuys

Robart

Hollander

Photos courtesy of West Virginia University

Researchers at West Virginia University have mapped the crystal structure of a protein that resides in our cells and determined - for the first time - how a drug latches onto it. The findings appear in Communications Chemistry, a Nature research journal.

The study - funded by the West Virginia Clinical and Translational Science Institute - centered on a protein called "mitoNEET." MitoNEET inhabits the outer membrane of our mitochondria, which act like power plants that energize our cells.

"MitoNEET is a novel therapeutic target for metabolic-based diseases and could possibly lead to disease-modifying treatments for Alzheimer's disease and stroke," said Werner Geldenhuys, an associate professor in the School of Pharmacy and School of Medicine. He and his colleagues - including Aaron Robart, an assistant professor in the WVU School of Medicine, John Hollander, assistant dean for professional programs in the WVU School of Medicine, and Timothy Long, an associate professor in the Marshall University School of Pharmacy - carried out the project.

"This protein has been implicated in a lot of diseases that are very tough to tackle, like diabetes, stroke, heart disease," Robart said. "We don't actually know what the protein does yet, but it hangs out in proximity to the powerhouse of the cell, and all of these diseases have an energy-flow theme to them."

To explore the role mitoNEET plays in our energy processes, the researchers isolated mitoNEET from both bacterial overexpression and animal models. Then they synthesized 11 molecules similar to furosemide - a common diuretic sold under the brand name LASIX - and exposed the mitoNEET to them.

After the molecules bonded to the mitoNEET, the researchers built atom-by-atom maps of the pairings. They remotely controlled Argonne National Laboratory's Advanced Photon Source - which bombards samples with ultra-bright, high-energy X-rays - to reveal precisely how the molecules came together.

The team discovered that the molecules docked into a cluster of iron and sulfur atoms that made up part of the protein. Raisa Nuñez, an undergraduate participating in the Research Apprenticeship Program, collected preliminary structural data. "This highlights that significant scientific discovery can come at any career level," Robart said.

"These findings are of importance as they allow us to continue to understand the role played by mitochondria and bioenergetics in many disease states," Hollander said. "The modulation of mitochondrial function through targeted therapeutics may be a critical avenue of drug discovery."

Understanding mitoNEET's cellular function could improve the performance of drugs that work by altering the protein's activity.

The potential upshot for patients who take the drug? Better symptom relief.

Above: The Marshall University Forensic Science Center partnered with the U.S. Department of Justice International Criminal Investigative Training Assistance Program and Science Applications International Corporation in early May 2019 to train Iraqi forensic DNA scientists

Marshall Forensic Science Center hosts international training for U.S. Department of Justice program

By **Jean Hardiman**

The Marshall University Forensic Science Center (MUFSC) partnered with the U.S. Department of Justice International Criminal Investigative Training Assistance Program and Science Applications International Corporation in Huntington to provide advanced DNA Validation Training to 18 forensic DNA scientists with the Republic of Iraq Ministry of Interior Criminal Evidence Directorate, including its Director Major General Talib Khalil Raahi.

The training was designed and conducted by Valerie Mattimore Fuller, a Department of Justice contractor and DNA expert, and included lecture and advanced practical laboratory exercises using the training facility at Marshall's Forensic Science Center. The center boasts a state-of-the-art, functional DNA training laboratory offering the latest forensic DNA testing platforms and a computer lab equipped with full DNA analysis software, individualized software and learning workstations, as well as 24-hour on-call support staff.

This training was groundbreaking for the International Criminal Investigative Training Assistance Program and the Science Applications International Corporation. "MUFSC was one of only a handful of U.S. venues capable of handling the technical needs of this one-week accelerated learning course," Fuller said. "Marshall University can now say that they have advanced the fight against global terrorism that affects Iraqis, Americans and us all."

The course attendees included top Iraqi forensic DNA analysts/police, who have been doing this work since 2009 via their DNA reporting results and databasing efforts in Baghdad, Babil, Najaf and Al Hillah.

"I had worked onsite with Iraqi Ministry of Interior Criminal Evidence Directorate in Baghdad back in 2008-2009, establishing their DNA testing capability," Fuller said, "and now in 2019, the number of DNA analysts has grown into a group of frontline scientists, both men and women, who are DNA profiling captured ISIS fighters, terrorists and criminals. This course allowed them to up their game against crime and terrorism by providing them some recently developed, cutting-edge DNA mixture interpretation tools for better setting the standardized thresholds necessary for confident, high-quality, globally useful DNA database hits in this fight."

The training was a great opportunity for the Marshall University Forensic Science Center, as well as the attendees, said MUFSC Director Jason Chute. "Our own scientists enjoyed interacting and making a difference on an international level," he said. "We hope to provide more trainings of this caliber in the future."

In the past, the Marshall University Forensic Science Center has also provided training to officials from Mexico and Malaysia

The Center was established in 1999 and recognized as a Criminal Justice Agency by the State of West Virginia in 2016. It serves as a national and international resource for state and local criminal justice agencies.

Photo courtesy of Marshall University

National Science Foundation will continue to fund the Green Bank Observatory for science and education

By **Jill Malusky**

Green Bank Observatory (GBO) Director Karen O'Neil announced on July 30 that the Observatory will continue to operate as one of the premier radio telescope observatories in the world under the most recent National Science Foundation (NSF) Record of Decision (ROD).

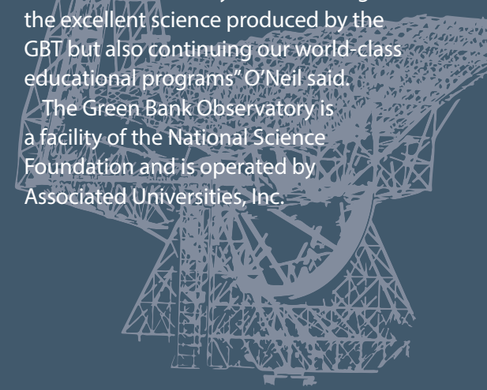
According to the NSF documentation, "after careful consideration of a variety of important factors … NSF now issues this Record of Decision (ROD) selecting Alternative A: Collaboration with interested parties for continued science-and education-focused operations with reduced NSF funding (Agency-Preferred Alternative) for implementation." Adam Cohen, President Associated Universities, Inc., which operates the Observatory shared, "AUI is extremely pleased to see a positive resolution of the divestiture recommendation and we look forward to the GBO continuing to serve as a premiere scientific and educational facility within the U.S. and the world for many more years."

Since October 1, 2016, the Green Bank Observatory has been operated by AUI as a standalone facility when it was separated from the National Radio Astronomy Observatory (NRAO) to encourage and enable development of operational partnerships. In addition to a continued partnership with the NSF, the Observatory will maintain its relationships with Breakthrough Listen, the North American NanoHertz Observatory for Gravitational Waves (NANOGrav), and the West Virginia University Center for Astrophysics.

The NSF acknowledged the "scientific value of GBO remains high, as demonstrated by the capabilities of and demand for its premier instrument, the Green Bank Telescope (GBT)," and that "hundreds of scientists use the GBT each year for research that spans virtually every field of modern astrophysics." O'Neil said, "Our focus looking forward is to ensure the GBT remains a competitive observatory well into the future, producing high quality science while maximizing access by the U.S. astronomy community," she said.

In addition to the solid scientific research and results produced by the Green Bank Observatory on a yearly basis, the Observatory also hosts several workshops, classes and camps throughout the year, including a recent workshop on Astrobiology that brought in well-known experts in the field of planetary science, astrochemistry, SETI and cosmology. This summer, approximately 124 students ranging from 4th grade through high school attended camps at the Green Bank Observatory, studying everything from star formation, the molecular cloud and pulsars. "I am very happy to see the focus remain not only on continuing the excellent science produced by the GBT but also continuing our world-class educational programs" O'Neil said.

The Green Bank Observatory is a facility of the National Science Foundation and is operated by Associated Universities, Inc.




Lateef

WVU student selected for NIH program

Sundus Lateef, a Bridgeport native and medical student in the WVU School of Medicine, was one of only 50 students selected from across the nation to participate in the National Institutes of Health (NIH) Medical Research Scholars Program (MRSP). The MRSP program was created to build the next generation of impactful clinician-scientists by inspiring biomedical research careers.


Schrader

Marshall University environmental science major named Gilman Scholar

Tatiana Schrader, a Yeager Scholar double majoring in environmental science and health sciences, spent her summer working in Tanzanian orphanages and HIV/AIDS clinics thanks to her Gilman Scholarship from the U.S. Department of State. She plans to pursue graduate degrees in environmental and human health.

West Virginia State opens Integrated Research and Extension Building

West Virginia State University hosted a media tour and open house at its Integrated Research and Extension Building, at the former West Virginia Rehabilitation Center. The facility, located along the west side of campus, is home to agricultural research laboratories and Extension Service educational facilities.

WVU robotics team on top again, wins second NASA competition in 3 years

WVU's robotic drilling team finished first in NASA's moon to Mars Ice & Prospecting Challenge, the team's second top finish in three years. WVU's Mountaineer Ice Drilling Automated System III placed ahead of Massachusetts Institute of Technology, Stevens Institute of Technology, Virginia Tech and Northeastern University.

Photos courtesy of West Virginia University, Marshall University, and West Virginia State University

COMMENTARY: Rodney Elliott and Olivia Young

Students provide perspective on opportunities available at Green Bank

On a cold and icy morning in early March, West Virginia University's (WVU) Sarah Burke-Spolaor and a group of her ASTR469 Observational Astronomy students carefully made their way down to Pocahontas County in southern West Virginia. During the trip, they would observe the nearby galaxy M33 (Triangulum) using the Green Bank Telescope (GBT), the world's largest fully steerable radio telescope. Thanks to WVU's close relationship with the Green Bank Observatory, the students would have a truly out-of-this-world, hands-on experience with one of the world's premier scientific instruments.

The purpose of this trip was to integrate hands-on learning into the coursework of undergraduate students. The students were tasked with planning observations and collecting and analyzing data on the neutral hydrogen emission lines from the direction of M33. Spectral lines can be used to analyze the motion of a galaxy in relation to our own, as well as allowing one to measure the mass of a galaxy using the famed "Tully-Fisher" relation, which was developed in 1977 by R. Brent Tully and J. Richard Fisher while the latter was staff at the GBT site.

Since M33 is a rotating object, some of the HI will be moving toward us as viewers, while some will be moving away, causing a Doppler effect that appears as HI emission lines shifted away from the rest frequency of approximately 1420 MHz. After scanning the GBT across the galaxy's extent on-site, back at WVU, students analyzed the data and plotted its spectrum. Due to the movement of the HI in M33, the HI emission will not be a sharp structure, but rather it will be spread out due to differences in velocity of the gasses along our line of site. By observing the movements of HI in other galaxies, much information about their rotation, movement and even mass can be determined, making HI observations an incredible tool for probing the characteristics of distant galaxies. Students used the data to determine the average relative velocity of M33 to us, which was found to be approximately -185 km/s based on the found blueshift of -0.0006, and were able to measure the total width of M33's HI line emission. Using the Tully-Fisher Relation, which relates a galaxy's line width to its total mass, the students were able to reproduce mass measurements of professional astronomers.


Elliott

Young

Each student in the class worked through this data processing methodology. Not only did this project expose the students to a side of astronomy that few had experienced, they also began to learn the absolutely invaluable skill of sharing our work through the project report. WVU senior Gabriella Agazie commented: "This project allowed us to apply concepts taught in class in a practical manner unlike any other course project I've ever done."

Many of the students are from West Virginia, meaning that being able to use both the Green Bank Telescope and employ the Tully-Fisher equation came with a sense of state pride. This state has so much to offer its students, from being taught and mentored by world-class astronomers to having hands-on experience like this project. Perhaps even more incredible than the fact that we are able to observe distant galaxies, stars, and nebula is the fact that as West Virginians, we can do so from our own back yard.

Rodney Elliott and Olivia Young were physics students of Sarah Burke-Spolaor in 2019. Elliott graduated from WVU in May with a degree in physics and is now attending graduate school in Colorado. Young is a senior studying physics and astronomy at WVU.

Photos courtesy of Rodney Elliott and Olivia Young

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