2019 – 2020
Annual Report to the Alabama Commission on Higher Education

Alabama EPSCoR

December 2020

NSF EPSCoR's primary goals are to provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in the R&D capacity and competitiveness and to advance science and engineering capabilities in EPSCoR juridictions for discovery, innovation and overall knowledget-based properity

DOE EPSCoR's primary goals are, in designated states and territories, to improve the capability to conduct sustainable and nationally competitive energy-related research; jumpstart infrastructure development through increased human and technical resources, train scientists and engineers in energy-related areas, and build beneficial relationships with DOE laboratories

NASA EPSCoR seeks to contribute and promote the development of research infrastructure in areas of strategic importance to NASA, improve the capabilities of designated jurisdictions to gain support from sources outside the NASA EPSCoR program; develop partnerships between NASA research assets, academic institutions, and industry; and contribute to the jurisdiction's overall research infrastructure.

DOD EPSCoR, reauthorized in 2019, seeks to enhance the capabilities of institutions of higher education in designated eligible state and territories to develop, plan, and execute science and engineering research relevant to the mission of DOD, increase the number of university researchers capable of performing research responsive to the needs of DOD and increase the probability of being awarded federal financial assistance for research

USDA EPSCoR is designed to help institutions develop competitive research, education, and extension/outreach programs in high-priority areas of national need in agriculture, food, and environmental sciences. Alabama is currently ineligible for USDA EPSCoR

The NIH Institutional Development Award (IDeA) program enhances the competitiveness for research funding and low aggregate success ratesd for grant applications to NIH. Alabama is currently ineligible for IDeA funding.

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TO THE ALABAMA COMMISSION ON HIGHER EDUCATION

The Alabama Established Program to Stimulate Competitive Research (ALEPSCoR), is dedicated to the advancement of economic development via scientific and engineering research through a collaborative effort among the State's research universities. The focus of activities is designed to attract and retain distinguished scientists and researchers for Alabama; to develop new cutting-edge technologies and high-tech industry; and to stimulate state competitiveness in medicine, biotechnology, engineering, and other applied sciences. Major achievements that stand out for 2019-2020 include: 1) thirty-one new FY2019 awards and thirty-four new FY2020 awards for two-year combined total of nearly $32M; 2) an update of the searchable research capabilities map/database for the eight university research institutions with the inclusion of Southern Research and HudsonAlpha on the Alabama EPSCoR web site at https://alepscor.org/; and 3) outreach programs to the Economic Development Association of Alabama.

Major awards for 2019-20 include the following: NSF EPSCoR Research Infrastructure Improvement (RII) Track 4 awards (4 in FY 2019 and 5 in FY 2020) and NSF RII Track 2 awards (two in FY 2019 and four in FY2020); seventeen (FY19) and nineteen (FY20) new NSF Co-funded awards; a DOE Implementation Grant in FY 19 and two DOE EPSCoR State Laboratory Partnership Grants in FY2020; one NASA Cooperative Agreement Notice (CAN) Award, a FY19 Research Infrastructure Development (RID) Award, four NASA EPSCoR Rapid Response (R3) awards in FY2019 and four in FY2020 and one FY2019 NASA EPSCoR International Space Station (ISS) Award.

In 2020, new EPSCoR research awards exceed $17M while estimated research expenditures exceed $16M. State support for the ALEPSCoR program during FY 2020 included 1.2M for administration and the Graduate Research Scholars Program (GRSP), which led to a federal return in research expenditures for state funding of more than 14 to 1 for ALEPSCoR in FY 19. Since 2006, the GRSP has supported over 300 graduate students, leading to 67 Master's degrees and 204 Ph.D. degrees as of December 2020. During the fall of 2020, 38 students were supported with GRSP Round 15 funding, 14 are new awardees. More information regarding the GRSP can be found in Volume 13 of the GRSP Booklet published December 2020.

The Research Capabilities Interactive Map/Database outlines Alabama expertise by each of eleven state research priorities including: Advanced Manufacturing, Agricultural Products/Food Production, Biosciences/Biotechnology, Chemical/Petrochemical, Energy, Forestry Products, Information Technology and Cybersecurity, Metal and Advanced Materials, Nanotechnology, Plasma Sciences, and Transportation. This resource can be used by residents and non-residents as an example of the depth of expertise in our state for new economic development and by researchers to locate collaborators.

The ALEPSCoR program continues to be a valuable contributor to scientific and engineering infrastructure, research capabilities, education, and economic development across the state. We look forward to continued investment for a stronger, more prosperous Alabama. We encourage you to review the many exciting EPSCoR research projects making an impact in our state.

Respectfully,

Christopher S. Brown, PhD
Chair, Alabama EPSCoR Steering Committee
Vice-President for Research
University of Alabama at Birmingham

Christopher M. Lawson, PhD
Executive Director, Alabama EPSCoR
Chair, Coalition of EPSCoR States
Professor, Department of Physics
University of Alabama at Birmingham

OVERVIEW & HIGHLIGHTS

The Established Program to Stimulate Competitive Research (EPSCoR), originally named *Experimental* Program to Stimulate Competitive Research was started by the National Science Foundation (NSF) in 1978 when Congress authorized the agency to create a new program in response to broad public concerns about the extent of geographical concentration of federal funding of research and development (R&D). Eligibility for EPSCoR participation is limited to those jurisdictions that historically received lesser amounts of federal R&D funding and demonstrated a commitment to develop their research bases and to improve the quality of science, technology and engineering research conducted at their universities and colleges.

The success of the NSF EPSCoR program during the 1980s subsequently prompted the creation of EPSCoR and EPSCoR-like programs that currently exist in four other federal agencies: the Department of Energy (DOE), the U.S. Department of Agriculture (USDA), the National Aeronautics and Space Administration (NASA), and the largest of all, the National Institutes of Health (NIH).

The mission of EPSCoR was originally designed to meet the NSF statutory function **"to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education."** During FY 2020, ALEPSCoR was eligible to receive new awards through EPSCoR programs associated with NSF, DOE, NASA and a new ititiative at the Department of Defense EPSCoR or DEPSCoR. We became ineligible for new USDA AFRI/FASE awards in 2016. Alabama is also ineligible for the NIH EPSCoR-like program called IDeA or the Institutional Development Award.

EPSCoR GOALS

- To provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in their R&D capacity and competitiveness.
- To advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity.

EPSCoR OBJECTIVES

- To catalyze key research themes and related activities within and among EPSCoR jurisdictions that empower knowledge generation, dissemination and application.
- To activate effective jurisdictional and regional collaborations among academic, government and private sector stakeholders that advance scientific research, promote innovation and provide multiple societal benefits.
- To broaden participation in science and engineering by institutions, organizations and people within and among EPSCoR jurisdictions.
- To use EPSCoR for development, implementation and evaluation of future programmatic experiments that motivate positive change and progression.

OVERVIEW & HIGHLIGHTS

ALEPSCoR Specific Goals

- Increase R&D funding in Alabama to the national level.
- Increase competitiveness of all research institutions in the state by measured publications, patents, research faculty, research equipment, etc.
- Increase minority and under-represented group participation.
- Develop industry-government-university partnerships to contribute to technology development and economic growth in Alabama.
- Increase effectiveness of EPSCoR programs.

ALEPSCoR Plan for Achieving Goals

- Develop a coordinated plan for research within the state and aid in the development of consistent plans for each agency.
- Provide guidance in conducting competitions, where possible.
- Select programs which have the greatest potential for achieving national competitiveness and determine the resources required to reach that potential.
- Use strengths and focus areas identified in the review and selection process.
- Function as a liaison with the Alabama Commission on Higher Education.
- Participate in EPSCoR Foundation and Coalition activities, as well as other groups that have impact on federal funding agencies.

ALEPSCoR is a consortium of academic, government, and industrial organizations established in 1985. The core ALEPSCoR academic institutions in Alabama include the eight Ph.D. granting research universities: Alabama A&M University, Alabama State University, Auburn University, University of Alabama, University of Alabama at Birmingham, University of Alabama in Huntsville, Tuskegee University, and the University of South Alabama. Other academic institutions participate in and benefit from program activities through satellite or outreach efforts and NSF Co-funding.

The primary goal of the consortium is to establish the infrastructure needed to increase sustained national science and technology research competitiveness. This goal is accomplished by:

1. Supporting research clusters based on current Alabama research strengths.
2. Carefully planning major equipment purchases that significantly increase state capabilities.
3. Facilitating the hire of new faculty and research personnel in targeted areas.
4. Broadening participation of students in research cluster-related science and engineering fields.
5. Linking these clusters with higher education, government agencies, and the private sector.

2019-2020 Alabama EPSCoR Notable Achievements

- GRSP funded 38 students in Round 15, 24 are renewing awardees while 14 are new to the GRSP Program. Thirty one awardees are pursuing a PhD while 7 are working towards a Master's. Funding began August 2020.
- The EPSCoR program at the Department of Defense (DEPSCoR) was reauthorized in FY2018 and appropriated with $12M in FY2019 to include a new mentor/mentee grant program called the Collaborative DEPSCoR Competition, the first solicitation was released in July 2019. Additional funds for EPSCoR jurisdictions were also allocated to support existing Young Investigator Program and the Defence University Research Instrumentation Programs. Funding for DEPSCoR increased to $24M in 2020.
- ALEPSCoR updated the searchable research capabilities database available at https://alepscor.org/.
- Estimated research expenditures exceeded $14.7M in FY2019 and $16M in FY2020.
- New EPSCoR awards exceeded $14.5M in FY2019 and $17.4M in FY2020.
- NSF EPSCoR - In FY 2019, ALEPSCoR received four new NSF Research Infrastructure Improvement (RII) Track 4 Awards and one NSF RII Track 2 Award. Track 4 awards went to Dr. Kannatassen Appavoo at UAB, Dr. Jeffrey Krause at the Marine Environmental Sciences Corsortium and Dr. Saeed Latif and Dr. Scott Glaberman at USA. Dr. Jeremy Schmutz at HudsonAlpha was awarded the NSF EPSCoR Track 2 award. In FY 2020, Alabama received five new RII Track 4 awards. These awardees include Dr. Biswajit Ray at UAH, Dr. William Jackson at USA, Dr. Steven Weinman at UA, Dr. Majid Beidaghi and Dr. Xu Wang at Auburn. In addition, Dr. Prabhakar Clement (UA) is leading a NSF Track 2 Collaboration award between Alabama, Louisiana, and Mississippi.
- NSF Co-funding - seventeen new FY 2019 NSF Co-funded projects ($7.9M) were awarded to AAMU, ASU, AU, UA, UAB, UAH, and USA. In FY 2020, nineteen new co-funded projects were awarded to Auburn, Tuskegee, UA, UAH and USA totaling $7.4 M.
- DOE EPSCoR- In FY 2019, nine Implementation Grant awards were announced in July and the University of South Alabama's Dr. Kevin West was Alabama's recipient; other project team members include Drs. Heath Turner, Jason Bara, and Paul Rupar at UA; Dr. Michael Curry at TU; and Amanda Coffman at the University of North Alabama. In FY2020, Alabama EPSCoR was awarded two State Laboratory Partnership awards for $1.5M. Recipients include Dr. Vladimir Kolobov at UAH and Dr. Suzanne Lapi at UAB.
- NASA EPSCoR- In FY 2019, Alabama NASA EPSCoR received at least one award from each of NASA EPSCoR's four funding mechanisms. These include one FY19 Cooperative Agreement Notice (CAN) Award; a Research Infrastructure Development (RID) Award; four EPSCoR Rapid Response (R3) awards and one International Space Station award. In FY2020, Alabama institutions (Auburn, UAB, and UAH) were awarded four new NASA Rapid Response Research (R3) awards.

OVERVIEW & HIGHLIGHTS

The ALEPSCoR program is dedicated to the advancement of economic development via scientific and engineering research through a collaborative effort among the State's research universities. The focus of activities is designed to attract and retain distinguished scientists and researchers for Alabama; to develop new cutting-edge technologies, companies and opportunities; and to stimulate state competitiveness in medicine, biotechnology, engineering, plasma science, mathematics and other applied sciences.

ALEPSCoR seeks to increase Research and Development (R&D) competitiveness through the development and utilization of science and technology resources residing in Alabama's major research universities. It strives to achieve its objectives by stimulating sustainable infrastructure improvements at the state and institutional levels that significantly increase the ability of ALEPSCoR researchers to compete for federal and private sector R&D funding, and accelerate the movement of ALEPSCoR researchers and institutions into the mainstream of federal and private sector R&D support.

As a member of the EPSCoR program, Alabama receives federal funds to stimulate nationally competitive research and to increase the ability of its scientists to compete successfully for research funds from NSF and other federal agencies. The ALEPSCoR consortium of academic, government, and industrial organizations supports projects that establish an infrastructure within the state capable of developing and sustaining high-quality science and engineering research and education that can potentially contribute to statewide national competitiveness.

Over the long term, ALEPSCoR is enhancing valuable resources that can influence Alabama's research capacity in the 21st Century. Alabama depends on its colleges and universities to provide well educated workers that leading companies require if they are to compete in a knowledge-based global economy. A highly educated work force is the most critical factor in attracting and retaining the kind of leading companies that bring 21st century jobs to the state.

Increasing Alabama's scientific and technology research competitiveness is critical for the long term economic health of the state. Specifically, ALEPSCoR makes a difference to Alabama through education, outreach, increased diversity, partnerships, infrastructure building, economic benefit/jobs, business opportunities, and a system that encourages graduation and self-sustainability.

ALEPSCoR Develops Research Expertise Searchable Database

In FY 2019 and 2020, Alabama EPSCoR updated the Science and Technology Capabilities database reflecting the expertise at Alabama A&M University, Alabama State University, Auburn University, Tuskegee University, University of Alabama, University of Alabama at Birmingham, University of Alabama in Huntsville, University of South Alabama, Southern Research and HudsonAlpha Institute for Biotechnology. This database was originally created in FY 2018 by AL EPSCoR, in response to a request by the Department of Commerce. Eleven research priority areas include: Advanced Manufacturing, Agricultural Products/Food Production, Biosciences/Biotechnology, Chemical/Petrochemical, Energy, Forestry Products, Information Technology and Cybersecurity, Metal and Advanced Materials, Nanotechnology, Plasma Sciences, and Transportation. Searchers on the web site enable one to access a list of research capabilities for each institution or drill down to specific areas within each research priority to discover the depth of research expertise in our state. Contacts at each institution are available for additional information, log onto: https://alepscor.org/

ALEPSCoR Improves Education

ALEPSCoR makes a difference through the state's colleges and universities, their science and engineering faculty, and students. A primary focus is preparing students for careers in engineering, materials sciences, biological sciences, physics, plasma science, energy, forestry, etc. Through mandates by NSF and other EPSCoR agencies, a portion of the agency investment goes to promote programs for K-12. Citizens of the state benefit by outreach efforts which includes basic community programs, teacher education opportunities, and development of new science-based curricula. These efforts improve K-12 education without significant investments from the state.

OVERVIEW & HIGHLIGHTS

ALEPSCoR Encourages Partnerships

ALEPSCoR cooperates with state leaders in government, higher education, and business to establish productive, long-term partnerships between universities, colleges, K-12 educational institutions, Alabama businesses, and other governmental agencies. These partnerships are designed to stimulate local action resulting in lasting improvements to the state's academic research infrastructure and increased national research and development (R&D) competitiveness.

ALEPSCoR Enhances Infrastructure

Human infrastructure is enriched by opportunities to establish relationships with national laboratories, to use equipment and collaborate with federal researchers, and hiring new faculty in targeted research "growth" areas which enables Alabama to achieve "critical mass" in these high growth research areas. Equipment infrastructure is improved by targeted equipment purchases which enable Alabama researchers to perform research in new cutting-edge technologies.

ALEPSCoR Provides Economic Benefits and Jobs

External EPSCoR funded grants support new faculty hires which provide salary for new research assistant professors, post-doctoral research associates, graduate student stipends and tuition, as well as undergraduate student support. These external grant funds provide jobs for hundreds of people in the state, helping to stimulate the state's economy. By establishing the research infrastructure in the state's targeted areas, Alabama researchers become competitive in obtaining federal non-EPSCoR grant funding. New external grant funds provide an additional economic benefit to the state by providing support for faculty and graduate students.

In FY 2019, Alabama was awarded four new NSF ESPCoR RII Track 4 awards and one Track 2 Award, seventeen new NSF Co-funded awards, one DOE EPSCoR Implementation Award and from NASA EPSCoR- one Research Infrastructure Development Award, one Cooperative Agreement Notice, Award, four EPSCoR Rapid Response (R3) Awards and one EPSCoR International Space Station Award.

In FY 2020, Alabama was awarded portions of four new NSF RII Track 2 multi-jurisdictional awards, one as the lead and three as a collaborating institution; five new NSF RII Track 4 Awards, nineteen new NSF Co-funded awards; 2 DOE State Laboratory Partnership awards; and four new NASA Rapid Response Research (R3) awards.

	FY 2019		FY 2020	
Agency	**New Awards**	**Estimated Research Expenditures**	**New Awards**	**Estimated Research Expenditures**
NSF RII	2,770,610	5,858,642	8,088,073	5,513,102
NSF Co-funding	7,258,619	6,334,998	7,443,941	6,960,229
DOE	2,710,993	1,208,206	1,499,146	2,307,348
NASA	1,825,000	933,852	400,000	1,216,111
USDA	0	354,869	0	74,951
DOD (Defense)	0	0	0	0
	$14,565,222	$14,690,567	$17,431,160	$16,071,741

Above: Former GRSP Awardee Dr. Karim Budhwani (Rounds 10 and 11), CEO of CerFlex, poses with Christopher Krebs (CFO), Dr. Lisa Johnson (CO) as winner's of the EDPA LaundPad award for a second year in a row. Shown here with the 2019 award for $50K and the 2020 award for $100K.

CerFlux is a biotech company that has developed a test to identify the most effective first-line cancer treatment for personalized medicine. Compared to traditonal protocols, this method saves precious time and money and keeps patients from enduring side effects from ineffective treatments.

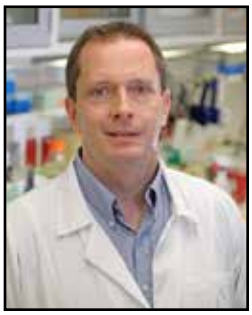
In February 2019, CerFlex won a $50K Economic Development Partnership of Alabama (EDPA) LaunchPad award toward the construction of a state-of-the-art lab in the historic Rush Hotel building in downtown Birmingham which included completing renovations and construction of the lab.

In February 2020, CerFlux won the $100,000 seed stage EDPA LaundPad prize. Their plan is to continue to equip the lab, refine the manufacturing and operational processes of the platform for matching tumors with treatments, and compile data specifically required for national Small Business Innovation Research (SBIR) grants. Their plan is to underwrite some of the research and development costs for translating this platform from lab-2-life by applying for grants. Alabama Launchpad Seed Award will be invested in all these areas ranging from procuring additional equipment, hiring and training scientists, to underwriting costs associated with intellectual property protection and regulatory approval processes. Almost all of the proceeds from the Seed award will be reinvested back in Alabama. Moreover, they seek to do the same with national grant funding hopefully secured in the coming months. Bottom line: they intend to multiply and reinvest this "seed" back in Alabama.

Jan. 24, 2020

<u>USA's Glen Borchert Laboratory Master's Student Thesis Selected as the 2020 Top Life Sciences Thesis in the Southern United States.</u>

Valeria King and
Dr. Glen Borchert



Valeria King, a GRSP Awardee during Rounds 11 and 12 and a Borchert Laboratory Master's student completed her thesis in Summer 2018. For her thesis, Ms. King studied a class of non-coding RNAs called snoRNAs which were known to have one function. It had recently been shown that specific fragments were excised from these snoRNAs which then go on to perform a completely novel function. She studied sno-derived RNA or sdRNA expression patterns and their association with prostate cancer type, size, and progression and found several significant correlations between certain sdRNAs and poor prognosis. She also cataloged the expression patterns of sdRNAs detected from several different tumor samples and types by bioinformatic analysis of RNA-seq data.

Ms. King's graduate thesis was selected as the Conference of Southern Graduate Schools (CSGS) Top Life Sciences Thesis for 2020. This is only the second time a USA student has ever won this award with the last being in 2004. The Conference of Southern Graduate Schools (CSGS) is an organization of over 200 graduate schools located in one of fifteen states located in the southern region of the United States. Graduate Deans at CSGS member institutions may nominate one person per category (total of two per institution) whose thesis has been accepted in partial fulfillment of master's degree requirements during the past two academic years. This is quite an honor for Ms. King, her graduate mentor (Dr. Glen Borchert), and the USA Graduate School and faculty.

Ms. King is pursuing a Ph.D. in Molecular and Cell Biology at University of California, Berkeley where she is studying herpesviris shut off factors.

MANAGEMENT

Alabama EPSCoR Steering Committee

The ALEPSCoR Steering Committee (AESC) is responsible for fiscal and programmatic aspects of ALEPSCoR activities. Members include representatives from eight research institutions: Alabama A&M University, Alabama State University, Auburn University, Tuskegee University, University of Alabama, University of Alabama at Birmingham, University of Alabama in Huntsville and University of South Alabama as well as the Alabama Commission on Higher Education and the Economic Development Partnership of Alabma.

In March 2018 and again in August 2020, Dr. Chris Brown was elected Chair of the Alabama EPSCoR Steering Commitee while Dr. Shaik Jeelani was elected the Vice-Chair. Dr. Brown serves as the Vice President for Research at the University of Alabama at Birmingham. Dr. Jeelani serves as the Vice President for Research and Sponsored Programs as well as Dean of Graduate Studies at Tuskegee University.

Dr. Chris Brown, Chair, ALEPSCoR Steering Committee

Dr. Shaik Jeelani, Vice-Chair, ALEPS-CoR Steering Committee

Dr. Chris Lawson (third from left), is one of the presenters for a "Panel Discussion: Public-Private Partnerships in Driving Innovation" at the 26th NSF National EPSCoR meeting, October 2019, Columbia, South Carolina.

Alabama EPSCoR Steering Committee

Standing Committee

Dr. Christopher S. Brown
Chair, Alabama EPSCoR Steering Committee
Vice President for Research
University of Alabama at Birmingham

Dr. Robin McGill
Proxy for Dr. James Purcell
Director Instruction / Special Programs
Alabama Commission on Higher Education

Dr. Shaik Jeelani
Vice-Chair, Alabama EPSCoR Steering Committee
Vice President for Research and Sponsored Programs
Dean of Graduate Studies
Tuskegee University

Dr. Robert (Bob) Lindquist
Interim Vice President for Research and Economic Development
The University of Alabama in Huntsville

Ms. Lynne U. Chronister
Vice President for Research and Economic Development
University of South Alabama

Dr. Daniel Wims
Provost and Vice-President for Academic Affairs
Vice-President for Research
Alabama A&M University

Dr. James "Jim" Weyhenmeyer
Vice President for Research and Economic Development
Auburn University

Dr. Russell Mumper
Vice President for Research and Economic Development
The University of Alabama

Dr. Christine Thomas
Associate Vice President for Institutional Effectiveness
Alabama State University

Mr. Greg Barker
President
Economic Development Partnership of Alabama

Advisory Committee

Angela Till
Deputy Secretary and Proxy for
Greg Canfield, Alabama Department of Commerce

MANAGEMENT

ALEPSCoR Executive Director


Dr. Chris Lawson

Dr. Christopher Lawson is a full Professor of Physics at the University of Alabama at Birmingham. His research specialty is optical sensing and nonlinear optics and he has published over 70 journal articles and 10 books or book chapters in these areas. Before coming to UAB, he led a group of 10 researchers first as Manager and then as Director/Principal Scientist at BDM International in McLean, Virginia. At UAB, Dr. Lawson has been Principal Investigator (PI) for numerous research grants awarded from the National Science Foundation (NSF), the Army Research Office (ARO), Army Research Labs (ARL), the Air Force Office of Scientific Research (AFOSR), DARPA and NASA. In 2004 he established the NSF funded Center for Optical Sensors and Spectroscopies (COSS) at UAB and led this Center until becoming Executive Director of Alabama Established Program to Stimulate Competitive Research (www.alepscor.org) in 2010.

Alabama EPSCoR is dedicated to the advancement of economic development via scientific and engineering research through a collaborative effort among the State's research universities. Overall, Alabama EPSCoR has brought in 268 federal EPSCoR grants for $165M from 2010-2020. As Alabama EPSCoR Executive Director, he oversaw the writing of Alabama's first Science and Technology (S&T) Plan/Roadmap endorsed by all major research institutions in the state, and formally adopted by Alabama Department of Commerce (DOC) Secretary Greag Canfield. Lawson worked with the Alabama DOC to incorporate this new S&T Roadmap into Alabama's Economic Development Plan, Accelerate Alabama 2.0, complementing it by identifying statewide research priorities and expertise that can provide target economic growth areas to create Alabama jobs.

Dr. Lawson also serves as the Director of the State funded Graduate Research Scholars Program (GRSP), designed to increase the pool of highly trained graduates available to Alabama industry. As of December 2020, GRSP support has resulted in 204 Ph.D. and 67 Master's degrees in high technology EPSCoR research areas.

In January 2020, Alabama EPSCoR participated in the January 2020 Economic Development Association of Alabama (EDAA) meeting to give a presentation on "University Research as an Economic Driver". Presenters included: Dr. Chris Lawson, Alabama EPSCoR, Dr. Mike Chambers, Associate Vice President of Research as the University of South Alabama; Dr. Karim Budhwani, CEO of CerFlux and former GRSP recipient; Dr. Steve Pelham, Associate Vice President for Economic Development, Auburn University.

(left to right) Chris Lawson, Mike Chambers, Karim Budhwani, and Steve Pelham presented "University Research as a Economic Driver" at the January 2020 Economic Development Association of Alabama (EDAA) Winter Conference.

Finally, Dr. Lawson since 2016 Dr. Lawson has served as the Chair of the Coalition of EPSCoR/IDEA States, which assumes a leadership role in coordinating national EPSCoR activities. He testified before the U.S. House Appropriations Committee on behalf of the EPSCoR Coalition in 2012 and 2013 and provided written expert witness testimony to the "Driving Innovation Through Federal Investments" full U.S. Senate Hearings in April 2014 and the House Appropriations Committee in 2019.

MANAGEMENT

ALEPSCoR Staff

Charlotte Nix has been with Alabama EPSCoR since 2006 and serves as the Alabama EPSCoR Program Administrator at The University of Alabama. Ms. Nix is responsible for managing the Graduate Research Scholars Program, EPSCoR grant listings, EPSCoR reports, and Steering Committee coordination and communication. Ms. Nix earned her B.S. degree from The University of Alabama.

Ms. Briauna Perryman graduated from the University of Alabama at Birmingham in 2017 with a degree in Marketing and Marketing Management and shortly thereafter joined Alabama EPSCoR as Program Coordinator II. She will begin the MBA program in Fall 2020.

Ms. Briauna Perryman at the Alabama EPSCoR booth during the Economic Development Association of Alabama (EDAA) January 2020 Winter meeting in Montgomery. Alabama EPSCoR demonstrated how to access the Alabama web based research capabilities database.

Briauna Perryman, Charlotte Nix, and Dr. Chris Lawson met with Congresswoman Martha Roby (District 2) during Alabama EPSCoR's annual congressional delegation visits, February 2020.

MANAGEMENT

Alabama Commission on Higher Education (ACHE)

In June 2020, Alabama EPSCoR wished ACHE's representative Dr. Paul Mohr a happy retirement and welcomed Dr. Robin McGill and Ms. Margaret Pearson to Alabama EPSCoR and the Graduate Research Scholars Program (GRSP). Dr. Robin McGill will be ACHE's representative on the Alabama EPSCoR Steering Committee while Ms. Pearson will serve in management of the GRSP.

Dr. Robin McGill joined the Alabama Commission on Higher Education in May 2019. As Director of Instruction and Special Projects, she manages ACHE's academic activities related to public colleges and universities, including program review, education and workforce alignment, and seamless transfer. Previously, she worked for the Rhode Island Office of the Postsecondary Commissioner as Director of Strategic Initiatives, where she led initiatives aimed at improving student success and integrating system-level data. Dr. McGill's training is in classical literature, and she has taught courses in literature, languages, and history to undergraduates and high school students. She earned her PhD from Brown University, and she also holds baccalaureate degrees in Latin and Greek from the University of Georgia and an MLitt from the University of St. Andrews.

Margaret Pearson began a career in education in 2005 at the Alabama Commission on Higher Education. For the past 15 years, she played a key role in reviewing new academic programs in the Academic Affairs/Instruction and Special Projects unit. In June 2020, in her new role as Coordinator of Strategic Programs, Ms. Pearson began coordinating statewide programs associated with the Southern Regional Education Board (SREB), serving as the state coordinator of the Academic Common Market and Doctoral Scholars program. Ms. Pearson also provides staff support for the Alabama EPSCoR program.

Agency Directors

The ALEPSCoR Agency Directors provide oversight responsibility for the day-to-day operations of federal EPSCoR research programs in Alabama, including responsibility for coordination, notification and supervision of all EPSCoR announcements and awards issued by the federal government. The ALEPSCoR Agency Director is the administrative officer for a designated EPSCoR program in Alabama. He/She is appointed by the ALEPSCoR Steering Committee and is responsible for the administrative functions of the AESC, providing management, coordination and direction of the EPSCoR program in Alabama and for such other duties assigned by the Executive Director and AESC. ALEPSCoR currently has an EPSCoR Agency Director for NSF, DOE, and NASA. Currently, Alabama is not eligible for awards from the USDA AFRI Program or NIH IDEA Programs.

Alabama NSF EPSCoR State Agency Director

Dr. Gary Zank is the Alabama NSF EPSCoR Agency Director as well as Principal Investigator (PI) on the NSF-EPSCoR RII Track 1 grant entitled, RII Track-1: CPU2AL: Connecting the Plasma Universe to Plasma Technology in Alabama headquartered at the University of Alabama in Huntsville. Dr. Zank joined UAH in 2008 and currently serves as Director of the Center for Space Plasma and Aeronomic Research (CSPAR) and Chair of the UAH Department of Space Science. He was elected to the National Academy of Sciences in May 2016. Dr. Zank is currently the only member of the University of Alabama System to be a member of NAS. In recognition of Dr. Zank's global achievements in teaching, research, and innovation, he was named the University of Alabama Board of Trustees

Trustee Professor, the highest award for a faculty member in The University of Alabama System, and he is also the Aerojet-Rocketdyne Chair in Space Science. Dr Zank has received numerous international and national awards, and is a Fellow of the American Physical Society (APS), the American Geophysical Union (AGU), the American Association for the Advancement of Science (AAAS), and and Honorary Member of the Asia, Oceania Geosciences Society(AOGS).

Dr. Zank earned his BS (1982) and PhD (1987) degrees at the University of Natal, South Africa and did Post-doctoral studies at the Max-Planck-Institut fuer Kernphysik and Max-Planck-Institut fuer Aeronomie (Germany) from 1987-1989 and Bartol Research Institute at the University of Delaware from 1989-1991. His research specialties include space and solar physics, plasma physics, and computational physics. Previous positions include Pei-Ling Chan Chair of Physics-and-Chair, Physics Department, University of Alabama at Huntsville; Chancellor's Professor of Physics and Astronomy, University of California, Riverside and Director, UCR Institute of Geophysics and Planetary Physics (IGPP) -and- System-wide Director, IGPP (July 2001 – June 2008). Dr. Zank can be reached at 256-961-7401 or garyp.zank@gmail.com.

Alabama DOE EPSCoR State Agency Director

Dr. John W. Steadman, P.E, serves as the Alabama Department of Energy (DOE) EPSCoR State Agency Director, Professor of Engineering at the University of South Alabama, and is a licensed professional engineer. Dr. Steadman previously served as Associate Dean and Head of the Department of Electrical Engineering at the University of Wyoming. He earned B.S. and M.S. degrees in electrical engineering from the University of Wyoming and the PhD degree from Colorado State University. Dr. Steadman was a research engineer for General Dynamics, Convair Division in San Diego, California before joining the faculty at the University of Wyoming and served as a Distinguished Visiting Professor at the United States Air Force Academy.

Dr. Steadman has received several awards, including the IEEE United States Activities Board Citation of Honor, the NCEES Distinguished Service Award with Special Commendation, the Wyoming Engineering Society Outstanding Engineer Award, and the AT&T Foundation Award for Excellence in Teaching. Professor Steadman was appointed to the Board of Registration for Professional Engineers and Professional Land Surveyors in Wyoming by three different governors serving on that board for more than sixteen years. He has also been active in the National Council of Examiners for Engineering and Surveying (NCEES), serving on several of the national committees, as treasurer, and as the national president in 1993-94.

In addition to his engineering education responsibilities, Dr. Steadman was 2004 President of IEEE-USA, Past Chair of the Board of Governors of the Order of the Engineer, and participates in accreditation of engineering programs for ABET. Dr. Steadman is the author of more than 60 journal publications, book chapters and patents. He has been honored with election to Fellow grade in the National Society of Professional Engineers and the American Society for Engineering Education. For more information, contact Dr. Steadman at 251.460.6206 or jsteadman@southalabama.edu.

Alabama NASA EPSCoR State Agency Director

Dr. L. Dale Thomas was appointed as the Alabama Space Grant Director in August 2017. Dr. Thomas currently serves as a Professor and Eminent Scholar of Systems Engineering in the Department of Industrial and Systems Engineering and Engineering Management at the University of Alabama in Huntsville. He teaches system engineering students in the art and science of systems architecture and design, systems integration, test, and verification, and systems management. Dale also serves as director of the Alabama Space Grant Consortium and as deputy director of the UAH Propulsion Research Center.

Prior to his retirement from NASA in July 2015, Dale served as the Associate Center Director (Technical) for the NASA Marshall Space Flight Center (MSFC) in Huntsville, Alabama, providing technical leadership for all MSFC spaceflight projects. For more information, Dr. Thomas can be contacted at 256-824-4243 or dale.thomas@uah.edu.

GRADUATE RESEARCH SCHOLARS PROGRAM

Graduate students who represent the next generation of researchers and innovators are critical to the advancement of Alabama's high-tech human resource capacity. To assist our institutions of higher education in training this next generation of scientists and engineers, investments are required to attract the brightest and best scholars who will contribute to the state's vision of economic growth and prosperity.

During FY 2020, the Alabama Legislature continued the appropriation to ALEPSCoR through the Alabama Commission on Higher Education for the purpose of funding the Graduate Research Scholars Program (GRSP). Since its inception in 2006, the program has funded over 320 exceptional graduate students.

Round Fifteen had 88 applications, 38 were awarded. Funding for the twenty-four renewing and 14 new awardees will begin in the fall semester of 2020. These recipients are conducting research funded by EPSCoR (Established Program to Stimulate Competitive Research) programs at the National Science Foundation, National Aeronautics and Space Administration, and the U.S. Department of Energy Office of Science. Of the thirty-eight students, thirty-one (31) are pursuing a PhD while seven (7) are working towards a Master's. Students are selected competitively by a team consisting of one campus coordinator from each of the PhD granting institutions in the ALEPSCoR Program. Renewals are granted each year subject to satisfactory progress in a given year and available funding. The goal of the ALEPSCoR GRSP is to invest in Alabama universities to expand research output and attract eminent senior faculty and quality graduate students. The program's objective is to provide a highly trained workforce to fuel the growth of high technology companies in Alabama.

The quality of work generated as part of the first fourteen funding rounds was both cutting-edge and novel. Encouraged by the success of the program, researchers have leveraged state funds with other research based resources to supplement the GRSP and increase participation in the program. Students whose proposed research or field of study and career interests are congruent with the funded science and technology programs of the NSF, DOE, NASA, and DOD at Alabama EPSCoR universities are eligible to apply. The AESC created a GRSP Subcommittee to monitor and continually make revisions to improve the program.

Additional information regarding the GRSP can be found in Volume 13 GRSP Booklet published December 2020.

UAH GRSP awardee Ryan Gott presents his plasma-based system for water purification research during the ACHE Commissioner's meeting on December 6, 2019.

GRSP Campus Coordinators

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GRADUATE RESEARCH SCHOLARS PROGRAM

Graduate Research Scholars Program (GRSP) Round 15 Awardees					
	First Name	Last Name	inst	target degree	EPSCoR grant
1	Kiran	Adhikari	UAB	PhD	NSF 1655280
2	Taiaba	Afrin	UAB	PhD	NSF 1350244
3	Sajid	Ahmed	UA	PhD	NSF 1655280
4	Syed Salman	Ahmed	TU	MS	NSF 1655280
5	Keshab	Bashyal	UA	PhD	NSF 1727875
6	Miles	Blanchet	AU	PhD	NSF 1809847
7	Chance	Boudreaux	UA	PhD	NSF 1800214
8	Alexandria	Bredar	AU	PhD	NSF 1809847
9	Muntaseer	Bunian	UAH	PhD	NSF 1606117
10	Kelli	Cannon	UAB	PhD	NSF 1632881
11	Wenqi	Cao	AU	PhD	NSF 1928770
12	Brennetta	Crenshaw	ASU	PhD	NSF 1900377
13	Taylor	Davis	UAB	PhD	NSF 1632881
14	Lam	Duong	AAMU	PhD	NSF 1655280
15	Guimu	Guo	UAB	PhD	NSF 1755464
16	Ellyn	Harges	AU	PhD	NSF 1604084
17	Jon	Hastings	USA	MS	NASA AL-19-EPSCoR-CAN 0002
18	Nabil	Hoque	UAH	PhD	NASA 80NSSC19M0033
19	Zabed	Iqbal	UAH	PhD	NSF 1653915
20	Shardai	Johnson	TU	PhD	NSF 1655280
21	Emre	Kayali	AU	PhD	NSF 1929195
22	Sungyoon	Kim	UA	PhD	NSF 1856054
23	Tanzeela	Mitha	UAH	PhD	NSF 1653915
24	Zaheeruddin	Mohammed	TU	PhD	NSF 1655280
25	Pinaki S	Nakod	UA	PhD	NSF 1604677, 1749837
26	Erin	Nicole-Smith	TU	MS	NSF 1655280
27	Emmanuel	Opokuma	ASU	MS	NSF 1510479
28	Sharave	Palwai	AAMU	PhD	NSF 1655280
29	Adam	Pfeifle	AU	PhD	NSF 1848344
30	Christopher	Phillips	UAH	PhD	NSF 1352046
31	Gabrielle	Prince	USA	MS	NSF 1738564
32	Michael	Russell	USA	MS	NSF 1738564
33	Irene	Sanchez	UA	PhD	NSF 1831512
34	John	Schoelz	UAB	PhD	NSF 1552586
35	Pavithra	Srinivas	USA	PhD	NSF 1655280
36	Md.	Tanmoy	USA	MS	NSF 1833016
37	Azizi	Turner	TU	PhD	NSF 1655280
38	Thanh	Vu	UAH	PhD	NSF 1606117

SUMMARY

In summary, the Alabama Established Program to Stimulate Competitive Research is dedicated to the development of scientific and engineering capabilities through state research university collaboration. Research performed by our universities represents a substantial industry in Alabama. Activities are designed to attract distinguished scientists, young investigators, and researchers from various fields, fostering economic development through investments that result in cutting-edge technologies and stimulate competitiveness in medicine, biotechnology, engineering, mathematics, and other applied sciences.

Alabama EPSCoR was successful in securing new funding from the NSF, DOE, and NASA during FY2019 and FY2020 Significant state commitment is necessary to sustain the ALEPSCoR activities and to provide concrete evidence to the NSF and other agencies that the State is willing to partially match the large federal research investment in these activities. Continued state support ensures EPSCoR federal funding will continue to be available for our scientists and demonstrates a willingness on the part of the State of Alabama to make a full commitment to building research capabilities to support state economic development. For more information on Alabama EPSCoR programs within the NSF, DOE, USDA, and NASA see the following sections.

NATIONAL SCIENCE FOUNDATION EPSCoR

The EPSCoR program was designed to fulfull the mandate of the National Science Foundation to promote scientific progress nationwide. The NSF EPSCoR program began in 1978 and is a federal-state partnership designed to help America maintain its global leadership by capitalizing on talents and resources available in all states of the union. The program promotes the intellectual and human development missions of NSF by supporting basic research activities which span a broad range of science, engineering and technology and by supporting training of future scientists and engineers. The NSF EPSCoR Office is located in the Office of the NSF Director where all EPSCoR awards are made through a rigorous merit review process.

NSF's EPSCoR Program is broadly set up as federal-jurisdiction partnerships. To participate in the program, an eligible jurisdiction is required to form its own EPSCoR steering committee and develop a science and technology (S&T) plan specific to the jurisdictions needs and goals. Each steering committee is expected to undertake "a recent comprehensive analysis of the strengths, barriers, and opportunities for further development of its institutions in support of overall objectives in research, education and innovation." Through these activities, steering committees work closely with partners in academia, government, and the private sector to build statewide networks.

NSF EPSCoR Eligible Jurisdictions

Guam	Nebraska
Virgin Islands	Oklahoma
Puerto Rico	Kentucky
South Dakota	Alaska
North Dakota	Hawai'i
West Virginia	Delaware
Vermont	Alabama
Wyoming	Louisiana
Nevada	Kansas
Mississippi	New Hampshire
Idaho	New Mexico
Maine	Rhode Island
Arkansas	Iowa
Montana	

Eligibility

Alabama first became eligible for EPSCoR funding in 1985. Eligibility to participate in the NSF EPSCoR program is based on the level of NSF research funding. Each year, NSF EPSCoR compiles annual summary data for NSF Research funding to recipients within a jurisdiction. In January 2020, new elibility criteria was announced which changed eligiblity from a 3-year average to a 5-year average. It also removed EPSCoR support from the elibility calulation and bases calculations on NSF Total award funding instead of only NSF Research Support. Eligibility in FY 2021 will be restricted to jurisdictions that recieve equal to or less than 0.75% of the total NSF budget. Jurisdictions that have been established in the program and whose share of total NSF funding is above 0.75% but less than 0.80% are allowed to remain EPSCoR-eligible for up to 5 years. Calculations are based on data from the NSF Office of Budget, Finance

Alabama Eligibility for NSF EPSCoR (for FY 2021)										
	FY 2015 Research Support	FY 2016 Research Support	FY 2017 Research Support	FY 2018 Research Support	FY 2019 Research Support	FY2015-2019 Total	EPSCoR Total	Federal Total	Adjusted $	% of Total $
	Amt $K	Amt $K	Amt $K	Amt $K	Amt $K	Amt $K	Amt $K		Amt $K	
Grand Total	$6,967,463	$7,110,054	$7,016,546	$7,457,851	$7,734,408	$36,286,322	$678,498	$773,646	$34,834,178	100%
Other	$25,489	$26,715	$18,894	$23,354	$27,131	$121,583				
US Total	$6,941,974	$7,083,339	$6,997,652	$7,434,497	$7,707,277	$36,164,739				
Alabama	$34,281	$46,041	$51,155	$60,140	$58,987	$250,604	$20,319		$230,285	0.66%

Source: https://www.nsf.gov/od/oia/programs/epscor/Eligibility_Tables/FY2021_Eligibility.pdf

A jurisdiction is eligible to participate in NSF EPSCoR if their most recent 5-year level of total NSF funding is equal to or less than 0.75% of the total NSF budget. Jurisdictions above 0.75% but less than 0.80% are allowed to remain EPSCoR-eligible for up to 5 years.

and Award Management and listed on NSF's Budget Internet Information System (http://dellweb.bfa.nsf.gov/). The FY 2019 and FY 2020 eligible tables remained the same and included twenty-four states, Guam, Puerto Rico and U.S. Virgin Islands, these juridctions receive approximately 10 percent of the NSF budget. The remaining ninety percent of NSF funding goes to non-EPSCoR jurisdictions.

In FY 2019, the grand total of NSF awards distributed across the world was $7,734,408K while the US total was $7,704,277K. Alabama recieved $58,987K. NSF's Office of the Director awarded $9,835,524 across Alabama including PhD granting institutions for EPSCoR related research, major instrumentation awards, graduate research fellowships, and EPSCoR Co-funding.

NSF EPSCoR uses four major investment strategies to achieve its goal of improving the R&D competitiveness of researchers and institutions within EPSCoR jurisdictions. These strategies are:

Research Infrastructure Improvement (RII) Program: There are four RII investment strategies, these make up approximately 83% of the EPSCoR budget.

- **Track-1 (RII Track-1) Awards**

  RII Track-1 awards provide up to $4 million per year for up to five years. They are intended to improve the research competitiveness of jurisdictions by improving their academic research infrastructure in areas of science and engineering supported by the National Science Foundation and critical to the particular jurisdiction's science and technology initiative or plan. These areas must be identified by the jurisdiction's EPSCoR governing committee as having the best potential to improve the jurisdiction's future R&D competitiveness.

NSF Funding Rates FY 2013-2019								
		2013	2014	2015	2016	2017	2018	2019
All NSF Directorates	No. of Proposals	49,150	48,206	49,630	49,306	49,425	48,334	41,030
	No. of Awards	10,981	11,120	12,016	11,893	11,457	11,716	11,250
	funding rate	22%	23%	24%	24%	23%	24%	27%
Alabama Portion (All NSF Directorates)	No. of Proposals	648	666	583	607	656	672	525
	No. of Awards	95	103	85	102	116	113	98
	funding rate	15%	15%	15%	17%	18%	17%	19%
NSF Office of the Director O/D (includes EPSCoR)	No. of Proposals	579	755	671	420	416	444	605
	No. of Awards	269	223	312	217	249	119	136
	funding rate	46%	45%	46%	65%	60%	27%	22%
Alabama Portion (O/D) (includes EPSCoR)	No. of Proposals	11	17	12	11	10	26	13
	No. of Awards	4	3	2	6	7	7	2
	funding rate	36%	18%	17%	55%	70%	27%	15%
All NSF Funding	Total*	6,548,925	6,766,552	6,967,463	7,110,054	7,016,546	7,457,851	7,734,408
Alabama (All NSF)	Total*	45,987	45,305	34,281	46,041	51,155	60,140	58,987
Overall NSF O/D Funding	Total*	343,784	385,949	460,863	462,073	454,777	503,917	577,175
Alabama NSF O/D	Total	5,262,194	4,797,819	2,611,006	4,486,653	9,151,080	17,283,205	9,835,524
Alabama EPSCoR	Total	4,851,399	4,239,226	2,420,866	4,017,754	9,140,280	15,189,507	6,400,650

*Amount shown in thousands

Source: NSF Budget Internet Information System

- **Track-2 (RII Track-2) Awards**
  Track-2 Focused EPSCoR Collaborations (RII Track-2 FEC) awards build interjurisdictional collaborative teams of EPSCoR investigators in scientific focus areas consistent with NSF priorities. Projects must include researchers from at least two RII-eligible jurisdictions with complementary expertise and resources to tackle proposed projects. Funds provide up to $1 million per year for up to four years as collaborative awards between two EPSCoR jurisdictions or up to $1.5 million per year for up to four years to a consortia of three or more EPSCoR jurisdictions. Science, Technology, Engineering, and Mathematics (STEM) research and education activities should work to broaden participation though stategic inclusion and integration of different types of individuals, institutions and sectors. The project should have a comprehensive and integrated vision to drive discovery and build sustainable STEM capacity with diversity of all types (individual, institutional, geographical and disciplinary). Development of early-career faculty in a critial component.

- **Track-3 (RII Track-3) Awards**
  Piloted in FY 2013, RII Track-3 awards provide up to $750,000 for up to five years to support the strategic goal of broadening participation to improve future R&D competitiveness of EPSCoR jurisdictions. These awards are intended to broaden participation of underrepresented groups in STEM fields supported by NSF - underrepresented minorities, women, persons with disabilities and those in underserved rural regions of the country.

- **Track-4 (RII Track-4) EPSCoR Research Fellows**
  Track 4 awards provide opportunities for non-tenured investigators to further develop their individual research potential through extended collaborative visits to the nation's premier private, governmental, or academic research centers. Through these visits, the EPSCoR Research Fellows will be able to learn new techniques, benefit from access to unique equipment and facilities, and shift their research toward transformative new directions. The experience gained through the fellowship is intended to provide a foundation for research collaborations that span the recipient's entire career. These benefits to the Fellows are also expected to in turn enhance the research capacity of their institutions and jurisdictions.

Co-Funding of Disciplinary and Multidisciplinary Research:

EPSCoR co-invests with NSF Directorates and Offices in the support of meritorious proposals from individual investigators, groups, and centers in EPSCoR jurisdictions that are submitted to the Foundation's research and education programs, and crosscutting initiatives. These proposals have been merit reviewed and recommended for award, but could not be funded without the combined, leveraged support of EPSCoR and the Research and Education Directorates. Co-funding leverages EPSCoR investment and facilitates participation of EPSCoR scientists and engineers in Foundation-wide programs and initiatives. Co-funding is approximately 16% of the EPSCoR budget

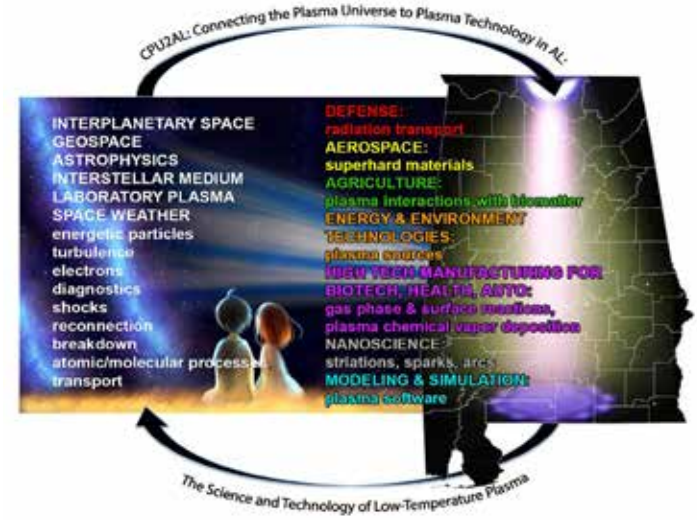
Workshops and Outreach:

The EPSCoR Office solicits requests for support of workshops, conferences, and other community-based activities designed to explore opportunities in emerging areas of science and engineering, and to share best practices in planning and implementation in strategic planning, diversity, communication, cyberinfrastructure, evaluation, and other areas of importance to EPSCoR jurisdictions. The EPSCoR Office also supports outreach travel that enables NSF staff from Directorates and Offices to work with the EPSCoR research community regarding NSF opportunities, priorities, programs, and policies. Such travel also serves to more fully acquaint NSF staff with the science and engineering accomplishments, ongoing activities, and new directions and opportunities in research and education in the jurisdictions. Workshops and Outreach utilize approximately 1% of the EPSCoR budget.

RII Track-1: CPU2AL: Connecting the Plasma Universe to Plasma Technology in Alabama

The NSF EPSCoR CPU2AL project is an integrated, statewide collaborative effort that seeks to understand, predict, and control the transfer of power from electromagnetic fields to electrons, ions, atoms, molecules, and surfaces, and chemical reactions in plasma and on surfaces in low-temperature plasma (LTP) environments. The project is led by the University of Alabama in Huntsville (UAH) and engages a consortium of nine Alabama (AL) universities including Auburn University (AU), the University of Alabama at Birmingham (UAB), Tuskegee University (TU), the University of Alabama (UA), Alabama A&M University (AAMU), the University of South Alabama (USA), Alabama State University (ASU), and Oakwood University together with an industrial partner, Computational Fluid Dynamics Research Corporation (CFDRC). The collaboration combines theory, modeling, and experimental validation of LTP and applies these to industrial applications with the goal of realizing the extraordinary potential of LTP science for transformative technological solutions that address societal grand challenge problems, advanced manufacturing and materials, biomedicine, agriculture, and food safety.

The revised Strategic Plan, developed throughout Year 3 and approved by NSF EPSCoR in May of 2020, together with the previously approved version from December 2018 was used to guide and direct the Year 3 effort and the allocation of resources to achieve the goals articulated in the proposal.



<u>Research Thrusts 1, 2, 3, working groups, and infrastructure improvements</u>

The three cross-institutional research thrusts (RTs) launched in Year 1 are now fully engaged in addressing the major challenges facing LTP science today: (i) basic understanding of plasma kinetics and diagnostic techniques (RT 1), (ii) collective processes (RT 2), and (iii) plasma interactions with solid, liquid, and soft matter (biomaterials) and bio-matter (seeds and food) surfaces (RT 3). Conceptually, RT 2, i.e., the basic plasma physics and diagnostic program, is the glue that draws together RT 1 in its formulation of plasma kinetics that enables theory and diagnostics and RT 3, which addresses plasma applications. An example highlighting the role of RT 2 as the "glue" is the use of high-resolution spectroscopy to diagnose plasmas used for plasma-treatment of polymers for biomaterial applications. The new aspect of the study was the role of a magnetic field in processing polymers.

RT 1 addresses the prediction, control, and diagnostics of LTP kinetics through two goals. The first goal is to develop the capability to accurately model the properties of LTP in order to understand naturally occurring plasma environments or to tailor a plasma state to accomplish a particular industrial task. Four objectives are pursued that address the development of theoretical and computational models from a physical kinetics perspective, including a focus on modeling the charged-particle kinetics in the presence of electromagnetic (EM) fields, collisions, and turbulence. The second goal of RT 1 is to design and develop diagnostics capable of measuring plasma properties in LTPs far from equilibrium and their initial formation through steady-state conditions. It is crucial to perform high-quality measurements of plasma properties with sufficient temporal and spatial resolution to enable validation of theoretical models. Three objectives are pursued to (i) develop plasma diagnostic tools based upon emission spectroscopy and laser-induced fluorescence to measure line-integrated basic plasma parameters such as the plasma density and electron temperature, (ii) acquire and develop in-situ diagnostics that can provide localized

NSF RII Track 1 CPU2AL PI List

University of Alabama in Huntsville
Gary Zank (Project Director), Nick Pogorelov, Vladimir Kolobov, Jakobus Le Roux, Lingling Zhao, Haihong Che, Ying Zou, Gabe Xu, Gang Li

Alabama A&M University
Srinivasa Rao Mentreddy (AAMU Lead PI), Armitra Jackson-Davis, Ernst Cebert
Leopold Nyochembeng, Padmaja Guggilla

Alabama State University
Komal Vig

Auburn University
Edward Thomas (AU Lead PI), David Ennis
David Maurer, Stuart Loch, Uwe Konopka, Yu Lin, Emefa Monu

Tuskegee University
Vijay Rangari (TU lead PI), Michael Curry, Maria Calhoun, Shaik Zainuddin

University of Alabama
Rich Branam (UA Lead PI), Gary Cheng, Mruthunjaya Uddi, Xiaowen Wang

University of Alabama at Birmingham
Yogesh Vohra (UAB Lead PI), Vinoy Thomas, Chen Cheng-Chien, Arron Catledge, Wenli Bi, Renato Camata

University of South Alabama
Edmund Spencer

Oakwood University
Alexander Volkov

CFD Research Corporation
Robert Arslanbekov

measurements of plasma parameters, and (iii) develop fast diagnostic systems that can measure the time evolution of a variety of plasma structures.

RT 2 addresses electron kinetics and collective phenomena through two goals. The first goal is to study the temporal and spatial ordering of plasma systems, and investigate fundamental properties of waves, instabilities, nonlinear processes, and self-organization in LPT. Two objectives are pursued focusing on the physics of dusty plasmas and understanding and controlling plasma stratification. The second goal of RT 2 is to develop a state-of-the-art computational tool to simulate high-frequency EM field interactions with plasma, validate the tool for selected benchmark problems, and apply it to problems of interest to the CPU2AL Team.

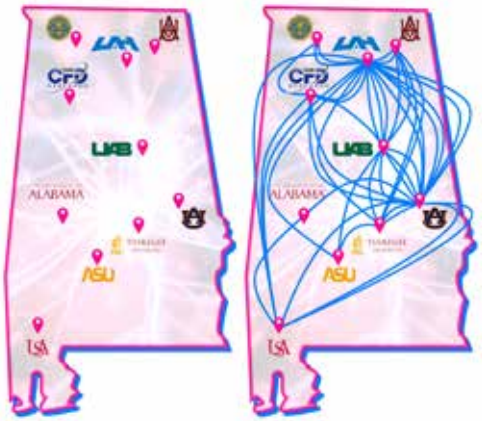
RT 3 addresses plasma interfaces (solid, liquid, bio-matter) through two goals. The first goal is the LTP synthesis of novel superhard materials, specifically to study the formation of superhard materials from C, N, O, and B (CNOB) in LTPs and develop an understanding of the formation process and resulting material properties. Two objectives are pursued: (i) to synthesize novel superhard materials based on CNOB using existing LTP systems and carry out plasma treatment of graphitic carbon synthesized from renewable waste sources for incorporation into polymer composites and (ii) to develop large-area (> 100 cm2) plasma systems required for synthesis of superhard materials for applications in automotive, biomedical, and aerospace industries. The second goal of RT 3 is related to plasma interactions with soft matter and biomatter, specifically to understand the effect of LTP on biomaterials, plants, seeds, and agricultural products, and the fundamental processes responsible for their bioactivity. Two objectives are pursued: (i) to study effects of LTP on scaffold biomaterials and (ii) to investigate seed and food decontamination and protection, and electrical and biophysical responses of plants.

Our overarching efforts are focused on using the LTP research thrusts above to:

- Build lasting collaborations between AL academic and industry institutions;
- Integrate historically black colleges and universities (HBCUs) into the statewide research collaboration;
- Build shared infrastructure as a statewide resource, and
- Expand the faculty.

Measurable progress has been made on all of these fronts. In Year 3, CPU2AL participants published 47 publications, in 28 of those CPU2AL was the primary support for the publication, submitted 73 proposals to various funding agencies and garnered 13 awards for a total of $4,220,153.

Summarized above is a map of the state of Alabama showing the geographic location of the CPU2AL institutions, and the connecting lines each represent an active, ongoing collaboration in LTP between different institutions – both before CPU2AL (left) and now (right). Evidently, all



institutions are linked by several lines, illustrating the rapid diversification of collaborations that occurred during the last three years. The cross-institutional collaborations have been achieved through a mix of programs and efforts. For example, our seed funding initiatives require the recipients to propose to develop and run a cross-institutional program that engages faculty, students, and post-docs from different institutions, including available resource sharing.

Our effort of integrating HBCUs into the statewide research collaboration, has resulted in the CPU2AL HBCUs being fully involved in collaborations with the other partner institutions. Three of the four HBCU institutions have received seed funding awards in Years 2 and 3 and the only application received from an HBCU (ASU) for the graduate fellowship program administered through CPU2AL, was funded. In addition, during Year 2, we created a summer program for CPU2AL HBCU students. As we discuss further below, we have expanded the Industry Internship program to include companies outside of Alabama collaborating with HBCUs.

Upon RSV recommendation to strengthen interactions among RTs, three working groups were formed to address dedicated topics that cross Research Thrusts. During the retreat in October 2019, the project decided to create working groups on dedicated topics. Initially, three different topics were selected and turned into working groups:

a) Plasma Modeling
b) Diagnostics (electrical & optical)
c) Space Science in the Lab

Following the retreat, CPU2AL researchers joined the individual working groups which started their activities in winter and spring of 2019/2020. Due to the onset of the COVID-19 outbreak the some of the progress is lagging behind the initial plan, however promising results are already beginning to emerge.

Finally, in Year 3, we are now sharing and integrating resources across partner institutions. Specifically, we have acquired equipment for plasma processing and plasma diagnostics at AU (a Godyak-type Langmuir probe system and a scanning monochromator with backlit ICCD camera), a custom built plasma treatment rotating chamber for powder samples/polymer pellets at TU, a large-area 30cm x 30cm plasma deposition system for manufacturing of superhard materials at UAB, and a Spectrometer detector and associated power supplies at UAH. These instruments are being shared among partner institutions to the extent needed to strengthen collaborations.

Workforce Development and Diversity

The workforce development (WD) goal of CPU2AL is to make diverse, measurable, and long-lasting improvements in the Science, Technology, Engineering, and Mathematics (STEM) pipeline and workforce in Alabama in order to inspire and train the next generation of (Low Temperature Plasma) scientists – involving activities aimed at K-12, undergraduates, graduate students, and postdocs. These activities are designed to link academic research activities to the Alabama LTP industry. During Year 3, the CPU2AL Team continued to recruit and appoint several participants at all levels, with a total of about 99 active participants. The breakdown summary of the CPU2AL participants is illustrated below.

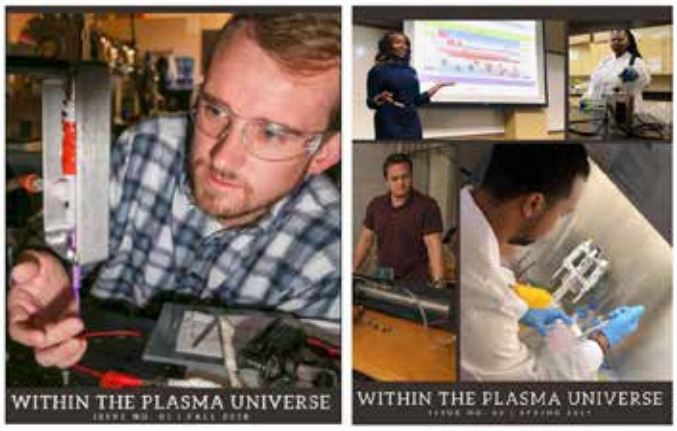
Whenever possible, the appointment of women and underrepresented minority (URM) participants was prioritized and special efforts were devoted to recruit and retain such groups of participants. In particular, three new faculty hires in Year 3 were women.

Communication and Dissemination

Summary of CPU2AL Personnel			
Participant Category	Total	URM*	Female
Faculty	43	8	10
Postdocs	10	1	2
Undergraduate Students	13	11	9
Graduate Students	33	9	7

*Underrepresented Minorities

During Year 3, we have widely promoted the CPU2AL project through (i) the CPU2AL website, (ii) email campaigns with program announcements, (iii) postings at career centers of all partner institutions, (iv) postings in national job search engines for students and URMs, (v) STEM outreach events, (vi) emails/meetings with industry partners, (vii) the CPU2AL speaker series, (viii) the Science and Technology Open House (STOH), (ix) the CPU2AL Annual Meeting, (x) presentations at national and international meetings, (xi) newsletters, (xi) email blasts to internal and external audiences who can subscribe on our website, and (xiii) social media.



Photos from CPU2AL Newsletters

Management

The CPU2AL Management Team comprises representatives from eight campuses and the industrial partner, together with the Project Manager (PM). Since its inception, the CPU2AL Management Team ensures that communication lines remain open and efficient and that cross-campus activities (scientific, academic, workforce, and diversity) are on schedule and achieving their specific goals. Communications include monthly virtual meetings and two in-person meetings of the Management Team. The CPU2AL Education, Outreach, and Diversity (EOD) Specialist plays an integral part in the coordination of project activities and participates in all meetings of the Management Team.

During Year 3, another annual retreat was held to continue building cross-campus scientific and social relationships. Similar to the Year 2 retreat, the Year 3 retreat focused on collaborative research brain-storming and discussions within and across Research Thrusts. One of the major outcomes was the formation of three Working Groups that have cross cutting topics. Additionally, each Research Thrust worked on a plan for Year 3 with new tasks and milestones in response to the Reverse Site Visit (RSV) recommendations.

The 2020 COVID-19 Challenge

Since March 2020, the CPU2AL project faces an unprecedented challenge in managing a major research and workforce development program across 10 institutions spread throughout the State of Alabama. This became especially acute with the imposition of “stay-at-home” orders, and the number of active COVID-19 cases has not eased materially with the State beginning to open up activities. We have been fortunate in that many of our management activities rely already on telecommunications, including our monthly management meetings, and these have continued to be effective. Our faculty and researchers who need to be in the labs, including our students and post docs, have faced considerable challenges due to not having access to their laboratories, but all have taken the opportunity to work on publications, organize and analyze data, etc. With the slow opening of the universities underway, our laboratory

researchers now have to develop work space utilization plans consistent with individual University and State guidelines, bringing a new set of challenges in how to conduct effective and meaningful experiments in an environment that is effectively limited through the amount of people that are permitted, social distancing measures, and the like in labs.

For those engaged with more portable research activities (theory and data), the situation is less difficult and everyone has adapted quickly and readily as conditions change. The PI's concern and emphasis is that everyone's safety is paramount and that the participants should be judicious, smart, and adept enough to develop work-arounds as the situation demands. This was communicated in telecons and via email to the CPU2AL family and thankfully everyone is so far safe and healthy. This approach has allowed at least the research, management, and sustainability activities to proceed robustly. Far more challenging was addressing the summer workforce development and enrichment programs at all levels. The project had to cancel the April Retreat that was to be held in Florence, AL because travel was prohibited in the State. We hope to resume the retreat later in the year, conditions permitting. We debated whether to hold the retreat via Zoom but the nature of a retreat with spontaneous, individual, unconstrained and unstructured discussion is simply impossible over a platform such as Zoom. Our biggest regret was our inability to hold the student summer programs. After discussing the value of doing these remotely, the project management team concluded that the importance of in-person mentoring far outweighed the continuation of the programs remotely. It is anticipated that next year we will be able to resume and expand on the canceled programs. The great challenges of what lies ahead remain e.g., the anxiety about a second wave, the development of hotspots – Alabama appears to be entering a new and dangerous phase as nationwide attention is currently (as of 5/22/2020) being focused on a number of AL cities and regions, some of which house CPU2AL institutions and members. The project management together with the participants will continue and adapt to the situations as they arise, consistent with the State and campus guidelines.

Left: Auburn University Principal Investigator Dr. Ed Thomas demonstrates lift as part of the 2019 K-12 Science and Technology Open House in Mobile, AL. Right: Auburn University Graduate Student Lori Scott demonstrates properties of plasma science, 2019 Science and Technology Open House, Mobile, AL.

NATIONAL SCIENCE FOUNDATION EPSCoR

Fall Break Campers with their tour guide at the U.S. Space and Rocket Center

Alabama Plasma Internship Program (ALPIP) interns with other Science Undergraduate Laboratory Internship (SULI) program at Princeton Plasma Physics Laboratory.

Dana Waller (front), CPU2AL Education Outreach Director, and participants at Auburn University's Destination STEM, an interactive experience and open house for middle and high school students considering STEM fields.

Dauphin Island Sea Lab volunteers prepare a demonstration of how water is contaminated in today's society.

NSF EPSCoR RII Track 2

In 2019 and 2020, the research focus was "Harnessing the Data Revolution" to solve problems of national importance.

In FY 2019, Alabama was awarded one NSF Track 2 grant as the lead and a second one as a collaborator. HudsonAlpha Institute for Biotechnology was awarded a NSF RII Track 2 award to investigate plant genomics to better understand how nitrogen affects plant growth and development. In addition, the University of Alabama is participating in a NSF Track 2 grant entitled, "RII Track 2: Consortium for Plant Invasion Genomics (CPING): Combining Big Data and Plant Collections to Understand Invasiveness" headquartered at the University of Louisiana at Lafayette.

In FY 2020, Alabama was awarded one Track 2 award as the lead and three others as a collaborator with another EPSCoR jurisdiction. Dr. Prabhakar Clement, at the University of Alabama, is leading a Track 2 Team investigating groundwater management across the Southeast. Other Alabama Track 2 investigators are collaborating with the South Dakota School of Mines and Tech; University of Kansas Center for Research and the University of Louisiana at Lafayette.

RII Track-2 FEC: Functional Analysis of Nitrogen Responsive Networks in Sorghum

Dr. Jeremy Schmutz
HudsonAlpha Institute for Biotechnology

The high yields typical of modern agriculture rely upon nitrogen fertilizer, yet the manufacture of synthetic nitrogen fertilizer is extremely energy intensive and represents a major cost for farmers. Additionally, fertilizer runoff produces many secondary problems such as aquatic dead zones with low oxygen contents, and reduced water quality, increasing the costs of providing safe drinking water in agricultural regions of the country. Genetic gains in nitrogen use efficiency (NUE) by plants will aid in protecting yield while mitigating both costs and negative environmental impacts associated with high rates of fertilizer application in agriculture. Through this Track-2 Focused EPSCoR Collaborations project, researchers at the HudsonAlpha Institute for

New NSF EPSCoR Track 2 Awards FY19 and FY20

Award No	Title	Type	Lead Inst.	AL Inst./PI	Start date	End Date	AL Award Amt.
FY 2019							
1826781	RII-Track 2 FEC: Functional Analysis of Nitrogen Responsive Networks in Sorghum	EPSCoR Research Infrastructure	Jeremy Schmutz	HudsonAlpha	10/1/2018	9/30/2022	$1,972,373.00
1920858	RII Track 2 FEC: Consortium for Plant Invasion Genomics (CPING): Combining Big Data and Plant Collections to Understand Invasiveness	Lead Inst.: Univ. of Louisiana at Lafayette, Univ. of Alabama, South Dakota State, West Virginia University, Wichita State	Lead inst. Univ. of Louisiana- Nicholas Kooyers; whole grant $3,835,497	UA: Michael McKain	8/1/2019	7/31/2023	$551,945.00
FY 2020							
2019561	RII Track-2 FEC: IGM--A Framework for Harnessing Big Hydrological Datasets for Integrated Groundwater Management	EPSCoR Research Infrastructure	Lead Inst. UA: Dr. Prabhakar Clement (whole project over 4 years is $5,998,507;	University of Alabama	9/1/2020	8/31/2024	$4,126,634
2019511	RII Track 2 FEC: Precise Regional Forecasting via Intelligent and Rapid Harnessing of National Scale of Hydrometeorlogical Big Data	EPSCoR Research Infrastructure	Lead Inst.: Univ. of Louisiana at Lafayette, PI: Dr. Nian-Feng Tseng; whole project is $2,509,859	University of South Alabama: Dr. Sytske Kimball	9/1/2020	8/31/2024	780,485
2019597	RII Track-2 FEC: The IceCube EPSCoR Initiative (IEI) - IceCube and the Data Revolution	EPSCoR Research Infrastructure	Lead Inst.: South Dakota School of Mines and Tech for $3M;	University of Alabama: Juan Santander and Dawn Williams	9/1/2020	8/31/2024	921,659
2019603	RII Track 2 FEC: Aquatic Intermittency Effects on Microbiomes in Streams (AIMS)	EPSCoR Research Infrastructure Improvement Track 2	Lead Inst.: University of Kansas Center for Research, whole award is 2,999,199;	University of Alabama: Carla Atkinson, Jon Benstead, and Charles (Nate) Jones	9/1/2020	8/30/2024	1,216,905

Biotechnology and the University of Nebraska will partner to conduct cutting-edge plant genomics research to better understand how nitrogen affects plant growth and development. HudsonAlpha Institute for Biotechnology will bring its biotechnology education and agricultural genomics research expertise to the collaborative project while the University of Nebraska-Lincoln will contribute its expertise in plant transformation and automated phenotyping with their state-of-the-art automated greenhouse system for imaging large plants. Researchers will collect information of how plants respond to nitrogen levels through a variety of genetic, biotechnological, and observational methods in the widely-used grain crop sorghum. Sorghum thrives in climates where many food crops struggle and is more efficient at utilizing resources such as water and nitrogen. It is an ideal crop to target for improvement to meet the predicted doubling of global food demand by 2050. In addition, the project will include an educational component, which will train and inspire students to pursue genetic and biotechnology-based research for agriculture. To accomplish this, HudsonAlpha will develop a three-week summer course for advanced high school students called the "AgriGenomics Academy." Additional activities include the recruitment of three undergraduates who will complete summer internships at both HudsonAlpha and University of Nebraska-Lincoln to learn advanced techniques, and support for the Launching Aspiring Biotechnology Students (LABS) program, which introduces low and moderate-income students to biotechnology. The project will also mentor four early career faculty. In addition to nitrogen use efficacy, the combined efforts of these two institutions will make significant progress toward understanding the biology of other complex agronomic crop traits.

Research Principal Investigator Jeremy Schmutz (left) and co-Investigator Kankshita Swaminathan (right) with a sorghum plant growing in HudsonAlpha's plant growth chamber".

RII Track-2 FEC: Consortium for Plant Invasion Genomics (CPING): Combining Big Data and Plant Connections to Understand Invasiveness

Sub: Dr. Michael McKain, UA

Lead: Nicholas Kooyers, University of Louisiana at Lafayette

Invasive species threaten biodiversity, impact crops, restructure ecosystems, promote disease, and damage infrastructure, costing the US $120 billion annually. Despite these impacts, understanding of how and why introduced species become invasive is shockingly incomplete. This knowledge gap reflects a lack of information about the early stages of invasions and the role of evolution in promoting invasiveness. The recent revolution in genome sequencing and computing technology promises to narrow this gap. By comparing genome sequences of historic herbarium specimens spanning the duration of an invasion, researchers are able to step back in time and examine the patterns and processes that promote invasion from initial introduction to present day. The Consortium for Plant INvasion Genomics (CPING) will harness the Big Data generated by this genomic revolution for the study of invasive species and train a generation of scientists in new genomic methods. Through collaborative projects focused on five invasive species of national concern, CPING initially housed at the University of Louisiana at Lafayette, South Dakota State University, the University of Alabama, Tuscaloosa, West Virginia University, and Wichita State University will expand to unite scientists and students at more than 60 institutions in 18 EPSCoR states to better understand how plants become invasive and provide insights into the management and prevention of invasive species. CPING incorporates a training program in new genomic methods designed for all levels of academia (undergraduate students to faculty) comprising 5-day genomics bootcamps that will train 36 scientists from

regional and local colleges and universities. All participants will contribute to projects on the five CPING focal species and conduct individual research projects in their own labs, providing hands-on research opportunities for 39 undergraduate students. By combining expertise and resources from scientists across many EPSCoR jurisdictions, CPING will facilitate highly collaborative investigation of plant invasions, provide training in key genomic techniques, enable EPSCoR researchers to better compete for funding, and foster genomics and bioinformatics STEM education.

RII Track-2 FEC: IGM--A Framework for Harnessing Big Hydrological Datasets for Integrated Groundwater Management

Dr. Prabhakar Clement, UA

Groundwater depletion is a major water management problem that is of global concern. Locally, the Southeastern US has experienced increased water stress due to the mismanagement of its water resources, especially during drought periods. Rapid agricultural expansion and unplanned urbanization have further aggravated this problem. Given that water-related industries contribute to over 150 billion of US dollars in annual revenues, the long-term sustainability of freshwater resources is of paramount importance to this region. While mapping the availability of water in topsoil, reservoirs, and rivers continues to receive much attention, mapping of groundwater storage changes at a fine spatiotemporal resolution over large areas is currently lacking. This is important because groundwater contributes around 40 percent of freshwater usage in the conterminous US, and its contribution in some Southeastern states, e.g., Mississippi, is over two-thirds. Groundwater also indirectly sustains surface water resources, and hence its actual contribution to freshwater usage is even larger than reported. The goal of this project is to harness the big data to implement an integrated groundwater management (IGM) framework that will provide new scientific insights and make useful groundwater predictions at an unprecedented fine spatiotemporal resolution. The IGM framework integrates hydrological, geological, and satellite datasets with machine learning tools and high-resolution simulation models. The information generated will be made available to a wide group of stakeholders through a web-based platform to help develop engineering and policy solutions. The research tasks and workforce development efforts will be jointly accomplished by a team of interdisciplinary researchers at five universities: The University of Alabama, Louisiana State University, University of Mississippi, Tuskegee University, and Southern University.

RII Track-2 FEC: Precise Regional Forecasting via Intelligent and Rapid Harnessing of National Scale of Hydrometeorlogical Big Data

Sub: Dr. Sytske Kimball, USA

Lead: Dr. Nian-Feng Tseng, University of Louisiana at Lafayette

Global warming has emerged as a stark problem of national importance, as it results in more frequent extreme weather and climate events that cause rising economic loss and adverse societal impacts on numerous sectors, such as agriculture, transportation, water resource management, urban planning, among others. For better observations and numerical models on weather and climate parameters

Dr. Sytske Kimball

to improve forecasting accuracy, this project addresses precise regional forecasting via intelligent and rapid harness on national scale hydrometeorological Big Data. It aims to improve meteorological and hydrologic forecasts at target regions of interest by integrating massive atmospheric data sets with gathered surface data for finer temporal and spatial predictions, containing both fundamental research and experimental activities. Its solution approach is innovative by leveraging the actual gathered data as feedback to make prediction models generate better products with multiple near-term time horizons. Better regional prediction results from harnessing Big Data intelligently and rapidly via utilizing (1) a collection of proposed simple neural network models (called modelets) and (2) multiple accelerating methodologies developed or under development by the research team members. The modelet-based solutions for improving weather prediction spatially and temporally are applicable to all regions in the nation, with easy portability. They are being undertaken synergistically by jurisdictional collaboration across five universities in Louisiana, Alabama, and Kentucky, plus U.S. Geological Survey, enabling broad engagement at the frontiers of discovery and innovation in science and engineering related to accelerating data analytics, meteorology, and hydrology. Besides promoting the progress of science, this multidisciplinary project advances the national prosperity and welfare by curbing potential disruption due to global warming. The project also includes comprehensive efforts for (1) building future leadership through collaboration and supervision of junior investigators for their career advances, (2) enriching educational materials on the focused disciplines and strengthening student research to boost workforce development, and (3) aggressively recruiting and engaging underrepresented participants to support diversity.

RII Track-2 FEC: The IceCube EPSCoR Initiative (IEI) – IceCube and the Date Revolution

Sub: Drs. Juan Marcos Santander and Dawn Williams, University of Alabama

Lead: Dr. Xinhua Bai Xinhua, South Dakota School of Mines and Technology

Top: Dr. Santander
Below: Dr. Williams

This Research Infrastructure Improvement Track-2 Focused EPSCoR Collaborations (RII Track-2 FEC) award brings together scientists from Alabama, Alaska, Delaware, Kansas, Nebraska and South Dakota to explore how Data Revolution can provide new insight into the Universe and its extreme phenomena: Where and how is the Universe producing microscopic particles that carry macroscopic energies? Traditional astronomy has progressed from telescopes for visible light to include the full electromagnetic spectrum from radio to gamma-rays. Cosmic rays were discovered over a century ago, but the sources of these high energy particles from outer space remain mysterious. Recent discoveries by LIGO, Virgo, and IceCube have opened new windows on the Universe through gravitational waves and high energy neutrinos from deep space. Observations of these cosmic messengers have brought us into the era of Multi Messenger Astronomy (MMA). As one can imagine, multi-messenger observations with a network of a variety of detectors produce huge amounts of data with enormous complexity. Managing and analyzing the data pose a tremendous challenge to the science community, particularly those groups spread in EPSCoR states. This project will grow Big Data capability across six EPSCoR jurisdictions to address the challenge. Scientists with complementary skill sets will cooperate to make advances in MMA, beyond what could be done within a single jurisdiction. The project supports five early career faculty and trains postdoctoral scholars and college students. It also exposes

secondary school students from underrepresented groups to IceCube and its Big Data challenges, which will help recruit young people into STEM fields and promote diversity and inclusion. The project?s vision is to establish a strong EPSCoR team that promotes new scientific ideas and innovates Big Data techniques to make discoveries in the era of MMA while preparing a high-tech workforce beneficial to all six participating EPSCoR states.

RII Track-2 FEC: Aquatic Intermittency Effects on Microbiomes in Streams (AIMS)

Sub: Drs. Carla Atkinson, Jon Benstead, and Charles (Nate) Jones, University of Alabama

Lead: Dr. Amy Burgin, University of Kansas Center for Research

Top to Bottom: Drs. Atkinson, Benstead, and Jones

Understanding of links among microbial communities (microbiomes), stream health, and water quality relies on studies of perennially flowing streams. However, more than half of global stream-miles do not flow continuously. These intermittent streams occur across the entire country--from western deserts to eastern forests. Despite their ubiquity, research on intermittently flowing streams is impeded by a lack of: 1) physical infrastructure designed to measure intermittency, and 2) scientific training that straddles aquatic and terrestrial ecology. The Aquatic Intermittency effects on Microbiomes in Streams (AIMS) project will address the first obstacle by creating a network of instrumented sites designed to generate "Big Data" to quantify flow intermittency, stream microbiomes, and water quality. AIMS will confront the second obstacle by using its network to provide training in collaborative science and interdisciplinary methods to study intermittent streams, and by providing workforce training in environmental "Big Data" tools through a new On Ramps to Data Science program, which will focus on data generated by microbiome sequencing, environmental sensors, and Geographic Information Systems (GIS). This infrastructure and training will support a team of 18 investigators, including nine early career scientists spanning five EPSCoR jurisdictions (AL, ID, KS, MS, OK). To build capacity in team science, 11 graduate students and two postdoctoral associates will be recruited using a cohort model that will provide cross-jurisdictional training in scientific communication, inclusive mentoring, data management and collaboration. Students will be trained through AIMS Undergraduate Program (AIMS UP), which will recruit participants from regional partners, such as Haskell Indian Nations University, Alabama A&M, and the Shoshone-Bannock Summer Youth Program. Our overarching objective is to create research infrastructure and training capable of integrating big data sources needed to address water quality at the critical nexus between intermittent and perennial streams.

NSF EPSCoR RII Track 4

NSF EPSCoR RII Track 4 - EPSCoR Research Fellows funds non-tenured faculty to further develop their individual research potential through extended visits to learn new techniques, benefit from state-of-the-art equipment and facilities and shift their research toward transformative new directions to benefit the research capacities of their institutions and jurisdictions. Experiences gained through fellowships are intended to provide benefits impacting the recipient's career for years to come and in turn enhance the research capabilities of their institutions and jurisdictions. Any research topic that fits within NSF's overall portfolio is available for support. There is a limit of three proposal submissions per eligible jurisdiction.

During FY 2019, Alabama was awarded three new NSF RII Track 4 awards. The list includes Dr. Kannatassen Appavoo at the University of Alabama at Birmingham; Saeed Latif at the University of South Alabama; and one to Jeffrey Krause, (University of South Alabama) at the Marine Environmental Sciences Consortium at Dauphin Island Sea Lab. In FY 2020, Alabama EPSCoR was awarded five new NSF RII Track 4 Awards. Awardees include Dr. Majid Beidaghi at Auburn University; Dr. Xu Wang from Auburn University; Dr. Steven Weinman from The University of Alabama; Dr. Biswait Ray from the University of Alabama in Huntsville and Dr. William Jackson from the University of South Alabama.

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NEW NSF EPSCoR Research Infrastructure Improvement (RII) Track 4 Awards, FY19 and FY20							
Award No	Title	Type	PI	Inst.	Start date	End Date	Award Amt.
2019							
1832898	RII Track-4: Designing Solution-Processed Hybrid Metamaterials via DNA Self-Assembly	EPSCoR Research Infrastructure	Kannatassen Appavoo	UAB	10/01/2018	09/30/2020	$246,292.00
1833016	RII Track-4: Investigating 3-D Dispersed Smart Antenna Arrays for Nearly Full Spherical Scanning by New Radios (NRs)	EPSCoR Research Infrastructure	Saeed Latif	USA	10/01/2018	09/30/2020	$170,046.00
1833053	RII Track-4: Peering into Nature's Glass Boxes - using nano-Raman Spectroscopy to answer Novel Questions in Diatom-focused Environmental Research	EPSCoR Research Infrastructure	Jeffrey Krause	Marine Environmental Sciences Consortium	10/01/2018	09/30/2020	$121,325.00
2020							
1929195	RII Track-4: Electrochemical Modulation of Permeability and Selectivity of Conductive MXene Membranes	EPSCoR Research Infrastructure	Majid Beidaghi	Auburn University	12/01/2019	11/30/2021	$183,801.00
1928770	RII Track-4: Transcriptome Profile and X Chromosome Dosage Compensation in the Zonary Placenta	EPSCoR Research Infrastructure	Xu Wang	Auburn University	12/01/2019	11/30/2021	$245,298.00
1928812	RII Track-4: Use of Positron Annihilation Lifetime Spectroscopy to Engineer Membrane Selective Layers	EPSCoR Research Infrastructure	Steven Weinman	University of Alabama Tuscaloosa	12/01/2019	11/30/2021	$233,463.00
1929099	RII Track-4: Real-Time Radiation Dosimetry Using Flash Memory	EPSCoR Research Infrastructure	Biswajit Ray	University of Alabama in Huntsville	12/15/2019	11/30/2021	$233,345.00
1929117	RII Track-4: Using Zircon (U-Th)/He Thermochronology to Explore a Link Between Mesozoic Tectonism and Nonmarine Sedimentation in the Eastern Tibetan Plateau	EPSCoR Research Infrastructure	William Jackson	University of South Alabama	12/15/2019	11/30/2021	$146,483.00

RII Track-4: Designing Solution-Processed Hybrid Metamaterials via DNA Self-Assembly

Dr. Kannatassen Appavoo, UAB

With increasing demands to build devices that have a smaller footprint but operate at greater speeds, it is critical to develop materials with never-before-seen properties. These demands in performance are tied with developing nanofabrication techniques that are cheap and scalable in order to rapidly deploy these advanced materials into novel energy, communication and medical technologies. Metamaterial, a class of material that does not occur in nature, can possess exotic properties as determined by their periodic, organized structures rather than the intrinsic material properties of their individual units. However, fabricating metamaterials is often costly and time-consuming, thus requiring sophisticated tools to create periodic arrays of nanostructures with high precision. In this project, the Principal Investigator will partner with experts at Brookhaven National Laboratory to develop a low-cost solution-process technique to fabricate three-dimensional metamaterial (BNL). The goal is to use self-assembly, the natural process by which complex structures are put together, to arrange subunits of different nanostructures into a three-dimensional metamaterial, providing real-time insights on the environmental factors that modify this process. This highly interdisciplinary project provides education and training opportunities in the fields of photonics, nanofabrication and high-resolution microscopy, and enables graduate and undergraduate students from Alabama to conduct research at BNL. If successful, this project will offer a strategy to create metamaterial on a large scale, aligning with the Materials Genome Initiative's vision to discover, manufacture, and deploy advanced materials in half the time and at a fraction of the cost.

RII Track-4: Investigating 3-D Dispersed Smart Antenna Arrays for Nearly Full Spherical Scanning by New Radios (NRs)

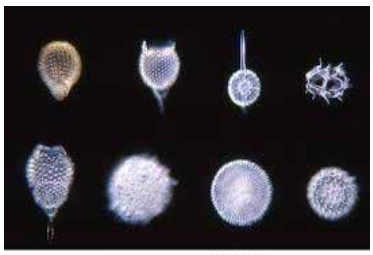
Dr. Saeed Latif, USA

The existing 4G cellular systems have stretched their capabilities to a limit that they can no longer be extended or incrementally improved to meet the mounting demand for high bandwidth-consumptive mobile services. As the demand for large bandwidth and high data rate for mobile applications is at all-time high, future 5G (5th Generation) mobile terminals must operate at unused millimeter wave (mmWave) bands. It is also expected that existing lower frequency 4G bands will continue to be needed for wide area coverage. In this project, it is proposed to investigate the performance of a new generation of smart dispersed array antenna architecture for future 5G new radios (NRs). The mmWave arrays will be integrated into recently designed 4G/LTE multi-slot antennas for interoperability between cells of 4G networks and future 5G heterogeneous cells. This will provide a unified connectivity platform for existing and emerging connected services. This fellowship will be a unique opportunity for the PI and a graduate student to access state-of-the-art facilities and advanced fabrication equipment. The project outcomes will be utilized to attract members of minority and underrepresented groups to engineering education in the Gulf Coast region. This will also boost the University of South Alabama's recruiting effort to attract outstanding undergraduate students, and drive up new mobile-based economic development opportunities in the Gulf Coast and in the State of Alabama.

RII Track-4: Peering into Nature's Glass Boxes - using nano-Raman Spectroscopy to answer Novel Questions in Diatom-focused Environmental Research

Dr. Jeffrey Krause, Marine Environmental Sciences Consortium

Diatoms are abundant microscopic oceanic 'plants' which have a protective shell made of glass. Despite their small size, diatoms' collective importance in marine ecosystems is immense. They produce as much oxygen globally as all the rain forests combined. Their glass shell (i.e. diatomaceous earth) also has many industrial applications. Unlike land plants which grow relatively slow, diatom biomass accumulates fast and is rapidly recycled in seawater. The recycling of diatom biomass releases 5-10 billion metric tons of carbon back into the ocean annually -a quantity of carbon which exceeds global fossil-fuel emissions. This project will use state-of-the-art technology to examine the properties of the glass shell and determine how they affect diatom-biomass recycling. This technology uses single-cell analysis, instead of traditional methods which require thousands of cells, thereby enabling new understanding and insight of single-cell material composition and structure. This project will help entrench this technology into diatom-based research and provide training for a Ph.D. student. The project collaboration with Stony Brook University based scientist will help researchers at the Alabama-based Dauphin Island Sea Lab personnel to emerge as leaders in their subfields. Also considering the vast industrial application for diatomaceous earth, these approaches may be useful for industry. This expertise will enable future work to serve the unique environmental research needs in the northern Gulf of Mexico (Alabama, Mississippi, Louisiana).



RII Track-4 Real-Time Radiation Dosimetry Using Flash Memory

Dr. Biswajit Ray, UAH

Throughout the world, radiation exposure has been on the rise due to the increased use of nuclear power, medical procedures, nuclear weapons and natural disasters affecting power plants such as in Fukushima, Japan. Increased exposure to radiation has both short- and long-term detrimental effects on the human body and rapid diagnosis (triage) of an absorbed dose of radiation is critical for survivability. Thus, it is critical to have a fast, cost-effective and field-deployable personal dosimetry solution without the overhead of additional hardware or processing equipment. The project will develop a handheld, real-time radiation dosimetry solution using commercially available flash memory chips. Since memory chips are widely used in many embedded systems (e.g., smartphones) and wearable devices (e.g., fitness belts), this project's concept could provide a paradigm shift in radiation dosimetry through distributed smart devices, which will be very useful for health monitoring, remote sensing, military applications, nuclear-reactor safety and space applications. In addition, the project has a strong educational component that includes the training of underrepresented students, the involvement of undergraduate students in research and the incorporation of the project's research findings into coursework.

The objective of this project is to develop a novel cost-effective radiation-dosimeter technology using the bit error rate of commercial flash memory. The dosimetry solution will provide real-time read-out of absorbed dose value, which is ideal for rapid diagnosis applications to minimize health risk for those who work closer to radiation environment. The technology can also facilitate a wireless sensor network (e.g., through smartphones), and transmit data to a central facility to provide better situational awareness over a larger area. The project takes advantage of the instrumentation and expertise at Oak Ridge National Laboratory to demonstrate the validity of a flash memory-based dosimetry concept through a series of radiation-exposure experiments. Both modeling and experimentation will be performed to determine the range of operation of the proposed dosimeter and to enhance its accuracy, sensitivity and selectivity. In addition, we propose novel measurement techniques in order to understand and quantify the (i) dose-enhancement effect when ionizing radiation goes through the back end of the line metal layers of a chip, (ii) directionality effects of the incident radiation beam on the memory and (iii) ionization vs. displacement damage effect in the flash-memory array. Thus, this research advances our knowledge on the radiation-matter interaction and the radiation-related reliability physics of semiconductor devices. The research will also enable a wireless, passive, in-situ, real-time radiation-dosimetry solution that can be customized for a wide range of applications including personnel dosimetry, safety, space and commercial applications.

For more information log onto Dr. Ray's website at:] https://sites.google.com/a/uah.edu/ray_biswajit/

RII Track-4 Using Zircon (U-th)/ He Thermochronology to Explore a Link Between Mesozoic Tectonism and Nonmarine Sedimentation in the Eastern Tibetian Plateau

Dr. William Jackson, USA

The Tibetan Plateau, the largest and highest plateau on Earth, is a product of the India-Asia continent-continent collision. Because collision is ongoing, geologic processes can be observed and measured, making the Tibetan Plateau an ideal natural laboratory for tectonic investigations. While modern observations and measurements provide details pertaining to active tectonics of the plateau, studies show that ancient, inherited crustal features are a primary control for how the plateau is currently developing. In the eastern Tibetan Plateau, sedimentary and igneous rocks are exposed at the surface that provide a record of these ancient, pre-India-Asia tectonic events; however, these rocks remain largely unstudied. Therefore, the goal of this proposal is to investigate the age and geologic relationships of sedimentary and igneous rocks in the eastern Tibetan Plateau. This study will utilize field and laboratory methods to determine the timing and rates of pre-India-Asia geologic processes. By integrating field data with modern age dating techniques, the ability to quantify when and how these rocks were exhumed to the Earth?s surface will be possible. Advancing our knowledge in this region will allow us to better understand the Tibetan Plateau, as well as older mountain belts and large plateaus on Earth.

Dr William Jackson

Modern observations and measurements of Tibetan Plateau provide insights into active tectonic processes during plateau development. However, to fully incorporate these data a better understanding of inherited, Mesozoic tectonic fabrics must be established. In the eastern Tibetan Plateau, the northern Yidun terrane contains Mesozoic sedimentary and igneous rocks that record contractional deformation and exhumation; thereby, providing an opportunity to understand the spatial and temporal development of deformation in the Tibetan Plateau prior to the Cenozoic India-Asia collision. The goal of this proposal is to investigate a link between the exhumation of the Late Triassic Ganzi Pluton and development of two nonmarine sedimentary basins that are in stratigraphic and structural contact with the pluton. To approach this goal, the Principal Investigator (PI) proposes to use bedrock

and detrital zircon (U-Th)/He thermochronology, working in collaboration with the Basin Analysis and Helium Thermochronology Laboratory (BAHTL) at the University of Connecticut, directed by Dr. Julie C. Fosdick. The proposed work is designed to address two main objectives, train the PI in zircon (U-Th)/He techniques and interpretations, and collect thermochronology data to explore a link between Mesozoic tectonism and nonmarine sedimentation. Results from this project will advance our understanding of Mesozoic tectonics in the eastern Tibetan Plateau, providing initial crustal input parameters for mechanical models. Advancing our knowledge of geologic processes that develop high-elevation (> 4 km) mountains and plateaus will help us better integrate large data sets that seek to understand global-scale natural processes.

RII Track-4 Use of Positron Annihilation Lifetime Spectroscopy to Engineer Membrace Selective Layers

Dr. Steven Weinman, UA

This project seeks to build on the water research at The University of Alabama at Tuscaloosa (UA). With a wealth of natural water sources and access to the Gulf of Mexico, Alabama is an ideal location for research in water treatment processes. As such, UA has made water one of its four research pillars to provide better water quality for all people. Polyamide membranes, often called reverse osmosis or RO membranes, are commonly used for seawater desalination. However, their molecular level properties are not well understood. This project will allow researchers from UA to conduct studies at the National Institute of Standards and Technology (NIST) to learn a new technique to characterize the molecular-level properties of water treatment polymer membranes. This research seeks to understand how synthesis conditions affect membrane performance at the molecular level, specifically those involved in seawater desalination. The polymer characterization technique will be of great benefit to make these membranes more energy-efficient and cost-effective. This work will initially provide training for one graduate student, and results will be integrated into undergraduate curriculum and research. The research collaboration formed through this project will help develop capacity at UA to characterize polymers using cutting-edge technology, providing additional opportunities to educate and train graduate and undergraduate students.

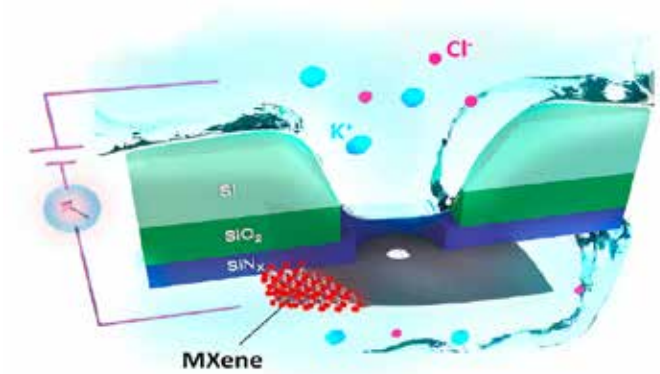
WEINMAN RESEARCH GROUP

Dr. Weinman's research group logo. Representing water membranes, the "W" has contaminated water on the left side and clean water on the right side, the middle part of the letter W acts as a membrane (specialized filter) to clean the water.

RII Track-4 Electrochemical Modulation of Perameability and Selectivity of Conductive MXene Membranes

Dr. Mejid Beidaghi, Auburn University

The development of efficient membrane-based water desalination and purification technologies is essential for addressing the global challenges of water scarcity and pollution. An ideal separation membrane should show high permeance (transport of desired species) and high selectivity (rejection of undesired species), two properties that are often inversely correlated. In processes such as water desalination and removal of heavy metals from water, charged ions are separated from water by size exclusion or electrostatic interactions with a membrane. Two-dimensional (2D) materials are crystalline materials consisting of one or few layers of atoms and have attracted much interest in recent years for the fabrication of efficient membranes. Nanoporous or lamellar membranes based on 2D materials can potentially separate ionic species from water at higher rates and more efficiently compared to current membranes. The main goal of this project is to understand the effects of applied electrochemical potential on the separation performance of conductive membranes based on 2D transition metal carbides (MXenes). To achieve this goal, the PI will partner with researchers at Northeastern University to fabricate nanoporous and lamellar MXene membranes and study their separation properties. In addition, this project will provide opportunities to train graduate students in advanced membrane materials synthesis and characterization methods and will establish a long-term collaboration between Auburn University and Northeastern University. The PI will also integrate the result of this research into a recently developed course focused on applications of 2D materials.



RII Track-4 Transcriptome Profile and X Chromosome Dosage Compensation in the Zonary Placenta

Dr. Xu Wang, Auburn University

Prenatal development of mammalian fetuses relies on an important organ known as the placenta. Despite its critical function in gas exchange, nutrient transport and immunity at the maternal-fetal interface, the placenta is the most morphologically diverse organ in mammals, with at least five different forms. One of these forms include the zonary placenta, which has a unique belt-like structure that wraps around the fetus. The zonary placenta consists of multiple tissues in three major zones: the transfer zone, the pigmented zone and the allantochorion. The function of each of these zones remains poorly understood. Female dogs have two X chromosomes and males only have one, resulting an unequal dose of X-linked genes. Dosage compensation is achieved by inactivating one X chromosome in females through a process called X chromosome inactivation. Different strategies, including random and imprinted X chromosome inactivation, are observed in mammalian placentae. The mechanism of X chromosome inactivation in canine placenta is unknown. To fill in these gaps, we propose to characterize gene expression profiles and regulation of X chromosome inactivation in different canine placental tissues. This proposed research will lead to comprehensive understanding of regulated gene expression and a comparative analysis of dosage compensation across different types of animals.

The goal of this research is to understand the gene expression and epigenetic control of X chromosome dosage compensation in the zonary placenta. The mammalian placenta is a key evolutionary innovation that dramatically improves the reproductive success through in utero development of the embryos. Despite its critical function, placenta is the most morphologically diverse organ with five major placentation forms. Zonary placenta is observed in carnivores including companion animals such as cats and dogs. The band shaped placenta encircles the fetus with three distinct zones: the transfer zone, the pigmented zone and the allantochorion. Their functions and transcriptome profiles are still poorly understood. In therian mammals, females and males have unequal dose of X-linked genes, and this is solved by a mechanism called dosage compensation (DC). In somatic tissues of eutherian mammals, DC is achieved by random X chromosome inactivation (XCI) in females, in which one of the two X chromosomes is inactivated and the choice is random. In the extraembryonic tissues that give rise to placenta, imprinted XCI was observed in rodents, in which it is always the paternal X that is inactivated. The XCI status remains to be characterized in zonary placenta. This project will achieve the following objectives: 1) Characterize the full-length transcriptomes and functional enrichment of gene networks in the transfer zone, pigmented zone and allantochorion of the canine placenta, 2) Investigate the form, status, escaping profile and epigenetic regulation of XCI in the zonary placenta. This proposed research will lead to comprehensive understanding of the profile and epigenetic regulation of XCI in zonary placenta through single-cell RNA sequencing, which opens the door to comparative phylogenomic analysis of dosage compensation.

An adult Vapor Wake detection dog and her puppies at Auburn University's College of Veterinary Medicine Canine Performance Science Program. Vapor Wake dogs are trained to detect explosives and other illicit substances on moving targets in crowded areas.

NATIONAL SCIENCE FOUNDATION CO-FUNDED EPSCoR

NSF Co-funding

To accelerate the movement of EPSCoR researchers and institutions into the mainstream of NSF support, EPSCoR Co-funding is available to provide support for proposals submitted to NSF's research, education and cross-cutting competitions. The objectives of the EPSCoR Co-funding mechanism are:

- To increase the number and competitiveness of EPSCoR jurisdiction investigators and institutions who participate in NSF research, technology, and education programs;
- To increase the participation of EPSCoR jurisdiction researchers and institutions in regional alliances and national collaborations;
- To broaden participation in science and engineering by institutions, organizations and people within and among EPSCoR jurisdictions.

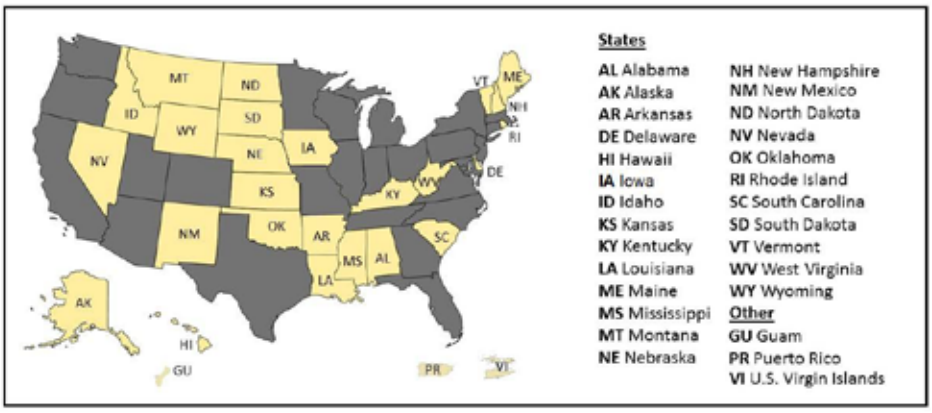
NSF Co-funding is not a program that can be applied to directly but works internally at NSF to provide joint support for certain meritorious proposals submitted to NSF's research, education, and cross-cutting Directorate competititions. The EPSCoR Co-funding mechanism focuses on those "Fund-if-Possible" proposals, which the NSF merit review process finds to lie at or near the cutoff for funding by the programs to which they were submitted. EPSCoR co-funds meritorious proposals that would otherwise not be supported due to availability of funds or other overriding program priorities.

For such proposals, the managing Program Officer first decides whether to make an award recommendation and the amount and duration to be recommended for the award. The decision to recommend an award or declination rests with the managing program. Once these decisions are made, a request for partial support via EPSCoR Co-funding can be forwarded to the EPSCoR for consideration. NSF EPSCoR Co-funding Mechanism is dependent on the number and quality of proposals submitted from EPSCoR jurisdictions and the availability of EPSCoR funds for Co-funding.

Proposal characteristics that will enhance the likelihood of EPSCoR co-funding are: (a) researchers who have not previously received NSF awards or researchers whose awards ended three or more years ago; (b) requests reflecting collaborative efforts within and across participating jurisdictions and at regional, national and/or international levels; (c) projects submitted to cross-discipline or cross-directorate programs; (d) projects that are synergistic with NSF investment and funding priorities in the current fiscal year; (e) projects that increase participation of members of underrepresented groups and/or institutions; (f) requests for instrumentation that build research capacity at the institutional or jurisdictional level; (g) student programs that will significantly enhance institutional research capability and competitiveness or provide training opportunities for K-12 students and professional development for K-12 teachers; and (h) programs that exemplify NSF's commitment to the integration of research and education.

In FY 2019, Alabama was awarded seventeen NSF Co-funded awards which include three CAREER awards and four MRI awards. In FY 2020, Alabama was awarded 19 new NSF Co-funded awards, which include four CAREER awards; two RAPID award to study the COVID-19 pandemic, one MRI award, and three REU sites.

NSF EPSCoR FY19 Co-funding Eligibility



EPSCoR states and other U.S. jurisdictions eligible for EPSCoR co-funding during FY 2019
This includes twenty-five states, Guam, Puerto Rico, and the U.S. Virgin Islands.

NATIONAL SCIENCE FOUNDATION CO-FUNDED EPSCoR

CAREER awards are a Foundation-wide funding mechanism and is NSF's most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the mission of their institution. GOALI (Grant Opportunities for Academic Liason with Industry) awards seek collaboration between academic research institutions and industry. The Major Research Instrumentation (MRI) Program's goal is to increase access to shared scientific and engineering instruments for research and training in U.S. institutions of higher education, not-for-profit museums, science centers, and scientific/engineering research organizations. EAGER awards fund exploratory work in its early stages on untested, but potentially transformative research ideas of approaches, this is often considered high-risk, high payoff. REU (Research Experiences for Undergraduates) supports active participation by undergraduates in research projects. RAPID (Rapid Response Research) awards respond to a severe urgency with regard to availability of, or access to, facilities or specialized equipment, including quick response research on natural or anthropogenic disasters and similiar unanticipated events. RCN-UBE (Research Coordination Networks in Undergraduate Biology Education) awards, RCN awards seek to advance a field or create new directions in research or education by supporting groups of investigators to communicate and coordinate their research, training, and educational activities across disciplinary, organizational, geographic and international boundaries.

CAREER: Investigating the mechanistic basis of host adaption in close and distant relatives within Xanthomonas species complex

Dr. Neha Potnis, Auburn University

Increased global trade, modern agricultural practices and global climate change have predisposed agro-ecosystems to the increased risk of outbreaks of old and new diseases. These outbreaks impacting food security are a major societal concern. To manage disease outbreaks, understanding various mechanisms employed by diverse pathogenic species to infect a common host or, at times, to acquire infectivity on a new host is crucial. While molecular mechanisms underlying pathogenesis on a given host have been uncovered in individual pathogenic species, understanding whether these mechanisms are conserved across diverse species infecting common host remains elusive. The goals of this project are to 1) understand various mechanisms that diverse pathogenic bacteria use to specialize on a common host, 2) identify traits that allow pathogenic bacteria to acquire infectivity on a new host. This knowledge will help resolve complex interactions between plants and pathogens and foster development of effective strategies to respond and manage pathogen populations. The educational goals include fostering STEM research interests by providing research opportunities for high-school students from high-need schools in Alabama and first-generation minority undergraduate students, and raising public knowledge of emergence of plant disease outbreaks, their influence on plant health and, ultimately, on our lives. The project will educate students on what makes bacterium pathogenic and how diseases emerge in the modern era of agriculture. his project is jointly funded by IOS-Plant Biotic Interaction and the Established Program to Stimulate Competitive Research (EPSCoR).

Graduate student, Prabha, is inoculating tomato plants to study how pathogens evolve different infection strategies on different types of host plants.

NATIONAL SCIENCE FOUNDATION CO-FUNDED EPSCoR

FY 2020 New NSF Co-funding						
Award No	Title	PI	Inst	Start Date	End Date	Award Amt
2005194	Twist and route canalized polariton nano-light in MoO3 microstructures	Siyuan Dai	Auburn University	8/1/2020	7/31/2023	217,928
1942956	CAREER: Investigating the mechanistic basis of host adaptation in close and distant relatives within Xanthomonas species complex	Neha Potnis	Auburn University	02/15/2020	01/31/2025	849,698
1950304	REU Site: Collaborative Approaches among Scientists and Engineers	Kimberly Mulligan	Auburn University	04/15/2020	03/31/2023	404,476
1950488	Concurrent Multiscale Moving-Window Scheme for Shock Wave Interaction with Material Microstructure	Vinamra Agrawal	Auburn University	06/01/2020	05/31/2023	408,164
1950563	REU Site: Research Experience for Undergraduates in Algebra and Discrete Mathematics at Auburn University	Overtoun Jenda	Auburn University	04/01/2020	03/31/2023	259,200
2012081	Catalyst Award: Tuskegee University CURES	Deloris Alexander	Tuskegee University	08/15/2020	07/31/2022	199,990
1932547	CPS: Small: Collaborative Research: RF Sensing for Sign Language Driven Smart Environments	Sevgi Gurbuz	University of Alabama Tuscaloosa	10/01/2019	09/30/2021	366,252
1944374	CAREER: Photovoltaic Devices with Earth-Abundant Low Dimensional Chalcogenides	Feng Yan	University of Alabama Tuscaloosa	07/01/2020	06/30/2025	391,090
1950855	REU Site: Interdisciplinary Convergence to Advance the Biotechnological and Bioscience Workforce	Ryan Summers	University of Alabama Tuscaloosa	05/15/2020	04/30/2023	428,647
1951552	IRES Site: Fractional-Order Circuits and Systems Research Collaboration with EU COST Action	Todd Freeborn	University of Alabama Tuscaloosa	09/01/2020	08/31/2023	299,861
2007013	Collaborative Research: The Circumgalactic Dictionary: An Interpretation Guide For Circumgalactic Medium Observations	Jeremy Bailin	University of Alabama Tuscaloosa	9/1/2020	08/31/2023	385,219
2012554	When Can We Cluster Data? Improved Conditions for Perfect Recovery and Numerical Methods	Brendan Ames	University of Alabama Tuscaloosa	08/15/2020	07/31/2022	129,374
2027085	RAPID: Approach-Avoidance Tendencies to Pathogen-Salience as a Function of Uncertainty and Regional COVID-19 Infection Rates	Philip Gable	University of Alabama Tuscaloosa	04/01/2020	10/31/2020	77,472
2042786	Cluster Algebras, Quiver Representations, and Rigid Curves	Kyungyong Lee	University of Alabama Tuscaloosa	08/01/2020	10/31/2021	72,139
2019120	MRI: Acquisition of a 3.0 Tesla Magnetic Resonance Imaging Scanner	Rajesh Kana	University of Alabama Tuscaloosa	9/1/2020	8/31/2022	1,605,115
2042683	CAREER:Hybrid Data-driven Synthesis by Design of Atomically Thin Quantum Materials	Kasra Momeni	University of Alabama Tuscaloosa	07/27/2020	02/28/2025	509,509
1943465	CAREER: Understanding the Combined Effect of Microstructure and Topology on the Mechanical Behavior of Additively Manufactured Lattice Structures	Kavan Hazeli	University of Alabama in Huntsville	08/15/2020	07/31/2025	540,001
1951488	IRES Track I:Collaborative Research:Application-Specific Asynchronous Deep Learning IC Design for Ultra-Low Power	Na Gong	University of South Alabama	09/01/2020	08/31/2023	99,996
2030080	RAPID: Exosomal tRNA fragments may constitute an innate viral defense against SARS-CoV-2 and other respiratory RNA viruses.	Glen Borchert	University of South Alabama	05/15/2020	04/30/2021	199,810
						$7,443,941

NATIONAL SCIENCE FOUNDATION CO-FUNDED EPSCoR

REU Site: Research Experience for Undergraduates in Algebra and Discrete Mathematics at Auburn University

Dr. Overton Jenda, Auburn University

This NSF award will support 8 undergraduate students for 8 weeks at Auburn University in each of the summers 2020-2022 to conduct research in algebra and discrete mathematics. The program is a continuation of successful NSF funded REU programs conducted by the proposers at Auburn in 1999, 2000, 2005-2008, and 2010-2019. Almost all of our alumni who are no longer undergraduates went to graduate school, slightly more than half in mathematics and the others in mathematics education, computer science, statistics and statistical sciences, including mathematical branches of biology. This shows that our program has positive impact on undergraduates and various mathematical disciplines. Our goal of having half of the participants to be women, our effort in recruiting minority students, and our focus on the American Southeast support NSF's vision of developing a diverse workforce. In 2013-2017, a number of our recent and not-so-recent alumni participated in the Masamu Program, NSF Award No. 1343651, by going to Southern Africa for the annual Southern Africa Mathematical Sciences Association conference, workshop, and Masamu Advanced Study Institute for the purpose of fostering US-Africa collaborative research with Sub-Saharan African mathematicians; this participation will continue. This project is jointly funded by the Workforce Program in the Mathematical Sciences and the Established Program to Stimulate Competitive Research (EPSCoR).

CPS: Small: Collaborative Research: RF Sensing for Sign Language Driven Smart Environments

Dr. Sevgi Gurbuz, UA

Deaf individuals who rely on American Sign Language (ASL) as their primary mode of communication heavily rely on technology as an assistive device. Yet, many technologies are designed for hearing individuals, which precludes the Deaf community from benefiting from advances, which, if designed to be compatible with ASL, could in fact generate tangible improvements in their quality of life. This proposal aims at transforming ubiquitous sensing technologies through the integration of a new sensing modality - radio frequency (RF) sensing - into smart environments designed to respond to the needs of ASL users. RF sensors are uniquely desirable for this application because they are non-contact, can operate in the dark or through-the-wall, protect privacy, and bring to bear a new type of information that will aid in ASL understanding: namely, the micro-Doppler signature, which is reflective of the time-varying velocity profiles of motion. Thus, RF sensing is uniquely suited to capture the rapid progression of dynamic sign sequences that is characteristic of ASL usage. This collaborative project not only brings to bear, for the first time, a linguistic perspective to RF-based motion recognition, but also a physics-based machine learning approach achieved through integration of kinematics with deep learning. In this way, the project aims at 1) improving ASL recognition technologies and the design of smart environments for deaf individuals, 2) augmenting the tools linguists use to analyze language and related cognitive processes, and 3) advancing machine learning approaches specifically geared towards RF signal classification.

(left to right) Dr. Darrin Griffin, Dr. Caroline Kobek-Pezzarossi (visiting Advisory Board Member from Gaulladet University), Dr. Sevgi Z. Gurbuz and Ali Cafer Gurbuz (Mississippi State University)

This project is jointly funded by the Cyber Physical Systems Program and the Established Program to Stimulate Competitive Research (EPSCoR).

RAPID: Approach-Avoidance Tendencies to Pathogen-Salience as a Function of Uncertainty and Regional COVID-19 Infection Rates

Dr. Philip Gable, UA

The growing presence of COVID-19 in the United States creates a social psychological problem of a scale never before encountered in modern times. This time-critical research project investigates how peoples' feelings of uncertainty about the spread of COVID-19 across the United States impacts emotional and motivational behaviors to avoid the virus, even when people may be unaware of how they feel and act. Emotion-based responses are hypothesized to be amplified because of the uncertainty involved in a contagion spread. To test this hypothesis, the project develops a novel smart phone application that participants can use around the country, even when they are in physical isolation. The smart phone application creates a novel way to study the emotional impact of virus transmission as well as educate participants about their own motivations to stay healthy. This project informs and educates about the science of COVID-19 transmission and prevention to help develop interventions for this and future pandemics.

This time-critical RAPID project utilizes the smart phone application to engage in immediate nationwide testing of one thousand individuals from across the country. Testing will continue for nine months so that peak and declining rates of disease are captured. The smart phone application assesses non-conscious motivational tendencies to avoid objects and people which could potentially transmit COVID-19. The research also tests how these motivational tendencies promote or hinder health-related behaviors such as handwashing and social distancing. Importantly, the project investigates regional differences of infection rates across the United States to test the influence of increasing and declining infection rates on peoples? feelings and actions. The research and the software developed in this project will facilitate the development of future interventions aimed at reducing the emotional distress caused by the spread of deadly diseases and to increase healthy behaviors in response to them.

This project is jointly funded by the Social Psychology Program and the Established Program to Stimulate Competitive Research (EPSCoR).

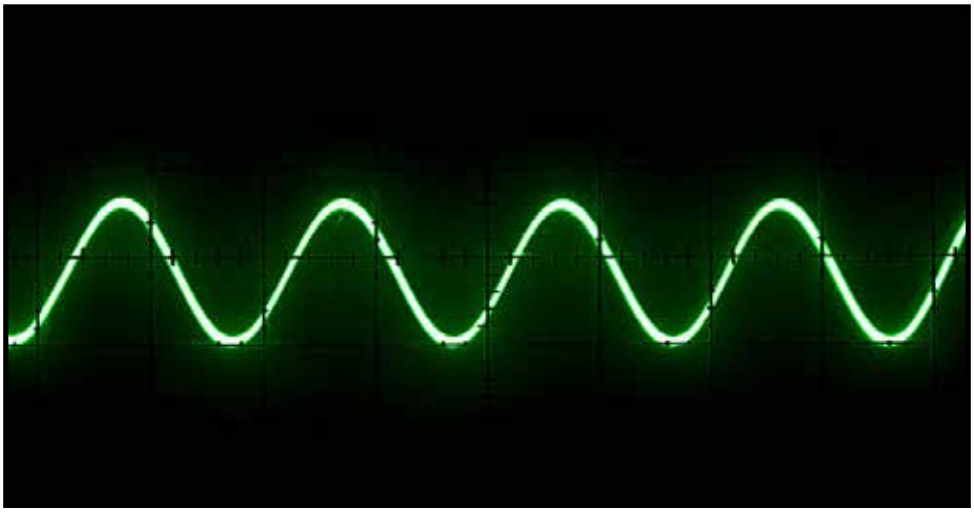
As part of the NSF funded project, Dr. Gable developed a smartphone application which uses smartphone technology to measure people's reactions to objects that could spread COVID-19. The smartphone application allowed the research to be conducted in over 1000 participants around the U.S. during stay-at-home orders.

Concurrent Multiscale Moving-Window Scheme for Shock Wave Interaction with Material Microstructure

Dr. Vinamra Agrawal, Auburn University

Shock waves occur in a material when it is subjected to extreme pressure and temperature changes in a very short time. This is commonly observed in applications when a material is subjected to high speed impact. The need to design advanced materials resistant to shock damage has driven the research into the material's response to shock waves from the nano- and micro-meter scales to the large application scale. This grant, co-funded by the Established Program to Stimulate Competitive Research (EPSCoR), supports fundamental research into the multiscale response of the material when subjected to shock loading. It will provide new knowledge on how shock waves interact with material features at the micro and nano scales leading to deformation and failure at the macroscale. The research will accelerate the design of advanced materials with superior shock resistant properties for n aerospace, automotive, infrastructure and defense industries. Additionally, the project will provide opportunities to educate and train graduate and undergraduate students in the interdisciplinary areas of materials science, computational mechanics, and applied physics and mathematics through research in the laboratory. The PI will also engage in outreach activities related to science and engineering to K-12 students through university programs.

Shock response of the material is multiscale in nature, introducing defects such as voids and dislocations at the microscale and cracks and plastic deformation at the macroscale. This work develops a concurrent multiscale method, with coexisting atomistic and continuum domains, to study shock wave propagation through a material and its interaction with material microstructure. State of the art concurrent multiscale schemes are unable to capture high speed dynamic processes such as shock waves and moving atomistic regions. The framework uses a control volume based moving-window scheme, where the atomistic domain follows a moving shock wave, to circumvent issues with current state of the art schemes. Using this new framework, the work will study microstructural evolution, shock induced defect generation, and the influence of microstructural features such as grain boundaries on shock resistance properties, e.g., spall strength. The framework will be systematically validated against existing experimental data on shock induced defect generation available in the literature.



Career: Hybrid Data-driven Synthesis by Design og Atomically Thin Quantum Materials

Dr. Kasra Momeni, UA

Two-dimensional (2D) crystalline materials consisting of a single atomic layer have unique quantum mechanical properties that are critical for several advanced technological applications such as photovoltaic and electronic devices. However, the synthesis of 2D materials is generally accomplished through exhaustive trial-and-error experimentation that hinders their commercial exploitation. The main impeding factors are the lack of a comprehensive understanding of the underlying growth mechanisms and the lack of real-time measurement of growth states for implementing feedback process control. The research goals of this CAREER project are to (i) develop a computational model to understand the mechanisms governing the growth of 2D materials, (ii) build a database relating the synthesis process to the properties of these materials, and (iii) use artificial intelligence to find the optimum synthesis conditions. The proposed integration of research and education includes course development and laboratory modules for undergraduate and graduate students and research internships for undergraduate students. The outreach program will engage K-12 students and teachers as well as faculty and minority students from a local minority-serving institution.

The proposed research focuses on developing a unified design multiscale framework addressing the growth of 2D materials using the more complex chemical vapor deposition-variant techniques that involve reactive flows of precursors. The objective is to understand the growth mechanisms, such as growth chemistry, and effect of different growth parameters, such as carrier gas flow rates, on the morphology and characteristics of the synthesized 2D materials. This multiscale framework will also be used to build a database of synthesis-morphology conditions to guide the design of new 2D materials. The developed synthesis-morphology database will be used in combination with the ML models, specifically Generative adversarial networks, to predict the morphology and properties of 2D materials significantly faster than the multiscale model. The objective is to develop a model that can be used as an observer with small enough response time that can be useful for real-time control of the synthesis process. The project will also focus on addressing the inverse problem of finding the optimal conditions for growing 2D quantum materials with desired properties. This problem will be first transformed into a classification problem using the synthesis-morphology database, which will be solved utilizing the ML models, and specifically Convolutional Neural Networks. Collaboration with industrial partners is planned through the I/UCRC Center for Atomically Thin Multifunctional Coatings (ATOMIC). The research results will be integrated into a new technical elective course and an existing undergraduate course on engineering materials. A light web-based version of the simulation software will be used for outreach activities and will be made available publicly through the website of the NSF-funded 2D Crystal Consortium - Materials Innovation Platform (2DCC). The outreach program will focus on engaging (1) K-12 students and teachers through STEM training camps and (2) faculty and students belonging to underrepresented minority groups in STEM from a local HBCU, Grambling State University, through computational teaching modules related to the Materials Genome initiative.

This project is jointly funded by the Process Systems, Reaction Engineering, and Molecular Thermodynamics Program and the Established Program to Stimulate Competitive Research (EPSCoR).

NATIONAL SCIENCE FOUNDATION CO-FUNDED EPSCoR

REU Site: Collaborative Approaches among Scientists and Engineers

Dr. Kimberly Mulligan, Auburn University

The Auburn University Collaborative Approaches among Scientists and Engineers (CASE) Research Experiences for Undergraduates (REU) aims to foster increased understanding of different approaches to experimental design through cross-disciplinary problem solving while also addressing the unique challenges faced by students who are traditionally underrepresented in STEM fields. During the 10-week summer program undergraduate students will engage in research that increases their understanding of the collaborative nature of STEM as well as how to utilize the convergence of disciplines to problem-solve. Students will utilize a team-based approach to conduct research on projects led by two faculty mentors from different disciplines. Cross-disciplinary projects include collaborations between Aerospace Engineering and Biological Sciences; Civil Engineering and Geosciences; Biosystems Engineering and Fisheries, Aquaculture, and Aquatic Sciences; as well as Chemistry and Physics. In addition to laboratory experience, the CASE REU will offer weekly professional development workshops that cover a wide-range of topics which address critical-thinking skills, scientific communication, sense of belonging, self-efficacy, and cultural competency. A key component of the CASE REU focuses on fostering effective mentor-mentee relationships both inside and outside of the laboratory, in order to provide students with an opportunity to further develop their scientific identity. This is accomplished in part through collaborative workshops with faculty mentors and participants. The program also includes social activities that provide networking opportunities with faculty, students, and colleagues across REU programs on campus. Upon completion of the program, participants will present their research to the Auburn community and also be provided with resources to travel to national conferences to present their work.

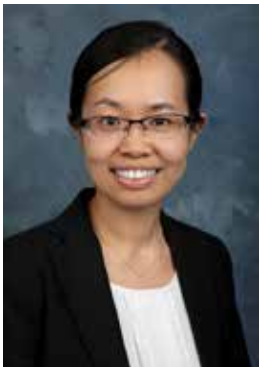
The CASE REU will recruit heavily from national conferences and partner institutions with an emphasis on broadening participation from students traditionally underrepresented in STEM fields. Novice, early-career students as well as those with prior research experience are encouraged to apply. Through participation in the CASE REU students will not only enhance their ability to examine real-world problems utilizing multidisciplinary approaches but also increase their exposure to scientific role models/potential mentors who will provide a supportive environment designed to increase retention and success in STEM.

This project is jointly funded by the Division of Engineering Education and Centers (EEC) and the Established Program to Stimulate Competitive Research (EPSCoR).

Previous REU activities

IRES Track 1: Collaborative Research: Application- Specific Asynchronous Deep Learning IC Design for Ultra Power

Dr. Na Gong, USA



This 3-year IRES Track I project recruits three cohorts of U.S. students to conduct research in China, with the major research goal as developing, fabricating, and testing an ultra-low power application-specific deep learning integrated circuit, and evaluating its performance through the integration with physical Internet-of-Things (IoT) edge computing devices. It brings together three research groups with unique expertise from University of Arkansas (ultra-low power asynchronous circuit design), University of South Alabama (context-aware memory design), and Peking University, China (deep learning algorithm development and optimization). The expected research outcomes will accelerate edge computing for a large variety of IoT applications such as advanced medical and elderly care systems, and self-driving vehicles. Each year six U.S. students work onsite at Peking University for eight weeks, leveraging the onsite research facilities. The multicultural, multidisciplinary nature of this project provides a unique training and career preparation opportunity for the students, including multidisciplinary discussion, teamwork, effective communication, and technical writing. The PIs continue their prior efforts in recruiting student participants from underrepresented and minority groups, leveraging their contacts and the existing mechanisms at each university. The research outcomes and student experiences will be disseminated nation-wide benefiting the research community and encouraging more students to participate in similar programs.

Deep learning is transforming many modern Artificial Intelligence (AI) applications, in many of which deep learning has begun to exceed human performance. However, the superior performance of deep learning comes at the cost of extremely high computational complexity associated with large datasets. Therefore, deep learning algorithms are traditionally implemented in software and executed on powerful general-purpose cloud computing platforms. In contrast to the prevailing research in general-purpose counterparts, the application-specific deep learning IC has much lower power consumption, thereby ideal for integration with power-constrained IoT devices. This IRES project is to develop, fabricate, and test an ultra-low power deep learning integrated circuit (IC), and evaluate its performance through the integration with physical IoT edge computing devices. Technical innovations to be developed by the students include: 1) optimization of application-specific deep learning algorithms for alleviating the requirements of hardware implementation; 2) delay-insensitive asynchronous circuit design for substantially improved energy efficiency; and 3) context-aware memory development for power savings and low implementation cost. This project uniquely connects deep learning algorithm optimization, asynchronous circuit design, and memory optimization together to achieve a highly optimized system, which will benefit the semiconductor and AI societies at large by the revolutions in hardware-tailored deep learning algorithms and specialized computing hardware. It is expected that this research will demonstrate the advantages of application-specific deep learning hardware and layout the foundation of a new and promising direction for both academic research and industrial development.

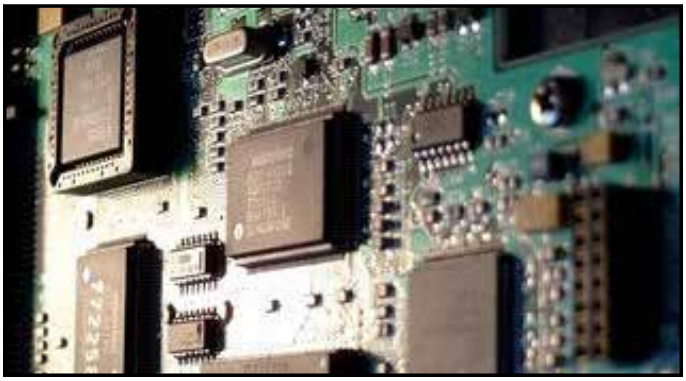
This project is jointly funded by the Office of International Science and Engineering (OISE) and the Established Program to Stimulate Competitive Research (EPSCoR).

IRES Site: Fractional-Order Circuits and Systems Research Collaboration with EU Cost Action

Dr. Todd Freeborn, UA

This IRES Track I project provides U.S. students from the University of Alabama (UA) in Tuscaloosa with 12-week summer international research experiences at the Brno University of Technology (BUT) in the Czech Republic. This project supports the collaborative research efforts of UA and BUT faculty focused on fractional-order circuits and systems. "Circuits and systems" refers to the field encompassing all design, analysis, and implementation efforts related to electrical circuits. Electrical circuits are the foundation upon which all smart devices, wireless communications, automotive systems, power systems, and healthcare devices are built. Advancing circuits and systems in each of these fields requires highly qualified engineers who can not only design and implement circuits and systems, but who can creatively import concepts from new fields to overcome challenges not yet even imagined. Fractional-order circuits and systems is an emerging field expanding the boundaries of realizable electrical circuits; changing how circuits are designed and implemented. Applications of fractional-order systems range from the control of industrial machines with lower control effort and lower energy costs to modelling the electrical impedance of skeletal muscle to track changes in tissue properties to monitor for injury and disorder. However, advances in the design and practical implementation of fractional-order circuits and systems are needed before they can be quickly and efficiently adopted into control systems and biomedical signal processing circuits. The need for further research into this field was recognized by many universities in the European Union (EU), who launched the COST Action CA15225, "Fractional-Order Systems: Analysis, Synthesis and their importance for Future Design" to coordinate research efforts; with collaborators from 23 EU countries, 2 near-neighbor countries, and 3 international partner countries. This IRES site supports advancing the COST Action by providing US students with research experiences focused on the design, simulation and characterization of fractional-order circuits, systems, and devices under the mentorships of faculty at BUT, who are leading efforts with the COST Action. Six U.S. students each year participate in a one-semester course prior to their international experience to prepare them for their 12-week research under the mentorship BUT faculty in Brno. The specific challenges addressed by student projects include i) how to design and simulate fractional-order circuits for the electronic filtering of signals, ii) methods to improve the emulation and fabrication of fractional-order devices, and iii) alternative methods to characterize fractional-order material properties. Beyond technical skill development, this international research introduces students to the administrative and technical challenges of coordinating and executing a large international collaborative research effort.

This project is jointly funded by the Office of International Science and Engineering (OISE) and the Established Program to Stimulate Competitive Research (EPSCoR).

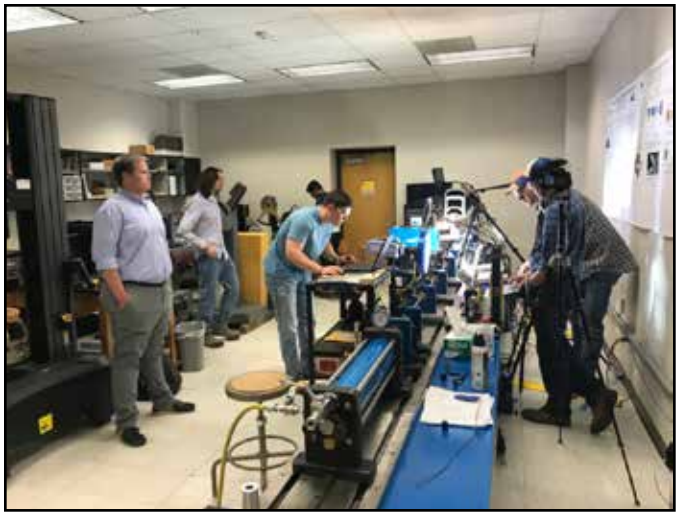


CAREER: Understanding the Combined Effect of Microstructure Behavior of Additively Manufactured Lattice Structures

Dr. Kavan Hazeli, UAH

This Faculty Early Career Development (CAREER) grant, co-funded by the Established Program to Stimulate Competitive Research (EPSCoR), focuses on understanding the mechanical behavior of additively manufactured lattice structures (AMLS). AMLS are hierarchical materials whose effective properties depend upon both the topology of the lattice structure and the base metallic material microstructure. Therefore, understanding the interplay between topology and microstructure is necessary to maximize the potential application of AMLS. In general, one of the major factors that limits a complex engineering system's performance is that conventional structural metallic materials serve a singular purpose of providing structural support. However, flexibility in the design of AMLS enables an array of multifunctional applications, such as controlled heat transfer, vibration, energy management, and light-weighting. In this research, the potential of AMLS will be enhanced with an in-depth experimental-computational investigation of the combined role of microstructure and topology in the mechanical deformation mechanisms that control the mechanical behavior over a wide range of loading conditions. The educational part of this grant will provide: (1) an opportunity to senior design teams to build educational tools and techniques to teach mechanical engineering concepts to people with visual impairment; and (2) a hands-on research opportunity to low-income students.

The research objectives of this project are understanding the specific contribution and interplay between the microstructurally driven mechanisms (e.g., those due to grain structures, orientation, and porosity) and geometrically driven events (e.g., unit-cell buckling, node fracturing, and macroscopic shear) on the deformation of AMLS, and determining which mechanisms dominate under different loading conditions. In order to elucidate the specific contribution of local microstructural features relative to topological attributes, experimental data obtained from microstructural and mechanical behavior characterization will be coupled with the local state of stress computed from finite element (FE) simulations. The FE analysis will use a yield criterion that will be customized for AMLS to capture the anisotropic behavior of the struts originating from the repeated solid-phase changes during layer deposition. The new yield criterion will be built based on the strut-level tension, compression, and shear experiments for different microstructures controlled by heat-treatment.



Dr. Hazeli's students are setting up the split-Hopkinson pressure bar for impact testing of additively manufactured lattice structure.

REU Site: Interdisciplinary Convergence to Advance the Biotechnological and Bioscience Workforce

Dr. Ryan Summers, UA

The University of Alabama-Tuscaloosa (UA) REU in Biotechnology will train ten undergraduate students per year over three years to carry out interdisciplinary research in biotechnology-related areas. Biotechnology is a rapidly growing industrial sector throughout the United States, with applications in health, energy, and defense. However, there are very few academic programs dedicated solely to teaching undergraduate students biotechnology techniques. In this REU site, an interdisciplinary team of faculty members in biochemistry, biology, and biological engineering has been assembled to mentor students, with a focus on applications and instrumentation commonly found in the biotechnology field. Participating students will gain additional experience through several planned activities, including invited speakers and field trips. These activities will help to build a diverse cohort of students and provide them with the skills necessary to succeed in the biotechnology workforce.

This project will develop a new 10-week interdisciplinary REU site at UA with a focus on biotechnology and bioscience research. This REU program will provide students with training in biotechnology-related research areas while helping them develop the skills necessary to excel in the biotechnology workforce. The students will first participate in a biochemistry and instrumentation bootcamp to develop a fundamental understanding of the biotechnology tools and techniques that will benefit them throughout their time in the program. The project will place a heavy emphasis on teaching students many common biotechnology methods and research techniques, which will enable them to succeed in graduate school or the industrial sector. Several opportunities to present their research, both in reports and oral presentations, are designed to improve written and verbal communication skills and enable the students to communicate to peers and the general public. The project will place a strong focus on recruiting students from HBCUs, Hispanic-serving community colleges, and organizations that are traditionally underrepresented in STEM fields. All of these activities will enable this REU to achieve its goal of training the next generation of leaders, researchers, and educators in biotechnology-related disciplines.

This project is jointly funded by the Division of Engineering Education and Centers and the Established Program to Stimulate Competitive Research (EPSCoR).

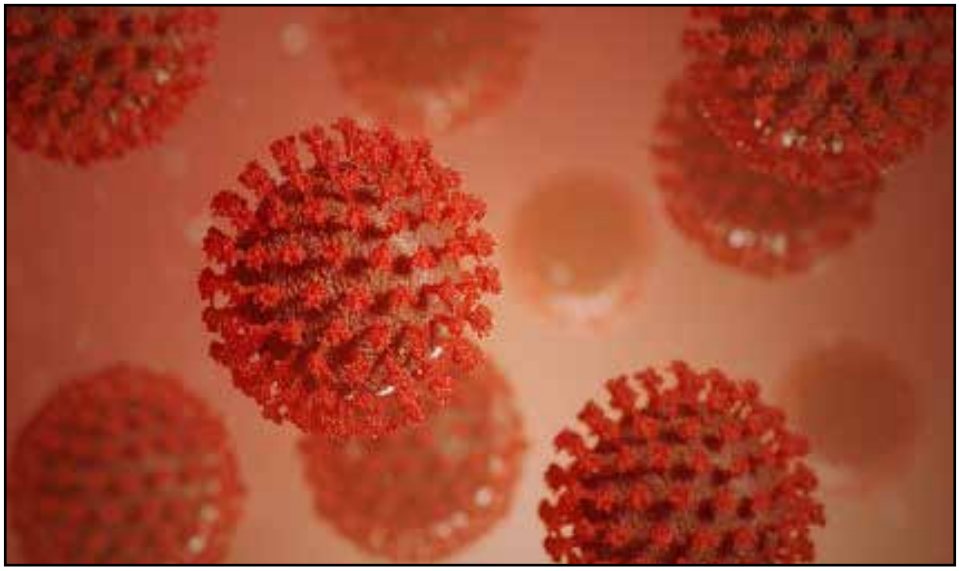
ERAPID: Exosomal tRNA fragments may constitute an innate viral defense against SARS-COV-2 and other respiratory RNA viruses

Dr. Glen Borchert, USA

Viral infection can induce formation of specific transfer RNA fragments (tRFs) that are packaged and released from host cells in exosomes. The project aims to discover the biological role of exosomal tRFs, specifically investigating whether uptake of these tRFs into uninfected cells triggers an innate antiviral immune response against SARS-CoV-2 and other respiratory RNA viruses. New insights into the influence of tRFs on host defense mechanisms against viral infections could be exploited to combat COVID-19 and future outbreaks of related viruses. The project also offers training opportunities for graduate and undergraduate students, the latter through bioinformatics course-based research.

The project is based on preliminary data suggesting that tRF exosomal delivery constitutes a novel mechanism of innate antiviral immunity whereby tRFs prime host cells for a more robust interferon response. The research on SARS-CoV-2 will be guided by specific questions, for example, about the extent of exosomal tRF uptake and bioavailability in recipient cells, whether the tRFs hybridize with viral RNAs and activate interferon production through association with RIG-I, and whether intracellular tRFs inhibit viral replication in cells. Characterization of a novel host defense mechanism could potentially inform strategies for therapeutic intervention against COVID-19.

This RAPID award is jointly funded by the Genetic Mechanisms Program in the Division of Molecular and Cellular Biosciences and the Established Program to Stimulate Competitive Research (EPSCoR), using funds from the Coronavirus Aid, Relief, and Economic Security (CARES) Act.



When Can We Cluster Data? Improved Conditions for Perfect Recovery and Numerical Methods

Dr. Brendan Ames, UA

The clustering procedure is ubiquitous in science and engineering, especially in analysis of massive data sets and complex networks. The purpose of clustering is to divide a given data set into groups of similar items, called clusters. Although many heuristics for clustering exist (and are widely used), the theoretical properties of this learning task are less well-understood. Relatively few theoretical analyses have been performed establishing conditions under which we may expect to successfully cluster data. The goal of this project is to establish realistic theoretical guarantees for clustering, both in terms of data amenable to clustering as well as in the development of effective, computationally efficient algorithms. The project will facilitate interdisciplinary research via applications in image processing, astronomy and physics, mathematical biology, social network analysis, and high-dimensional statistics. The project will also provide educational opportunities for graduate and undergraduate students through the development of new courses focusing on the interaction of machine learning and large-scale optimization, interdisciplinary undergraduate research programs, and K-12 outreach programs.

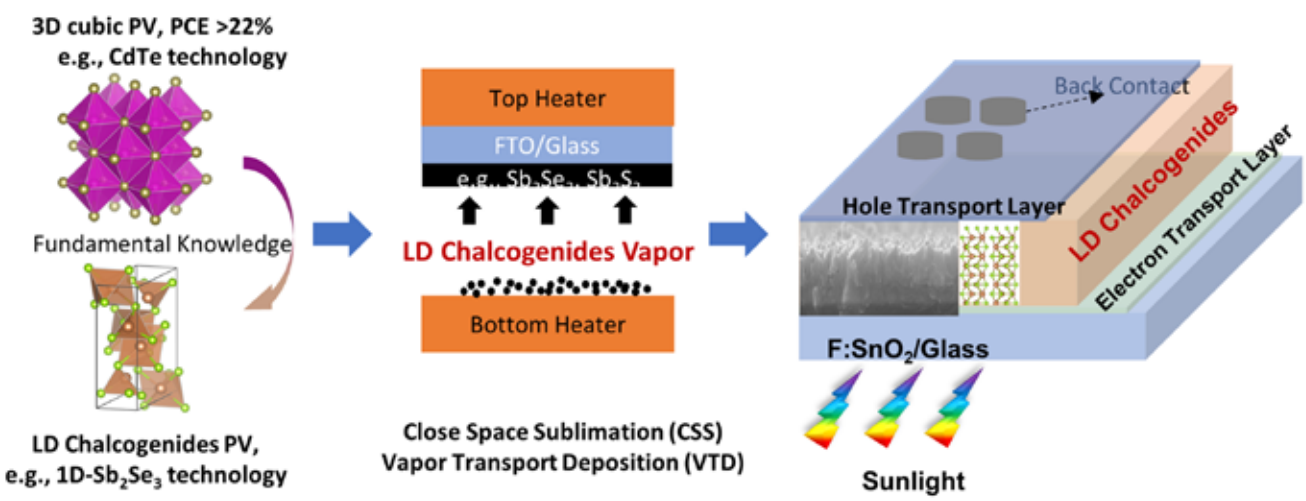
The project focuses on two main research thrusts. The first concerns the generalization of average case analyses and theoretical guarantees for perfect recovery for convex relaxations of model problems for clustering, such as the densest submatrix localization and graph partition problems. The goal of these analyses is to extend the existing state of the art to probabilistic models for data that are more representative of data observed in practical applications. Extensive average planted case analyses will be performed to establish computational and information-theoretic bounds for perfect recovery under generalizations of the stochastic block model. The second thrust will focus on the design, analysis, and implementation of numerical methods for large-scale semidefinite and nonlinear optimization, with specific focus on the algorithms for model problems for clustering and classification. Theoretical convergence analysis and numerical simulation will be performed to illustrate the efficacy of the methods. This project is jointly funded by the Computational Mathematics program and the Established Program to Stimulate Competitive Research (EPSCoR).

CAREER: Photovoltaic Devices with Earth-Abundant Low Dimensional Chalcogenides

Dr. Feng Yan, UA

The sun provides abundant sources of renewable energy such as wind, solar, and hydro power. Solar cells, also known as photovoltaic devices, directly convert sunlight into electricity. Dramatic efficiency improvements and cost reductions have led to widespread adoption of solar power. There are still problems that limit further adoption. These include incorporation of expensive or toxic raw materials as well as the need for energy intensive, high temperature production processes. This project will investigate an emerging solar technology based on low dimensional chalcogenides as light absorbers. These materials are earth abundant, non-toxic and stable upon exposure to sunlight under ambient conditions. They can also be processed at relatively low temperatures with fewer raw materials consumption and less carbon footprint, making this emerging solar technology potentially cost-competitive and sustainable. This project aims to significantly improve the efficiency of solar cells based on low-dimensional chalcognides through advanced device engineering. The aim is to pave the way to commercialize this newly developed solar technology to provide more affordable solar electricity. This project will impact the community through a long-term partnership with local elementary schools. The PI will reach out to young students to introduce and foster clean energy concepts and solar technologies. The PI will also participate in an on-campus material summer camp for the local secondary school teachers, giving introduction lectures and providing hands-on demonstrations of solar technologies. Teachers can then implement these lessons in their home schools to attract more students, especially those from minority and underrepresented groups, to pursue science and engineering careers. This project is jointly funded by the Electronics, Photonics, and Magnetic Devices program of the Division of Electrical, Communications, and Cyber Systems and the Established Program to Stimulate Competitive Research (EPSCoR) program of the Office of Integrative Activities.

The objective of this project is to understand the electronic and photonic properties of a new class of thin-film photovoltaic (PV) devices based on earth-abundant low-dimensional noncubic chalcogenide absorbers to achieve highly efficient, sustainable, and affordable solar energy. Polycrystalline low dimensional chalcogenide absorbers possess anisotropic atomic

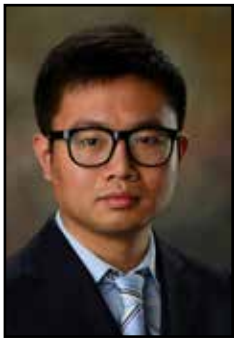


Low dimensional chalcogenides for the thin film solar cells application. The cystalline structure, vapor transport deposition techniques, and the solar cells architectures.

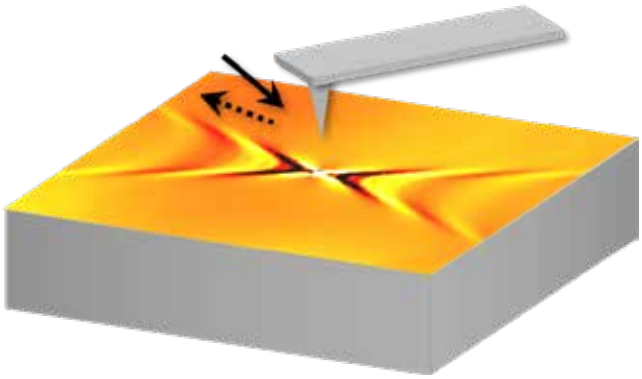
chains and intrinsically benign grain boundaries, which provide unique anisotropic carrier transport behaviors and great grain boundary defect tolerance. Considerable fundamental material and device challenges will be addressed in this project to achieve high-performance low dimensional chalcogenides based PV devices. The following four tasks with a combination of device-level characterization will be carried out: (1) understand the anisotropic growth mechanisms of the low dimensional chalcogenide absorbers layer, and how they impact the carrier transport in the atomic chains and device performance; (2) tailor bandgap of low dimensional chalcogenide absorbers by the alloying approach to maximize the photovoltage with optimized bandgap and minimize the photocurrent loss; (3) engineer defects and interfaces in the low dimensional chalcogenides based PV devices to reduce the carrier recombination sites and increase carrier extraction with a guide of theoretical prediction using first-principle density functional theory calculation; (4) conduct extrinsic doping engineering to increase the photogenerated carrier density and carrier lifetime of the low dimensional chalcogenides based PV devices. Fundamentally, this project will elucidate the relationship between absorbers material microstructure, photogenerated carrier transport properties, and device performance in low dimensional chalcogenide-based PV devices. Eventually, this proposed project will pave the way for the future development of next-generation high-efficiency low-cost thin film PV technologies.

Twist and route canalized polariton nano-light in MoO3 microstructures

Dr. Siyuan Dai, Auburn University



The manipulation of light at small scales is important for delicate biomedical treatment, fast optical circuits, super-resolution microscopy and many others. For this purpose, recent efforts typically involve a type of nanoscale optical waves called polariton nano-light. Polariton nano-light travel in materials like water ripples propagating in a pool. They carry the energy of light and are affected by material properties. This project explores the manipulation of polariton nano-light in a new type of layered material: molybdenum trioxide. The research team plans to tune the wavefront geometry of polariton nano-light by stacking and twisting molybdenum trioxide in a LEGO-like fashion. The energy flow of polariton nano-light can also be routed by geometric structuring of molybdenum trioxide, for a variety of practical applications including biochemical sensing, nano-manufacturing and optical forces. In addition, this project provides the training opportunity for undergraduate and graduate students, especially the underrepresented minorities, on scanning probe nano-optical characterization, electromagnetic simulation and van der Waals material fabrication. The



Dr. Dai's depiction of using scanning probe to study the control of canalized X-shape light at the nanoscale.

outreach and summer research activities provide K-12 students and high-school teachers hand-on research experience and teaching units for their curriculum.

The primary goal of the project is to explore the propagation routing and wavefront configuration of nanoscale light-matter waves polariton nano-light by van der Waals twisting and structuring of molybdenum trioxide. The routing and configuration rely on the electromagnetic directionality of polariton nano-light in molybdenum trioxide: they propagate along certain direction(s) with extremely anisotropic electromagnetic field. This electromagnetic directionality suggests the wavefront configuration via electromagnetic interactions of polariton nano-light in stacked vdW structures. The research team exploits state-of-the-art optical nano-imaging and electromagnetic simulation to reveal the configured polariton nano-light with straightforward real-space images. Furthermore, the research team plans to investigate exotic optical physics that are ungoverned by conventional optics laws, when additional geometric structuring is applied to the already directional nano-light. This project is expected to complement current knowledge in van der Waals materials and polaritonic nano-optics with the understanding of twisting configuration and exotic optical physics of directional polariton nano-light, and demonstrate the prototype van der Waals structures with tailored and reconfigurable properties for on-demand nano-optical functionalities. This project is jointly funded by the Electronic and Photonics Materials Program in the Division of Materials Research and the Established Program to Stimulate Competitive Research (EPSCoR).

Collaborative Research: The Circumgalatic Dictionary: An Interpretation Guide For Circumglatic Medium Observations

Dr. Jeremy Bailin, UA

The history of the formation of a galaxy like our own Milky Way is recorded in the properties of gas between the visible stars in the galaxy. The gas is in low density clouds and is difficult to study. This surrounding gas is usually detected by observing its silhouette in the light of background quasars, known as “quasar absorption lines”. The investigators will develop tools to help astronomers to better interpret the chemical history of this gas. They will develop tools to use quasar absorption lines to determine the gas composition, temperature and density. These tools will better determine where the gas clouds are in these galaxies and how clouds of gas are moving. By comparing the properties of these clouds of gas, they seek to understand the history of galaxy’s transformation of hydrogen and helium into more complex atoms. During this study, the investigators will train graduate and undergraduate students in a variety of astronomical and machine learning techniques. The investigators will reach out to K-12 students and the community at large.

This project is jointly funded by the Astronomy Division and the Established Program to Stimulate Competitive Research (EPSCoR).

NATIONAL SCIENCE FOUNDATION CO-FUNDED EPSCoR

Catalyst Award: Tuskegee University CURES

Dr. Deloris Alexander, Tuskegee University

Catalyst Projects provide support for Historically Black Colleges and Universities to work towards establishing research capacity of faculty to strengthen science, technology, engineering and mathematics undergraduate education and research. It is expected that the award will further the faculty member's research capability, improve research and teaching at the institution. and involve undergraduate students in research experiences. This project at Tuskegee University will provide research opportunities in undergraduate course work. The students will engage in research projects, collect and interpret data and present their findings to audiences.

The novelty of the Tuskegee CUREs (Course-based Undergraduate Research Experiences in STEM) project lies in its ability to provide authentic research experiences to early career college students as a part of undergraduate STEM courses, equipping them with strong research interests, fostering integrative or interdisciplinary learning, and to improving research skills. As a result of this effort, the over-arching goal/objective of this proposed project is to increase the opportunities for undergraduate students to increase both the number and percentage of undergraduate students who have science knowledge/ technical skills, persist to graduation, and obtain advanced degrees in STEM disciplines. These goals/objectives will be accomplished by 1) increasing undergraduate participation in authentic research experiences by infusing traditional courses with CUREs; 2) fostering the develop of inquiry and scientific communication skills; 3) improving the persistence and retention of undergraduate students in STEM degree programs (especially freshmen) by using introductory biology CUREs to create learning communities; and 4) improving the persistence and retention of undergraduate students in STEM fields (especially freshmen) by using research experiences to foster/support the critical transition of undergraduates to graduate school and other STEM careers. The success of the Tuskegee CUREs project will contribute to increasing diversity in the STEM workforce, while serving as a model for such programs at other HBCUs. This project is jointly funded by HBCU-UP and the Established Program to Stimulate Competitive Research (EPSCoR).

Cluster Algebras, Quiver Representations, and Rigid Curves

Dr. Kyungyong Lee, UA

This project aims to investigate a central object in modern algebraic combinatorics: a class of cluster algebras. These cluster algebras are related to a wide variety of other mathematical objects arising in algebraic geometry, representation theory, and other areas, but are also important in particle physics, where they are related to scattering amplitudes in certain quantum field theories. Hence a better understanding of cluster algebras is not only interesting in its own right, but also has significant potential application in other areas of mathematics and beyond. The project will provide training for students through involvement in the research.

Rigid modules, invariant curves, and knots are fundamental objects in many branches of mathematics. This project takes a cluster-algebraic approach to studying these objects. The research goal, largely motivated by homological mirror symmetry, is to study invariants for indecomposable modules over hereditary algebras, for quiver Grassmannians, and for alternating knots. The project aims to develop new combinatorial and geometric objects to reveal more concrete relationships between cluster algebras and other areas of mathematics. The educational goal of this project is to train undergraduate and graduate students in topics at the intersection of algebra, combinatorics, geometry, topology, and representation theory.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

MRI: Acquisition of a 3.0 Tesla Magnetic Resonance Imaging Scanner

Dr. Rajesh Kana, UA

This award permits the University of Alabama to acquire a 3.0 Tesla Magnetic Resonance Imaging (MRI) system. Establishing an MRI research facility at UA will be a significant new direction in human neuroscience research at UA as well as allow for collaboration with other institutions on large multi-site projects. A neuroimaging facility at UA will provide a much-needed boost to the neuroscience initiatives (e.g., graduate research in neuroscience, undergraduate neuroscience minor, undergraduate and graduate programs in educational neuroscience) at UA. The 3.0T MRI system will have a lasting impact on the field beyond the specific projects that will be initially supported and advanced. Most importantly, sharing a critical research tool like the MRI scanner creates a platform to accelerate conceptual and methodological development across neuroimaging laboratories, capitalizing on the exceptional pool of talent available at UA and other universities in the region. Building a neuroimaging research environment will be a catalyst for training undergraduate and graduate students interested in neuroscience research, including women and underrepresented minority students. This will also provide opportunities for training students from historically black colleges nearby, such as Stillman College and other such universities in the state of Alabama. Establishing a neuroimaging environment at UA will, in addition to facilitating neuroscience research, provide opportunities for the surrounding rural communities to participate in research as well as students from rural areas in Alabama.

The proposed MRI system will stimulate interdisciplinary collaborative research projects at the basic and translational levels at UA. The following research projects at UA will utilize the MRI system: 1) Multiscale neural processing and the neurobiology of language processing and reading comprehension in healthy individuals and in disorders; 2) Developing brain algorithms to improve natural language processing; 3) Neurobiological bases of mathematical cognition, with specific emphasis on embodiment of number and arithmetic; 4) Examining the cognitive and neural changes associated with healthy aging, memory and attention; 5) Investigating lifetime stress, brain aging, and the racial differences underlying brain aging; 6) Biomedical imaging analysis and development of shape-controlled magnetic nanoparticles for MRI; and 7) Developmental neurobiology of social brain in healthy individuals and in disorders. The MRI system will enhance the collaboration across different schools, colleges and departments at UA, including Psychology, Education, Communicative Disorders, Biological Sciences, and Engineering.

Workshops and Outreach

EPSCoR solicits requests for support of workshops, conferences, and other community-based activities designed to explore opportunities in emerging areas of science and engineering, and to share best practices in planning and implementation in strategic planning, diversity, communication, cyberinfrastructure, evaluation, and other areas of importance to EPSCoR jurisdictions.

DEPARTMENT OF ENERGY EPSCoR

The DOE EPSCoR Program was established by the Energy Policy Act of 1992 and is positioned in the Office of Science and is the single largest supporter of basic research in the physical sciences. It supports both basic and applied research and development across a wide range of interdisciplinary program areas that including:

Advanced Scientific Computing Research
Basic Energy Sciences
Biological and Environmental Research
Fusion Energy Sciences
High Energy Physics, and Nuclear Physics

The goals of the DOE EPSCoR program are to:

- Improve the capacity of designated states and territories to conduct sustainable and national competitive energy-related research
- Jumpstart infrastructure development through increased human and technical resources, training scientists and engineers in energy-related areas
- Build beneficial relationships with ten world class laboratories in designated states and territories, leverage DOE national user facilities, and take advantage of opportunities for intellectual collaboration across the DOE system.

DOE uses NSF EPSCoR eligibility criteria. Twenty-five states, the Commonwealth of Puerto Rico, Guam, and the U.S. Virgin Islands are currently eligible for DOE EPSCoR. DOE EPSCoR provides funding support through three types of awards including the Implementation Grant, National Laboratory Partnership Grants, and the Early Career Research Program, each are described below.

The Implementation Grant is for a maximum period of six years with an initial period of three years. Maximum funding for Implementation Grants is $2,500,000 per year and until recently only one active implementation grant per state or territory was permitted at a time. Now any EPSCoR state or territory can apply when there is an open Funding Opportunity Announcement (FOA). .

The EPSCoR-State/National Laboratory Partnership Grant is for a maximum period of 3 years. Maximum funding for these grants is $200K per year with no state matching funds required. PIs on current DOE grant awards are not eligible to serve as PIs on Partnership Grant applications. Grants allow EPSCoR researchers to work closely with DOE National laboratories to conduct collaborative research and train students. Multiple submissions per state and laboratory are

DOE EPSCoR eligibility map

permitted and expected. There is no limit to the number of state or laboratory submissions per year. All funding resides within the EPSCoR state and no EPSCoR funds are permitted to support DOE National Laboratory activities.

DOE Office of Science Early Career Research Awards are limited to applications received from academic institutions in EPSCoR jurisdictions. A particular DOE Program Area/ Office many nominate meritorious applications that would not have been otherwise considered for joint consideration by multiple program areas on a funds available basis.

In July 2019, the Department of Energy announced $17 million in funding for nine energy research projects under the federal Established Program to Stimulate Competitive Research (EPSCoR) Implementation Grant Program. Selected projects covered a range of topics energy research, including fundamental science in chemistry and materials as well as research to advance fusion energy, grid integration/solar energy, fuel cells, and advanced manufacturing. The projects will improve research capabilities in the host institutions through the support of groups of scientists and engineers, including graduate students and post-doctoral fellows, working together on common research topics. Nine DOE Implementation awards were made to Alabama, Alaska, Hawaii, Idaho, Maine, Montana, Nebraska, West Virginia, and Wyoming. Drs. Kevin West and James Davis at University of South Alabama were our state's recipient of the DOE Implementation Grant. Dr. Kevin West is a professor in the Chemical Engineering Department while Dr. James Davis is a Professor of Chemistry.

In 2020, DOE announced $21 million in awards for thirty-one DOE EPSCoR State Laboratory Partnership Grants. Alabama was awarded two projects which include principal investigators Dr. Vladimir Kolobov at UAH and Dr. Suzanne Lapi at UAB. Dr. Kolobov will be collaborating with Sandia National Lab while Dr. Lapi will collaborate with Los Alamos National Lab.

NEW FY 19 and 20 DOE EPSCoR Awards				
Award No.	Type	Title	PI	Inst
2019				
DE-SC0020282	Implementation Grant	Understanding the molecular-level interactions between ionic liquids and molecular species to design and develop novel solvent systems for environmental and energy applications	Kevin West	Lead: USA, Collaborators: UA, TU and Univ. of North Alabama
2020				
DE-SC0021391	State Lab Partnership Grant	Self Organization of Plasma-Material Interfaces	Vladimir Kolobov; co-PI: Gabe Xu	UAH
DE-SC0021279	State Lab Partnership Grant	Production, Purification and Characterization of Radioisotopes via Neutron Spallation	Suzanne Lapi	UAB

Understanding the molecular-level interactions between ionic liquids and molecular species to design and develop novel solvent systems for environmental and energy applications

Dr. Kevin West, University of South Alabama

Dr. Kevin West, University of South Alabama

Project Objectives: To develop an understanding of how the molecular-level interactions in ionic liquid/molecular species mixtures affect macroscopic properties related to chemical reactions and separation, and how these interactions can be leveraged to develop energy efficient processes.

Project Description and Methods: Three topic areas will be explored: (I) aromatic/aliphatic hydrocarbon separations, (II) reactions in thermally-robust ionic liquids and (III) ionic liquid high-performance polymers. The PIs will use a complementary set of experiments and simulations to connect observed phenomena, such as phase behavior and reaction rates, to molecular-level interactions in the mixtures. In Topic I, the PIs will use thermophysical property and phase behavior measurement coupled with molecular dynamics simulations to understand factors that influence the partitioning behavior of model aromatic and aliphatic hydrocarbons in thermally-robust, perarylsulfonium- and perarylphosphonium-based ionic liquids. High temperature (ambient to 250°C) reactions in these same ionic liquids will be examined in Topic II, where nucleophilic aromatic substitution reactions, alkylation and cumene hydroperoxide decomposition will be examined. The latter two reactions are acid-catalyzed, with the acid provided by dissociation of phenolic hydroxyls at high temperature. Reactive Monte Carlo simulations will elucidate key solvent characteristic which promote the reactions. In Topic III, two areas related to polymerization are studied: the synthesis of ultra-high performance-ionene hybrid polymers inspired by ionic liquid anions and anionic polymerization in ionic liquids, again coupling experiment and simulation to understand solvent

environment and its effects on materials synthesis.

Potential Impacts: The work funded through this proposal has the potential to have transformative effects on the design of chemical reaction and separations processes. Developing an understanding of how the molecular-level interactions in ionic liquid solvent systems affect the behavior of solutes will enable the rational design of ionic liquids and processes which exploit them to decrease energy usage in industrial chemical reactions and separations. The importance of this understanding is echoed in the Department of Energy – Office of Energy Efficiency & Renewable Energy's areas of interest for advanced manufacturing technologies: "integrated reactor and separation technologies that improve both reactions and separations together, especially using non-thermal processes like reactive distillation, membrane reactors and ionic reaction media to result in simplified processes," and develop a "better understanding of molecular interactions between ionic liquids and other fluids in order to develop better separation methods to get pure and more stable ILs."

FY2019 DOE Implementation Grant Team	
Institution	PI(s)
University of South Alabama	Kevin West (Lead PI)
	W. Matthew Reichert (Project Director and Co-PI)
	James Davis
	Christy Wheeler West
	Brooks D. Radieau
University of Alabama	Heath Turner
	Jason Bara
	Paul Rupar
Tuskegee University	Michael Curry
University of North Alabama	Amanda Coffman

Self-Organization of Plasma-Material Interfaces

Dr. Vladimir Kolobov, University of Alabama in Huntsville

Low-temperature plasma (LTP) physics, chemistry and engineering offer breakthroughs and transformative technological solutions that address grand societal challenges. The subject of the proposed research – understanding LTP-induced self-organization at gas-solid-liquid interfaces – has been identified by DOE as one of the top priorities in the field. Two Plasma Research Facilities (PRFs) have been recently established at DOE's Sandia National Laboratories (SNL) and Princeton Plasma Physics Lab (PPPL). The proposed collaborative research between the University of Alabama in Huntsville (UAH), an Alabama small business - CFD Research Corporation (CFDRC), and the Plasma Research Facility at Sandia National Laboratories focuses on the interactions of LTP with solid and liquid surfaces, transport phenomena and heterogeneous chemical reactions at interfaces, and self-organization and pattern formation in non-equilibrium reactive plasmas. The collaboration will enable the development of theory, computational tools and experimental studies of LTP to control plasma stratification and filamentation, plasma-induced processes at gas, liquid and solid interfaces for applications in material synthesis, nanoelectronics, biomedicine and food safety. The project will a) improve the understanding of transport processes, chemical reactions and plasma-driven self-organization such as stratification and filamentation, formation of anode spots, liquid droplets ejection from cathodes, and plasma electrolysis, b) utilize and share among the project participants computational tools developed by the participants to understand plasma-based surface functionalization and plasma-enabled pattern nucleation in a wide range of scales from nano- to millimeters, and c) use experimental methods and facilities available at UAH and SNL to understand and control plasma processes, reaction pathways and the electric nature of self-organization of

the plasma-exposed interface structures. A combination of theory, computer simulations and dedicated experiments will be applied to selected DC/AC discharges in noble gases and plasma jets in air to clarify and control surface functionalization and plasma-assisted self-organization at material interfaces over a wide range of spatial scales.

Successful completion of the proposed research will result in an improved understanding of gaseous plasma interfaces with metal/semiconductor electronic structures, electric surface charging, electron emissions from nano-tips, and nanoparticle synthesis that can be applied for the design of electronic structures, plasma transistors, metamaterials, plasma-aided printing and additive manufacturing. The proposed collaboration of Alabama institutions with SNL will enable sharing expertise and resources to develop theory, perform computational studies, and conduct targeted experiments for clarifying fundamental processes at plasma-material interfaces for validation and fine-tuning of the models. Graduate students and post-doctoral researchers will participate in the research and collaboration with SNL. The project will complement and leverage the ongoing NSF EPSCoR project "CPU2AL: Connecting the Plasma Universe to Plasma Technology in Alabama". The proposed partnership will help establish a sustainable research partnership of Alabama researchers with SNL devoted to understanding and controlling LTP environments, strengthening the research capacity and building an inclusive workforce in plasma science and technology in the State of Alabama.

Production, Purification and Characterization of Radioisotopes via Neutron Spallation

Dr. Suzanne Lapi
University of Alabama in Birmingham

This collaborative proposal between the University of Alabama at Birmingham (UAB, PI Suzanne Lapi), and Los Alamos National Laboratory (LANL, collaborator Michael Fassbender) aims to develop novel techniques for isotope production. This proposal takes advantage of complementary techniques available at the UAB cyclotron facility and LANL isotope production facility (IPF) and will involve UAB faculty, postdocs, graduate students and undergraduates as well as LANL scientists and staff. Specifically, we aim to develop methods for isotope production that make use of the high energy neutrons generated at the LANL IPF high energy beam line. This project will involve the development of separation techniques for radioisotope production at UAB, using radiotracer analogues produced using the TR24 cyclotron, which would directly translate to separations of the desired isotopes produced at LANL via neutron spallation. Extended visits to LANL by UAB students involved in this initiative are also envisioned. This proposal also responds directly to the critical shortage of highly qualified scientists in the field of radiochemistry and radionuclide production in the United States. This proposal intrinsically encompasses a multidisciplinary training program that will include undergraduate students, graduate students, postdoctoral research fellows and other early career scientists. We strive to foster the development of a new generation of young scientists in isotope production and radiochemistry. Thus, while the grant will fund experimental supplies and support students and scientists, it is clear that the impact on the scientific program and workforce development in the state of Alabama from the support of this project will extend far beyond the scope of the work proposed.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION EPSCoR

The NASA EPSCoR program began in 1994, uses NSF eligibility criteria, and works to strengthen the research capabilities of 27 jurisdictions that have in the past not participated equably in competitive aerospace and aerospace-related research activities and to develop a more competitive research base within their jurisdiction and member academic institutions. NASA EPSCoR objectives are to:

- Contribute to and promote the development of research infrastructure in EPSCoR jurisdictions in areas of strategic importance to the NASA mission.
- Improve the capabilities of the jurisdictions to gain support from sources outside the NASA EPSCoR program.
- Develop partnerships between NASA research assets, industry, and EPSCoR jurisdictions' academic institutions.
- Contribute to the overall research infrastructure, science and technology capabilities, higher education, and/or economic development of the jurisdiction.

NASA EPSCoR Jurisdictions

Alabama	**Nevada**
Alaska	**New Hampshire**
Arkansas	**New Mexico**
Delaware	**North Dakota**
Guam	**Oklahoma**
Hawaii	**Puerto Rico**
Idaho	**Rhode Island**
Kansas	**South Carolina**
Kentucky	**South Dakota**
Louisiana	**Vermont**
Maine	**U.S. Virgin Islands**
Mississippi	**West Virginia**
Montana	**Wyoming**
Nebraska	

The primary funding opportunities of NASA EPSCoR are:

- Research Cooperative Agreement Notice (CAN) Grant, which solicits topic-specific proposals addressing high-priority NASA research and technology development needs. Awards are up to $750,000 for a three-year performance period. NASA intends to announce the EPSCoR Cooperative Agreement Notice, or CAN, for Research Awards yearly, pending funding availability; 50% cost share is required.
- EPSCoR Research Infrastructure Development awards, or RID. This component enables jurisdictions to build and strengthen relationships with NASA researchers. The RID has a three-year base period of performance with a potential one-year no cost extension. Awards are $125,000 per year and requires 100% cost share by the awardee. NASA intends to announce the RID opportunity every three to five years, pending funding availability.
- EPSCoR International Space Station, or ISS, Flight Opportunity Awards provide opportunities to launch mature research projects to the space station. Awards are up to $100,000 for a three-year performance period with no cost share obligations. NASA intends to announce the EPSCoR CAN for ISS Flight Opportunity Awards yearly, pending funding availability.
- NASA Rapid Response Research Solicitation (R3) is a funding opportunity from NASA for quick turn-around of research needs by NASA for one year period of performance, no cost share for the $100,000 award is required. Proposals are limited to three pages for the technical section, these proposals are submitted quarterly pending funding and topic availability.

The Alabama NASA EPSCoR program builds upon existing strengths within the State, using facilities and personnel at the Space Grant Universities and at the NASA Marshall Space Flight Center (MSFC) but extending these to a new set of teachers, researchers, students, and industrial collaborators. The Alabama NASA EPSCoR Program Director also serves as the Alabama Space Grant Consortium Director. The goals of Alabama NASA EPSCoR are to (1) effect a permanent increase in the national competitiveness of Alabama's basic research programs in

targeted areas; (2) enhance research areas which already have strength and which are closely related to the special needs of Alabama; and (3) provide the basis for continuing expansion of basic research in Alabama in the post-EPSCoR era.

Dr. Dale Thomas serves as the Alabama NASA Agency Director as well as the Alabama Space Grant Director, and is a Professor and Eminent Scholar of Systems Engineering in the Department of Industrial and Systems Engineering and Engineering Management at the University of Alabama in Huntsville.

In FY 19 Alabama NASA EPSCoR recieved at least one award in each of the four NASA EPSCoR funding mechanisms - one Cooperative Agreement Notice (CAN), one Research Infrastructure Development (RID) Award, four Rapid Response Research (R3) awards, and one International Space Station (ISS) Award. In FY 2020, new NASA EPSCoR awards included four R3 awards and an early FY21 ISS award. See lists below and on the next page.

NEW NASA EPSCoR Awards

	NASA EPSCoR Award	Lead PI	Science Investigator(s)/ Inst.	Title	award amt	Period of Performance
FY20 Rapid Response Research (R3) Awards	FY20 EPSCoR R3 Award	Dale Thomas, NASA EPSCoR, UAH	Ayayi Ahyi, AU	SiC Zener diode and Voltage References for extended operation (>1000 hr.) at 500 degrees C: SMD Planetary Division, High- Temperature Subsystems and Components for Long-Duration (months) Surface Operations	100,000	6/1/2020 - 5/31/2021
	FY20 NASA EPSCoR R3 Award # 80NSSC20M0134	Dale Thomas, NASA EPSCoR, UAH	Andrei Stanishevsky, UAB	Low-pressure plasma/photocatalytic nanofibrous membrane reactor system for harvesting fuel components from Martian atmosphere: KSC Partnership Office/Conversion of Co2 into Fuel.	100,000	4/15/2020-4/14/2021
	FY20 NASA EPSCoR R3 Award # 80NSSC20M0131	Dale Thomas, NASA EPSCoR, UAH	Uwe Konopka, AU	Physical Sciences Program / Dusty Plasmas	100000	9/1/2020-8/31/2021
	FY20 EPSCoR (R3) award # 80NSSC20M0136	Dale Thomas, NASA EPSCoR, UAH	Judy Schneider, UAH	Characterization of Bi_metallic Joints Formed by Different Processes	100,000	4/15/2020-4/14/2021
FY21 International Space Station (ISS) Award	FY21 NASA ISS Award # 80NSSC20M0141	Dale Thomas, NASA EPSCoR, UAH	Feng Yan, UA	In-Space Manufacturing of Assembled Lightweight Flexible Carbon-based Perovskite Thin Film Solar Cells with Radiation Stability in ISS	100,000	10/1/2020-9/30/2023

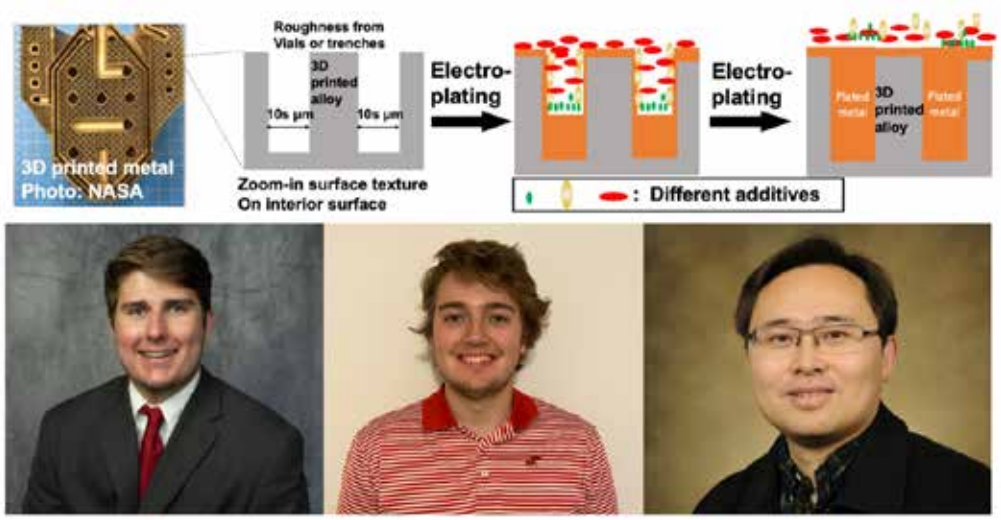
NATIONAL AERONAUTICS & SPACE ADMINISTRATION EPSCoR

Ongoing NASA EPSCoR Awards						
	NASA EPSCoR Award	**Lead PI**	**Science Investigator(s)/ Inst.**	**Title**	**award amt**	**Period of Performance**
Cooperative Agreement Notice (CAN) Awards	FY 16 CAN Award NNH16ZHA001C	Dale Thomas, NASA EPSCoR, UAH	Grant Glover, USA	FY 16 CAN Award: Development of Dust Free Binders for Spacecraft Air Reviatlization Systems	750,000	10/1/2016 - 9/30/2019; ext to 9/30/2020
	FY 18 CAN	Dale Thomas, NASA EPSCoR, UAH	Claudia Mewes; Co-Pis Tim Mewes and Greg Thompson, UA	Micro-Magnetic Driven Design of Multi-Component Magnetic Alloys for Advanced Electric Propulsion	750,000	5/1/2018-4/30/2021
	FY19 CAN, award 80NSSC19M0147	Dale Thomas, NASA EPSCoR, UAH	Kevin West (lead PI), James Davis, Grant Glover, William Reinhert; USA	Development of CO2-Capturing Ionic Liquid Solutions for Spacecraft Air Revitalization Systems	75,000	8/15/19 to 8/14/2022
Research Infrastructure Development (RID) Awards	FY 19 RID 3 yr, Award # 80NSSC19M0051	Dale Thomas, NASA EPSCoR, UAH	Yu Lei, UAH	Development for Advanced Fuel Coatings	375,000	6/1/19-5/31/2022
			Todd Freeborn, UA	Evaluating localized electrical impedance myography to quantify segmental fluid shifts induced by simulated micro-gravity conditions		
			Raziq Yaqub, AAMU	Cyber Security for Decentralized Aero-vehicle Control Systems		
			Nicholas Tsolas, AU	The Next Frontier in Space Exploration - Cubesats: Investigating the combustion characteristics of imidazole-based ionic liquids and HAN bipropellants to enable dual-mode propulsion systems		
			Kannatassen Appavoo, UAB	Effect of Space Radiation Environment on Emerging Photonic Technologies		
Rapid Response Research (R3) Awards	**FY19** EPSCoR R3 award	Dale Thomas, NASA EPSCoR, UAH	Judy Schneider, UAH	EPSCoR R3 - Characterization of Bi_metallic Joints Formed by Different Processes	100,000	11/19/18-11/18/19 NCE to 11/18/20
			Lingze Duan, UAH	EPSCoR R3 - Development of Fiber-Optic High-Temperature Heat Flux Sensors for Venus Exploration	100,000	11/30/18-11/29/19; NCE to 11/29/20
			Nima Shamsaei, AU with co-Pis J. Henderson, M. Kluttz, and A. Phillips	Characterization of Inconel 625 Blown Powder Freeform Deposition Material	100,000	6/6/2019-6/5/2020, 1 year NCE till 6/5/2021
			Masatoshi Hirabayashi, AU	Investigate Potential Mars or Lunar Resources	100,000	7/1/2019 - 6/30/2020
			Qing Peng, UAH	Reduction of Surface Roughness of Interior Surface of 3D-Printed Objects by Additive-Assisted Electroplating of Metals	100,000	7/1/2019-6/30/2020
International Space Station (ISS) Awards	FY19 EPSCoR ISS, award # NNHi8ZHA004C	Dale Thomas, NASA EPSCoR, UAH	Michael Banish, UAH	EPSCoR ISS: FY18 NASA ISS Flight Opportunity: Silicon-Cobalt Alloy Properties	100,000	11/30/18-11/29/21

Reduction of Surface Roughness of Interior Surface of 3-D Printed Objects by Additive-Assisted Electroplating of Metals

Science PI: Dr. Qing Peng, UA

The central objective of the proposal is to test if electrochemical deposition of metals can be used to reduce the roughness of the interior surface of three dimensional (3D) printed metal objects by filling up the micrometer-size trenches and voids on the interior surface. The methods: We plan to use small amounts of three types of additives, including a leveler, an accelerator, and a suppressor, to modulate the rate of electrochemical deposition of Cu or Ni so that the electrochemical deposition will selectively fill up the voids and trenches on the interior surface of any 3D printed metal objects. We will study how to control the key parameters in the additive-assisted electrochemical deposition, including electro-potential, concentrations of additives, and diffusion rates of electroplating species on the interior surface roughness mechanical properties, and thermo-mechanical properties of 3D printed metal objects,The impact for NASA:The proposed additive-assisted electrochemical deposition provides a superior solution than etching and polishing to meet NASA's requirements (in this proposal call), including reduction of the roughness of the interior surface of 3D printed objects to < 1µm, improvement of the mechanical strength, and maintaining the dimensions of the finest features inside of the 3D objects. This method will increase the mechanical strength of the objects because metals will be coated into the open voids and trenches on the surface. The coated metal will not affect the original structures and dimensions of the fine features inside 3D objects because the coating thickness will not exceed 100 µm, which is much smaller than the smallest features (~6,300 µm) inside of the 3D printed objects from NASA. The coated metal will increase the wall thickness of the components inside of the 3D printed objects so that the walls can tolerate pressure difference that is larger than 100 psi. The method will add metal coating of <100 µm on the object's outlet and inlet, whose function and connectivity will not be affected. Post-deposition cleaning step will remove all organic contaminations inside the object. In addition, this method is can be easily implemented in normal lab environments with low cost and manageable effort for 3D printed metal objects of any geometry and compositions.



(Top) The scheme of the project. (Bottom) Charles Hill (left) and Joshua Nahm (middle) are the undergraduates who work on this project. The graduate student image is not posted. Dr. Qing Peng (right) is the Principal Science Investigator, who leads this project.

SiC Zener diode and Voltage References for extended operation (>1000 hr.) at 500 degrees C: SMD Planetary Division, High-Temperature Subsystems and Components for Long-Duration (months) Surface Operations

Science PI: Dr. Ayayi Ahyi, AU

SiC and GaN are the materials of choice for High temperature electronics because of their wide bandgap and high chemical stability at high temperature and also because these technologies have recently seen a considerable development leading to commercialization on the consumer market. Although they both have acceptable thermal conductivity, SiC is exceptional in that regard, which prevents the occurrence of hot spots in the device when used at high power and high current densities. Several teams have been developing electronics devices for Venus like conditions. Power conditioning for these devices will be needed both for protection and for accuracy. In modern electronics, power conditioning is done using complex integrated circuits. However, GaN or SiC technology are not at the stage where these types of ICs are easily manufactured and tested within a reasonable amount of time. Therefore, discrete Zener diodes, which have been extensively used in earlier Si electronics (and are still used although less commonly) to stabilize voltages, shape signals and protect electronics from overvoltage events have a huge potential for SiC high temperature electronics.

We propose the fabrication and investigation of high temperature (500°C) SiC Zener diodes using ion implantation and evaluate their long term degradation at high temperature. Two main configurations will be pursued: (i) a vertical device, for high power applications and (ii) a lateral device that can be integrated into SiC ICs that are being developed by other groups. The different elements necessary to make the high temperature device will come from expertise developed by the Auburn group in their ongoing and previous studies of devices such as 500°C MOSFET transistors and high temperature integrated circuits. A measurement setup was developed for our ongoing interest in high temperature electronics and will also be used in this case for study of the device behavior over time.The device will be stressed at high temperature (typically 500°C) for over 1000 hours and the characteristics of the device will be monitored during the test. Of interest are the capacity of the devices to regulate power with minimal drift over time. For such precision devices, contact degradation and the effect of passivation layers will have an important effect on the device performance. The effect of using ion-implanted doped layer as opposed to the conventional way of using epitaxially doped material will also be investigated. Our study therefore will give to other groups involved in the development of devices for NASA missions, the recipes to incorporate Zener diodes into their designs with established properties over time. The difficulties of the project reside in the presence of crystal defects in SiC such as basal plane and threading edge dislocations that are known to grow over time especially at high temperatures. Unfortunately these defects are more prominent in highly doped layers. They are known to reduce the performance of diodes and may result in faster degradation of the devices at high temperatures. The study proposes both the fabrication and the long- term study of the devices in a set up that allows the parallel biasing of several devices simultaneously at high temperature. Devices will be characterized in situ while at high temperature and be characterized after 1000 hours stress to observe the presence of dislocations and their extent.

Low-pressure plasma/photocatalytic nanofibrous membrane reactor system for harvesting fuel components from Martian atmosphere: KSC Partnership Office/ Conversion of Co2 into Fuel.

Science PI: Dr. Andrei Stanishevsky, UAB

This project aims at the developing of a light-weight ceramic nanofiber-based, glow discharge enhanced, photocatalytic membrane reactor system operating at reduced pressures to support efficient in-situ resource utilization in future Mars missions. Current processes designed for Mars in situ resource utilization (ISRU) include Sabatier, steam/dry reforming, reverse water/gas shift, electrolysis, Fischer-Tropsch, methanol synthesis and several others. All these and related processes rely on relatively heavy and energy-thirsty equipment and frequently need the temperatures >150 oC and pressures e1bar (up to 50 bar). Several other approaches have been proposed to utilize the Martian atmosphere for fuel components, water and oxygen. Those include solid oxide electrolysis (MOXIE), photocatalysis, and glow-discharge plasma. Photoreduction of CO2 to CO and O2, or to other compounds through the reactions with H2 and H2O is possible due to reasonable solar irradiance (<300 W/m2) on Mars. Plasma technology is also gaining increased interest for the reduction of CO2 to CO and O2. Although some interesting results have been obtained, both plasma and photocatlytic approaches are still in their infancy.

To advance these promising technologies to the next level, the proposed study will explore the potential of plasma/photocatlytic conversion of CO2 into the fuel components by using a light-weight and scalable nanofibrous ceramic (NFC) membrane catalytic reactor system operating under simulated Martian atmospheric conditions. The proposed reactor incorporates the staked flat gas separation membrane, catalytic membrane, and metal mesh electrode system capable of operating at low pressures and down to cryogenic temperatures. The research objectives include the design, fabrication, and tests of NFC membranes for (1) CO2/N2 and CO/O2 separation, (2) CO2 splitting to CO and O2 in glow discharge and under visible light, and (3) CO2 and CO reactions with H2 and CH4 in glow discharge and under visible light at low pressures and temperatures. The feasibility of completion of the proposed tasks is based on the availability of the efficient process to fabricate NFC membranes with different composition and microarchitectures and total porosity up to 99.5%. The process involves a high-yield, free-surface alternating field electro-spinning (AFES) to prepare nanofibrous ceramic precursors, followed by calcination and sintering procedures to fabricate the membranes. This allows the fabrication and screening, in reasonable time, of a variety of prospective membrane compositions and structures. Targeted materials primarily include the nanofibrous transition metal oxides (TiO2, ZrO2, ZrxTi1-xO2) doped with Ni, Mn, Ru, Cu, Fe, and Co, and incorporating, in some cases, carbon nanostructures. Significant research findings on gas transport and catalytic performance of NFC membranes and entire reactor system under targeted environmental conditions are expected upon completion of these tasks.

Dusty Plasmas: Space Life and Physical Sciences and Research Apps

Science PI: Dr. Uwe Konopka, AU

Dusty plasmas are four-component plasma systems consisting of the standard plasma constituents of electrons, ions, and neutral atoms, with the addition of a fourth component: charged, solid, nanometer-to-micrometer-sized particulates (i.e, the dust particles). In both laboratory and space environments, the dust particles become charged through the acquisition of electrons and ions from the background plasma as well as various ionizing processes such as thermionic emission or photoelectron emission. Regardless of the charging processes, the dust particles are coupled to and become part of the plasma through their charge. However, the small charge-to-mass

ratio of the dust grains (relative to the electrons or ions) means that the plasma process of the dust component is slowed to time (~10-2 s) and space (~10-3 m) scales that enable simultaneous studies of plasma dynamics in both the kinetic (particle) and fluid (collective) regimes. Moreover, the small charge-to-mass ratio also allows the thermal state of the dust component to be experimentally tuned over a range of Coulomb-coupling parameters (i.e., G, ratio of electrostatic-to-thermal energy) from the weakly-coupled (G << 1) to strongly-coupled (G >>1) regimes. This provides opportunities to explore regimes of plasma behavior that are generally difficult to achieve in standard plasmas.

This proposed project seeks to perform a new investigation of controlled dusty plasma particle transport from weakly-coupled to strongly-coupled regimes. This work leverages the extensive expertise and experimental capabilities of the Auburn Dusty Plasma research group in laboratory and microgravity studies of dusty plasmas. In this work, two main activities are proposed for this one-year activity: (a) demonstration of passively-driven, long-range dust particle transport (i.e., transport distances >> collision mean free path) using biased electrodes to establish cyclical particle motion between several suspended dust clouds and (b) development of a programmable, segmented electrode with the ability to provide steady-state or periodic control of particle transport over long distances in a plasma. The long-term goals of this work are to develop a comprehensive understanding of dust particle transport over a broad range of experimental conditions that can lead to scaled studies of charged dust transport in environments relevant to lunar and Martian conditions. From these studies, it will be possible to provide a scientific basis for the next generation of remote and manned missions on airless and plasma exposed bodies throughout the solar system.

Characterization of Bi_metallic Joints Formed by Different Processes

Science PI: Dr. Judy Schneider, UAH

Development of the Space Launch System (SLS) vehicle at the NASA- Marshall Space Flight Center (MSFC) supports the Artemis Mission to the moon, Mars and beyond [1]. To sustain these missions, there is a need for fabrication of landers as well as reusable, reliable materials and processes for extraterrestrial fabrication and repair. Thus, the materials and fabrication processes must be suitable for a multitude of components as well as environments. Terrestrially, to support the SLS vehicle fabrication, upgrades are underway to improve the performance and reliability of the RS-25 liquid rocket engine (LRE) [2]. While this provides an opportunity to insert new materials and manufacturing processes, such as additive manufacturing (AM) into the RS-25 production upgrade, it is urgent to develop material property databases to ensure designers have relevant information for designing robust and reliable engine components.

A regeneratively cooled, RS-25 combustion chamber consists of a Copper (Cu) liner joined to a structural jacket [3, 4]. Heritage hardware initially used stainless steels (Fe based) whose coefficient of thermal expansion (CTE) closely matched that of the Cu liner [5]. Eventually, the Fe base material was replaced by higher strength nickel (Ni) based superalloys such as Inconel 625. While Inconel 625 provided improved strength, there was a trade off in increased CTE mismatch that affected the fatigue life of the combustion chamber. More recently, the NASA developed an advanced Ni based superalloy called NASA HR-1 that decreased the CTE mismatch [6]. The current evaluation of manufacturing methods, such as AM, provides an opportunity to evaluate improved materials to retain the high strength of the Ni based superalloy while minimizing the CTE mismatch to improve reliability. Of the various AM processes being evaluated for the RS-25 LRE, direct energy deposition (DED) processes offer the best approach

toward fabrication of bi-metallic combinations without size restrictions [7]. Improved reliability can be obtained if the resulting bi-metallic interface has adequate strength and microstructural stability at elevated temperatures during hot fire operation. This requires quantification of the properties of the AM materials in parallel with the development of AM processes for LREs. Thus quantifying the material properties from AM processing also must include those of the resulting interface between different families of materials encountered in regeneratively cooled LREs. Prior research has observed significant differences in the interface of samples obtained using different materials, processes and vendors [8-12]. Since there are no current standards or specifications for production of this hardware, the vendors currently apply their best practices, which can widely vary. This means that there is no consistency in the feedstock supplier or equipment settings, factors known to affect the melt pool formation and mixing between materials. Within the liquid metal of the melt pool, Marangoni currents influence the intermixing as influenced by atmospheric contaminations, injection velocity, heat source power density, and elemental composition, resulting in vastly different properties at the interface [13-15]. Since DED is of interest for the bi-metallic structures, characterization of two processes involving blown powder are proposed: blown powder deposition versus cold spray. Thus understanding how variations in DED processing affect the overall properties of the bi-metallic joint will contribute toward increasing the overall technical readiness level (TRL) of an AM RS-25 LRE. This is of relevant interest to both NASA and the commercial space companies [16-19]. Using the unique capabilities at UAH, this proposal will leverage mini-samples from actual hardware [12] in collaboration with NASA and commercial space to characterize and disseminate data.

Noah Nadan (front) and Giancarlo Puerto, Dr. Schneider's former undergraduate students and now graduate students, working in the laboratory.

US DEPARTMENT OF DEFENSE EPSCoR

Congress reauthorized the Department of Defense EPSCoR (DEPSCoR) in FY 2018 and appropriated $12M in FY 2019 and FY 2020 to fund DEPSCoR. DEPSCoR's objectives include:

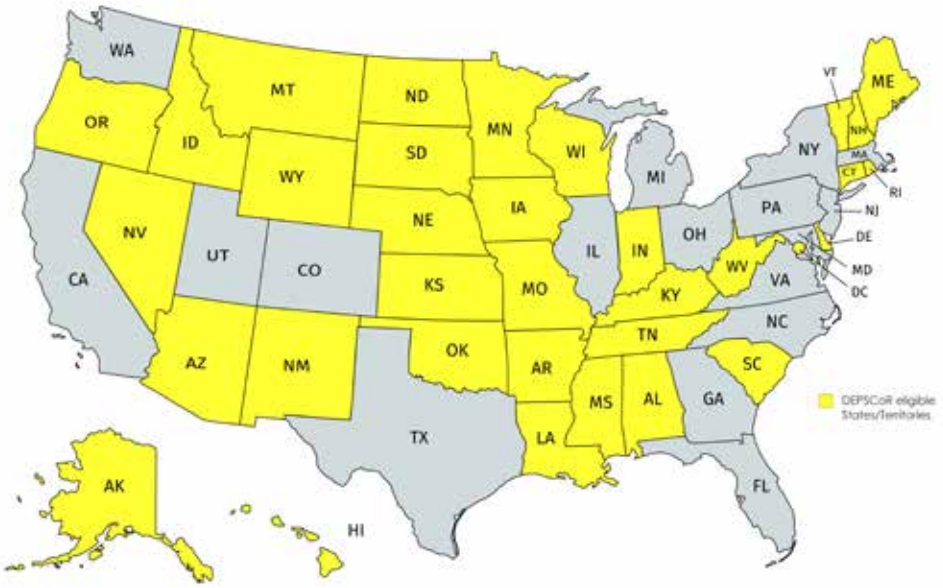
- enhance the capabilities of institutions of higher education in eligible states and territories to develop, plan, and execute science and engineering research relevant to the DOD mission and competitive under the peer-review systems used for awarding federal assistance
- increase the number of university researchers in eligible states/territories capable of performing science and engineering research responsive to the needs of the Department of Defense
- increase the probability of long-term growth in the competitively awarded financial assistance the institution of higher education in eligible states and territories recieve from the federal government for science and engineering research.

The authorization for DEPSCoR included a formula for determining elibility for a state or territory, it was based on the amount of Department of Defense Research and Development funds obligated to institutions of higher education with a state/territory over a three-year average. Thirty-four states, the Commonwealth of Puerto Rico, Guam and the U.S. Virgin Islands are eligible. "States that received less than 60% of 1/50th of the total Science and Engineering (S&E) research obligations to the U.S. Institutions of Higher Education are eligible if a commitment to developing S&E research is demonstrated."

The DEPSCoR Program has three general thrusts:

- increase funding to programs in the Services
- solicit applications for a stand alone competition
- host outreach meetings to educate researchers about DOD funding programs.

Collaborative DEPSCoR Competition is a new program and will be managed by the Basic Research Office, awarded by the Air Force Office of Scientific Research (AFOSR) and administered through the Office of Naval Research (ONR). The FY20 Funding Opportunity Announcement (FOA) was published in May 2020. It will support a mentee/mentor group with up to twelve awards totaling $7.2M at $600K each ($200K for 3 years). White papers were due by Sept. 21, 2020. Full proposals will be by invitation only and due Feb. 15, 2021.



US DEPARTMENT OF DEFENSE EPSCOR

The FY DEPSCoR competition seeks proposals in the following topics:

- Cognitive and Computational Neurosciences
- Space Science
- Agile Science of Test and Evaluation
- Materials with Extreme Properties
- Propulsion and Energetics
- Computational Architectures and Visualization
- Optoelectronics
- Propability and Statistics
- Molecular Structure and Dynamics
- Social and Behavioral Science
- Biotronics
- Aerospace Structures and Materials
- Ocean Acoustics
- Machine Learning, Reasoning, and Intelligence
- Power Electronics & Electromagnetism, Adaptive & Machinery Controls and Advanced Machinery Systems

Augment Exising Programs - Existing programs within DOD, the Young Investigator Program (YIP) and the Defense University Research Instrumentation Program (DURIP) were a part of the FY 2019 initial year of funding. In FY2020 only the DURIP Program will be enhanced with $4.8M in additional funds to benefit EPSCoR jurisdictions.

The DURIP supports university research infrastructure essential to high-quality Navy relevant research. DURIP funds are used for the purchase of major equipment in support of DOD-relevant research.. It is estimated that there will be two DURIP awards in each of the three services each at the $300K level. Each service branch's DURIP announcement closed on May 15, 2020. Additional information on DURIPs can be found at https://www.grants.gov/web/grants/search-grants.html?keywords=durip.

ALABAMA USDA EPSCoR

The National Institute of Food and Agriculture's (NIFA's) Food and Agricultural Science Enhancement (FASE) Grants are designed to help institutions develop competitive projects and to attract new scientists and educators into careers in high-priority areas of national need in agriculture, food, and environmental sciences. FASE Grants consist of New Investigator Grants, Pre- and Postdoctoral Fellowship Grants, and Strengthening Grants. Strengthening Grants are further divided into Sabbatical Grants, Equipment Grants, Seed Grants, Strengthening Standard Grants, Strengthening CAP (Coordinated Agricultural Project) Grants, and Strengthening Conference Grants.

Strengthening Grants are available during each funding cycle to ensure researchers at institutions and states underrepresented in terms of Federal research, education, and/or extension funding receive a portion of AFRI funds. Strengthening Grants are limited to: (1) small and mid-sized or minority-serving degree-granting institutions that previously had limited institutional success for receiving Federal funds; or (2) State Agricultural Experiment Stations or degree-granting institutions eligible for USDA Established Program to Stimulate Competitive Research (EPSCoR). When determining eligibility for these grant types, the following definitions apply:

- Small and mid-sized academic institutions with a current total enrollment of 17,500 or less including graduate and undergraduate and full- and part-time students.
- Accredited academic minority-serving institutions whose enrollment of a single minority group or a combination of minority groups exceeds 50% of the total enrollment, including graduate and undergraduate and full- and part-time students.
- Limited institutional success means institutions not among the most successful universities/colleges for receiving federal funds for science and engineering research.

Every year, NIFA determines the states eligible for USDA EPSCoR funding. This list includes states having a funding level no higher than the 38th percentile of all states based on a 3-year rolling average of AFRI funding levels, excluding FASE Strengthening funds granted to EPSCoR states and small-mid-sized and minority-serving, degree-granting institutions, see table below. In FY 2016, Alabama became ineligible for USDA EPSCoR funding.

USDA Established Program to Stimulate Competitive Research (EPSCoR) States FY2007-FY2020

State	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Alabama	yes	yes	yes	yes	yes	yes	yes	yes	yes	-	-	-	-	-
Alaska	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Arizona	-	-	-	-	-	-	-	-	yes	-	-	-	-	-
Arkansas	yes	yes	-	-	-	-	-	-	-	-	-	yes	-	-
Connecticut	-	-	yes	yes	yes	yes	yes	yes	yes	yes	-	-	yes	yes
Delaware	yes	yes	yes	yes	-	-	-	-	-	-	-	-	-	-
Hawaii	yes	yes	yes	yes	yes	-	-	-	-	-	-	-	yes	yes
Idaho	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Kentucky	yes	yes	yes	yes	yes	yes	yes	yes	yes	-	-	-	-	-
Louisiana	yes	yes	yes	yes	yes	-	-	-	-	-	-	yes	yes	yes
Maine	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Mississippi	-	-	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Montana	-	-	-	-	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Nevada	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	-	-
New Hampshire	-	-	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
New Jersey	yes	yes	-	-	-	-	-	-	-	yes	yes	yes	yes	-
New Mexico	yes	yes	-	-	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
North Dakota	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Oklahoma	yes	yes	-	-	-	yes	yes	yes	-	yes	yes	yes	yes	yes
Rhode Island	-	-	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
South Carolina	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
South Dakota	yes	yes	yes	yes	-	yes	-	yes	yes	yes	yes	-	-	yes
Utah	-	-	-	-	-	-	yes	yes	yes	yes	yes	yes	yes	yes
Vermont	yes	yes	yes	yes	yes	yes	yes	yes	yes	-	yes	yes	yes	yes
West Virginia	yes	yes	yes	yes	yes	yes	yes	-	-	yes	yes	yes	yes	yes
Wyoming	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Available on https://nifa.usda.gov/resource/history-usda-epscor-states

APPENDIX

Agency	FY15 Enacted	FY16 Enacted	FY17 Enacted	FY18 Enacted	FY19 Enacted	FY20 Enacted	FY21 Budget Request	FY2021 Coalition Goals
NSF	$159.7	$160.0	$160.0	$170.7	$175.6	$190.0	$163.7	$210.0
NIH	$273.3	$320.8	$333.4	$351.0	$361.6	$386.6	$351.8	$400.0
DOE	$10.0	$15.0	$15.0	20.0	$20.0	$25.0	$7.0	$25.0
USDA	$48.7*	$52.5*	$56.25*	$60.0*	$62.3*	$63.8*	$90.0*	15% Language
NASA	$18.0	$18.0	$18.0	$18.0	$21.0	$24.0	$0	$28.0
DOD	-	-	-	$0	$12.0	$12.0	$0	$25.0
Total	**$509.7**	**$566.3**	**$582.7**	**$619.7**	**$652.5**	**$701.4**	**$612.5**	

(amounts in millions)
***Represents 15% of the Agriculture and Food Research Initiative (AFRI) account**