Alabama Research and Development Enhancement Fund Quarterly Report December 2025

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Background

The Alabama Innovation Act (AIA) was established by Legislative Act #2019-404 and became effective June 6, 2019. The Act designated the Alabama Department of Economic and Community Affairs (ADECA) as the state agency to establish and administer the Alabama Research and Development Enhancement Fund (ARDEF) Program.

The purpose of the ARDEF Program is to encourage new and continuing efforts to conduct research and development activities within the state. The Fund is designated to receive appropriations from the legislature, or from the receipt of gifts, grants, or federal funds to be expended for the purpose of increasing employment opportunities, products and services available to the citizens of Alabama.

Overview of 2020 Program Year

Projects Funded Under 2020 Round One Grant Period

Applicant	Amount
Auburn University – Removal of Per- and Polyfluoroalkyl Substances (PFAS) in Water and Landfill Leachate in Alabama	$193,960.00
Auburn University – Knitting Micro-Resolution Mosquito Bite Blocking Textiles	$868,145.00
Auburn University – Advanced Biosensors from Forestry Products and Agricultural Resources	$245,864.77
Hudson Alpha Institute for Biotechnology – Advancing Genomic Health in Community Clinics and Employee Wellness Settings	$969,409.00

Auburn University – Removal of Per- and Polyfluoroalkyl Substances (PFAS) in Water and Landfill Leachate in Alabama

This project aimed to remove and destroy the so-called forever chemicals, per- and polyfluoroalkyl substances (PFAS), from Alabama water and landfill leachate. PFAS have been detected in chemical manufacturing wastes and landfill leachate in Alabama and have caused some serious cases of drinking water contamination in the state. Ongoing health concerns and regulatory development associated with PFAS are threatening the sustainable development of the Alabama economy and business. The goal of this research was to develop an innovative "Concentrate-&-Destroy" technology to cost-effectively remove and degrade PFAS in water and landfill leachate. The new remediation technology will provide the affected industries and water utilities with a powerful remediation means to mitigate the PFAS-related issues, thereby assuring sustainable development of the economy and the wellbeing of Alabama citizens.

In the final quarter of this project, we focused on writing and refining the final project report. We have submitted the final report to the sponsor. Overall, we are pleased to have preliminarily proven the novel "concentrate-&-destroy" concept and tested the technology for treating PFAS in water and landfill leachate. Despite the technical challenge due to the highly recalcitrant nature of PFAS

and the strong matrix effect of landfill leachate, we obtained some encouraging data, which warranted further development of this promising technology.

This research project ended July 31, 2023.

Auburn University – Knitting Micro-Resolution Mosquito Bite Blocking Textiles

Insects transmit crippling diseases to humans. Nearly a half-million people die of malaria each year. In Alabama, citizens encounter Dengue and Zika virus invasions as well as a multitude of encephalitis variants. The worse vector-borne diseases are transmitted in the hottest climates like Alabama, and it is uncomfortable to wear the thickest clothing. This project will research different textile and weave patterns to create clothing that is cool in heat and capable of blocking mosquito bites and develop prototypes based on this research. Beyond the prototype phase, research will be done to measure the effectiveness this product will have on the Alabama economy.

We started a new company, Material Masters LLC, in Alabama, teaming up with local knitting experts. We are preparing to launch our first products, such as special socks that mosquitoes cannot bite through, and we are working on protecting our invention with trademarks. Plus, we managed to make a lot more of our special fabric. Our next steps are to make sure everything is up to code for selling clothes in the U.S. and to turn our fabric into finished clothes. We also determined that our fabric works better than others at preventing mosquito bites, and we are finalizing our research.

This research project ended June 30, 2025.

Auburn University – Advanced Biosensors from Forestry Products and Agricultural Resources

The main goal of this project is to utilize Alabama's forestry products and agricultural resources for extracting cellulosic nanomaterials (CNM) by using these nanomaterials in advanced biosensing. As timber production and other agricultural products are essential for the economy in Alabama, these materials are a great resource for obtaining cellulosic nanomaterials.

This project is focused on using Alabama's forestry and agricultural products such as wood, cotton, and soybean hulls as sources of an exciting nanomaterial called cellulose nanocrystals (CNC). Cellulose nanocrystals are found in all biomass. Their high strength, large specific surface area, and natural organic chemistry make them exciting for a range of applications. We are focused on developing sensors to improve water safety and the health of Alabama citizens.

This research refined understanding of the different hydrolysis conditions needed to extract cellulose nanocrystals (CNCs) from soy and cotton, explored the processing window for making shear cast films from these materials, and evaluated film optical and mechanical properties. Additional efforts focused on optimizing CNC device fabrication conditions after a change in fabrication materials and equipment repair.

Auburn University's outstanding laboratory facilities and the support from ADECA helped the research team continue to gain insights on how exciting material hiding in our abundant forestry

and agricultural resources could be transformed to enable Alabama citizens to detect contaminants and allergens in their water and food.

This research project ended September 30, 2023.

Hudson Alpha Institute for Biotechnology – Advancing Genomic Health in Community Clinics and Employee Wellness Settings

Genomic medicine is a form of precision medicine that uses approaches customized to each patient to treat disease and optimize prescription medicine based on a genetic profile. This project will test and develop a complete delivery system for Alabama patients and physicians at healthcare systems and community hospitals with limited expertise in genomics. This system includes: 1) Partnering with Auburn University to develop community-based models for health programs; 2) Refining and optimizing the process including ensuring access by rural and underserved areas, and 3) Developing the health IT infrastructure needed to fully integrate genetic test reporting and education into an electronic health records system. The proposed development of new products and services will result in improved health outcomes for Alabamians, opportunities for employers to increase competitiveness and reduce costs, and modernization of health care in an equitable way for Alabama communities, large and small, regardless of socioeconomic status.

This Hudson Alpha project worked with partners across the state of Alabama to provide genetic testing as an employee wellness benefit. Genetic results provided as part of this project included pharmacogenetics, to inform the selection and dosing of medications, as well as risk for certain diseases such as cancer and cardiac conditions. We have completed the recruitment of participants through partnering employers and all results have now been delivered to participating employee clinics. Program impact continues to be assessed through the analysis of de-identified participant test results.

Disease causing variants were identified in 2.8% of participants, including variants associated with hereditary types of high cholesterol and cardiomyopathy. A larger portion of patients (26.7%) indicated a significant personal or family medical history, making them an appropriate referral for further evaluation and testing. More than half of participants (59.7%) received a result related to current medication. Medication recommendations include dosage changes, risk of side effects, increased monitoring, and in some cases a recommendation to avoid a particular medication and choose an alternative. De-identified project outcomes data was recently presented at national meetings, and a manuscript is being prepared for journal submission. Data disseminated through this Hudson Alpha project will provide valuable insight into the clinical and personal utility of genetic testing in the context of employee wellness.

This research project ended September 30, 2024.

Projects Funded Under 2020 Round Two Grant Period

Applicant	Amount
University of Alabama in Huntsville – Alabama Business Resiliency and Sustainability Index and Roadmap	$746,104.00
University of Alabama in Huntsville – Rural Employment and the Need for an Alabama Irrigated Acreage Survey, Demand Estimate and Forecast	$172,073.00
University of Alabama at Birmingham – A Comprehensive Data Science Software Toolkit to Improve Alabama's Mobility Planning for Serving Businesses and Vulnerable Populations	$394,926.00
Auburn University – Design, Fabrication and Testing of Novel Medical Facemasks to Prevent COVID-19	$75,374.00
Auburn University – Formaldehyde Paper-based Device (PAD) for a Cost-efficient Detection of Formaldehyde Emissions from Wood Panels	$247,142.00
University of Alabama at Birmingham – Commercialization of Small Diameter Artificial Vascular Graft for an Animal Trial	$906,458.00
Bashan Institute of Science – Exploring the Use of Cellulose Fibers as Microcapsules for Plant Growth-promoting Bacteria (PGPB) Inoculants	$7,500.00

University of Alabama in Huntsville – Alabama Business Resiliency and Sustainability Index and Roadmap

Recent events, such as the global COVID-19 pandemic, are having detrimental impacts on companies throughout Alabama, including the products and services they provide and the citizens they employ. Other impactful events that can occur may include the sudden loss of a major customer or supplier, a natural disaster, or even a diminishing source of skilled labor. The objective of this project is to research potential impacts on businesses and organizations across several business sectors to develop and deploy a comprehensive Resiliency and Sustainability Index and Roadmap (RSIR) model. The RSIR can be further tailored to fit each business sector and individual organization. Additionally, the UAH team will directly support businesses in the customization and implementation of their RSIR along with assistance in developing the ability to execute the roadmap and plan should the need arise.

In the last quarter, the focus of our effort has been on completing engagements with customers and grant close-out reporting, which included: finalizing customer reports, submitting final customer deliverables, providing implementation support, and compiling a comprehensive report on the Future Ready program. A robust sustainability and resiliency model was developed, and 37 companies were assisted under the Future Ready program.

This research project ended February 29, 2024.

University of Alabama in Huntsville – Rural Employment and the Need for an Alabama Irrigated Acreage Survey, Demand Estimate and Forecast

As irrigated agriculture develops in our rural communities, it is imperative Alabama has the tools and data needed to ensure water resources are available for sustainable economic development. The goals of this project are to update the existing manual center pivot irrigation survey completed by UAH for the years to include 2017 and 2019 and develop a state-specific machine-learning framework from multiple sources of remote sensing products to efficiently and semi-autonomously identify the irrigated areas in Alabama to include all irrigated land such as golf courses and other irrigation system types beyond just center pivots. This information will be used to update the report "Estimates of Future Agricultural Water Withdrawal in Alabama," produced by the Water Resources Center, Auburn University for OWR in 2017. The result will include updated estimates as well as methodologies utilizing more recent urban growth and land use change data. The results and outcomes of this project will support the Alabama Department of Economic and Community Affairs (ADECA) Office of Water Resources (OWR) to accurately analyze and forecast water use across the State.

During Q4 2022, this project's final quarter, the team finalized the results and concluded the project. The results and outcomes of this project will support the Alabama Department of Economic and Community Affairs (ADECA) Office of Water Resources (OWR) to accurately analyze and forecast water use across the State. In 2015, a total of 121,394 acres of center pivot irrigation was identified. This was about a 37,000-acre increase from 2013. The current study mapped center pivot irrigation for the years 2017, 2019 and 2021. We show that irrigation has continued to increase, though the rate of increase has decreased.

Overall, center pivot irrigation grew 24,594 acres from 2015 to 2021 at an average annual rate of approximately 4,000 acres per year. This varied by region with the Wiregrass region increasing the most over the same period (5,600 acres total). A pilot project was developed to assess the potential of automating the center pivot survey. Though the Alabama specific methodology performs as well as or better than many national products, there are still improvements that are needed to meet the accuracy needed for water use surveys. Lastly, a land use change model was employed to estimate the future growth in irrigation to inform future water use estimates. Overall, our results show a greater than 50% increase in irrigation by 2040.

This research project ended October 15, 2022.

University of Alabama at Birmingham – A Comprehensive Data Science Software Toolkit to Improve Alabama's Mobility Planning for Serving Businesses and Vulnerable Populations

This project focuses on the development of a comprehensive data science software toolkit to support transportation planning for Alabama's businesses and vulnerable populations. Research activities include: (i) use of transportation user surveys and open data source collection to build a web-based data portal for mobility analysis in Alabama; (ii) development of agent-based urban transportation simulation models, and employment of machine learning techniques for transportation forecasts; and (iii) use of the developed tools to study scenarios that address pressing mobility needs in Alabama. Examples include (1) building a COVID-19 simulator to explore how

various business reopening strategies affect the population's mobility and hence the virus spread; and (2) studying the impact of shared mobility services such as Uber/Lyft/Via, Zyp Bikeshare stations and dockless electric scooters on local traffic congestion, transit use; and accessibility and mobility of vulnerable populations. The project will provide helpful recommendations to transportation policymakers about transportation initiatives that can help Alabamians, including economically and physically disadvantaged ones, to gain access to jobs and critical amenities in an equitable and efficient manner.

During the Q2 2024 reporting period, the team worked on the web-based data portal. The portal is part of the project's comprehensive data science software toolkit and aims at integrating the data sources and findings of the project with convenient interface for file retrieval. The information on the data portal showcases the project accomplishments and supports future data-driven mobility analysis and planning studies in and around Birmingham, AL.

During the reporting period, we also summarized our recent work on the analysis of temporal and spatial patterns of e-scooter trips in Birmingham, AL, and their impacts on local traffic congestion in a technical paper. The paper was submitted to the 7th International Conference on Sustainable Mobility (CSuM 2024)- Climate Crisis and Resilient Transportation Systems which will be held in Lake Plastira, Greece, Sept 4-6, 2024. The paper was accepted for presentation and publication in the conference proceedings.

This research project ended July 15, 2024.

Auburn University – Design, Fabrication and Testing of Novel Medical Facemasks to Prevent COVID-19

One of the most effective ways to prevent viral spread of the Coronavirus is to use face masks and respirators. Available reusable face masks are often not as effective as single-use coverings, which are costly and environmentally irresponsible. Currently, there is limited knowledge available on the performance of fabrics used in masks. Filtration efficiencies as a function of aerosol particulate sizes in 10 nm to 10 nm range are relevant for respiratory virus transmission but lack evaluation. The purpose of this research was to develop novel face masks to fight the pandemic based on scientific and engineering principles. In this research, novel medical face masks were designed, produced, and tested to reduce the spread of COVID-19 while improving on deficiencies present in currently used textile reusable face coverings. The project incorporates additive manufacturing, computer aided design (CAD), third party testing of both Bacterial Filtration Efficiency (BFE) and differential pressure measurements, and laser-visualization tools for illuminating leakage.

This project resulted in a textile face mask design with enhanced capabilities as compared to other textile masks currently available on the market. Through the employment of various testing methods, including bacterial filtration efficiency, breathability, initial filtration efficiency, laser leakage illumination, and performance testing, various mask iterations were evaluated and improved to perform better.

Different engineering methods were utilized, including textile engineering, additive manufacturing, and laser imaging, all to construct a device with the capability of reducing the spread of COVID-19 or another disease, if a pandemic such as COVID-19 were to occur again.

This research project ended May 15, 2022.

Auburn University – Formaldehyde Paper-Based Device (PAD) for a Cost-Efficient Detection of Formaldehyde Emissions from Wood Panels

Formaldehyde emission can be toxic to people depending on the time of exposure coupled with formaldehyde concentration. This level of exposure is generally not high in forest products because companies that make indoor products currently measure formaldehyde through quality control techniques. Companies also use safe adhesives ("glues") by partnering with their suppliers. Nevertheless, these companies are regulated by federal standards such as the California Air Resources Board (CARB) to ensure this safety. To assist with the more expensive and laborious methods in CARB, this project endeavors to create a relatively cheap paper-based sensor that changes color based on formaldehyde exposure. Such a product can help to reinforce the safety of our forest products while maintaining the jobs of our many Alabamians.

The funding for this project has not only allowed us to develop a prototype for detecting formaldehyde in the air, but it has also enabled our team to train two master's students of the Sustainable Biomaterials and Packaging Program in the area of paper-based sensor development. The acquisition of small instruments for material characterization was essential in achieving the set objectives, and it will continue to assist our team in advancing new projects aimed at developing novel sensors.

To secure the intellectual property rights for commercializing the idea in the near future, our team has successfully filled out a patent application. In addition to developing the prototype, our team has gathered high-quality results and is in the process of drafting manuscripts for submission to peer-reviewed scientific journals, aiming to share our findings and contributions with the wider scientific community.

We want to thank the ARDEF Program from ADECA for the opportunity to work on this project.

This research project ended January 15, 2024.

University of Alabama at Birmingham – Commercialization of Small Diameter Artificial Vascular Graft for an Animal Trial

The goal of the project is to finalize the development of artificial vascular graft for surgical implantation. The graft has relevance to the current COVID-19 pandemic in that numerous patients are reporting kidney infections and blood clots. UAB has been working on this project since 2007 and has reached a point where funds are needed for an animal trial. Once this graft has been validated through this process, we plan to market it to a biomedical implant company to set up a division in Alabama or to establish a spin-off company for production and distribution.

This graft has the potential for an estimated $50 million in annual sales based on conservative estimates of the number of surgical interventions that could use the implant in an unmet market and lead to a number of jobs for highly skilled workers in the State of Alabama.

In the past quarter, we have completed the last surgical implantation, and the animal survived until it was euthanized to recover the implant.

We are completing our analysis on the latest implant and for the study as a whole. We will be publishing our results in various journals.

This research project ended August 31, 2024.

Bashan Institute of Science – Exploring the Use of Cellulose Fibers as Microcapsules for Plant Growth-Promoting Bacteria (PGPB) Inoculants

Inoculation of plants with plant growth-promoting bacteria (PGPB) that enhances the yield of crops and growth performance of environmental plants is an old practice. Two main factors control the success of inoculation—effectiveness of the bacteria and application technology. If the suspensions of bacteria are inoculated into the soil without a proper carrier, the bacteria population declines rapidly. These unprotected inoculated bacteria must compete with the often better-adapted native microflora and withstand predation by soil microfauna. Consequently, a major role of formulation of bioinoculants is to provide a more suitable microenvironment, combined with physical protection for a prolonged period to prevent a rapid decline of introduced bacteria. This project explored the feasibility of using cellulose fibers as carriers, to improve survival and enhance the PGPB viability. During the final quarter we assessed the success on bacterial colonization of the fibers, as well as the viability of the bacteria after being immobilized and freeze-dried.

This research project ended March 15, 2022.

Overview of 2022 Program Year

Projects Funded Under 2022 Grant Period

Applicant	Amount
The University of Alabama – Innovative Wood-Concrete Composite Structural Elements for Resilient Modular Building and Transportation Structures	$341,679.00
Auburn University – Advanced Liquid Transportation Fuels from Co-Liquefaction of Forest Biomass and Waste Plastics	$727,677.00
Auburn University – Novel Biotechnology that Converts Agricultural and Municipal Waste into Bioplastics	$294,008.00
Hudson Alpha Institute for Biotechnology – Next Generation Crops for a Diverse Alabama Agricultural Economy	$968,365.00
University of Alabama in Huntsville – Versatile Training to Provide an Agile, Advanced Manufacturing Workforce in Alabama	$603,206.00
Auburn University – Polymer Smart Machines	$268,353.00
University of North Alabama – Surface Plasmon Resonance-based Biosensors	$10,353.33
Auburn University – Novel and Sustainable Feed Binder from Soybean Hulls	$300,432.00
University of Alabama at Birmingham – Amputation	$700,000.00
University of Alabama at Birmingham – Pneumococcal Vaccine	$635,926.67

The University of Alabama – Innovative Wood-Concrete Composite Structural Elements for Resilient Modular Building and Transportation Structures

This research project focuses on the development of innovative materials and construction techniques that can help improve the sustainability and resilience of Alabama building and transportation infrastructure. The overall research goal of this project is to develop innovative hybrid structural building elements using fiber reinforced concrete and laminated wood materials (traditional lumber and/or bamboo); and characterize their performance under several loading conditions. As part of this research, we will develop two types of hybrid elements and perform large-scale testing of these elements whereby they will be subjected to mechanical and impact loading (representing expected debris impact during a tornado event). We will also investigate the acoustic and thermal performance of these elements to understand their energy efficiency for building applications. The novel and validated structural elements can provide opportunities to attract new industries and supply chains related to prefabricated building systems.

This quarter advancements were made in the fabrication and testing of CLT-UHPC composite deck systems. Formwork was prepared and UHPC was cast for two composite deck specimens (164 × 45 in.) in a two-step sequence—first casting the top UHPC layer, allowing it to air cure, then flipping the specimens to cast the bottom layer. Both three-layered and five-layered CLT panels were used, each with 1.25-inch-thick UHPC layers on both faces. Fifteen embedded strain gauges were installed in each layer prior to casting to monitor shrinkage behavior, with data collected over five days. Preparations for the fatigue test setup are underway, featuring a two-span

continuous deck configuration with 6-ft spans and load application via dual actuators. The instrumentation plan for this test has been finalized. Additionally, ongoing monitoring of moisture ingress in epoxy-coated CLT showed effective water resistance for the first 90 days, though cracks have recently developed due to thermal cycling, potentially increasing future moisture penetration. A preliminary debris-cannon test was also conducted on three layered CLT to assess equipment capabilities and testing conditions.

Over the lifetime of the grant, the project team successfully executed all six major tasks. Laboratory testing was completed for CLB material development, interface shear and moisture performance, large-scale deck and wall systems, and thermal behavior. Full-scale structural evaluations were performed to simulate bridge deck service loads, tornado debris impacts, and environmental durability. All proposed activities were completed as planned, providing a comprehensive dataset on hybrid CLT/CLB–UHPC systems.

This project has advanced knowledge and application of hybrid CLT/CLB–UHPC systems as sustainable and resilient solutions for storm shelters and bridge decks. Results demonstrate both structural viability and sustainability benefits, positioning Alabama as a leader in innovative prefabricated construction. The outcomes lay a strong foundation for future adoption of bamboo and hybrid systems in U.S. infrastructure.

This research project ended June 30, 2025.

Auburn University – Advanced Liquid Transportation Fuels from Co-Liquefaction of Forest Biomass and Waste Plastics

The main goal of this project is to advance economic development in Alabama (and the nation) through reinvigoration of our natural resource-based industries and to establish new industries based on advanced liquid fuels from woody biomass grown in the state and the waste plastics collected from our local cities. Woody biomass prevalent in Alabama will be co-liquefied with waste plastics using a pyrolysis technology, which will then be subjected to hydrogen treatment to produce jet- and diesel- fuels. The funding from the Alabama Innovation Fund will be used to overcome technical barriers faced in converting woody biomass to biofuels and waste plastics recycling. The research will be focused on developing: (i) a process that would require lower capital and operating cost for biomass liquefaction; (ii) catalysts for the production of jet- and diesel-fuels; and (iii) a pathway for recycling waste plastics for the production of liquid fuels along with woody biomass. The team will leverage existing infrastructure and expertise at the Center for Bioenergy and Bioproducts at Auburn University.

In the past quarter, the team performed catalytic co-pyrolysis of biomass (southern pine) and plastics (polystyrene cutlery) and investigated the effects of feedstock composition, reaction conditions, and the usage of catalysts on the yield, characteristics, and composition of the pyrolysis products. The co-pyrolysis of polystyrene (PS) and pine chips was investigated to understand the effect of blending two distinct feedstocks to formulate aviation fuel range products. The non-catalytic co-liquefaction at 550°C was found to be the optimal temperature to generate kerosene range aromatic hydrocarbons. Also, pyrolysis was applied to liquify two common plastic materials: high-density polyethylene (HDPE) and polystyrene (PS) in an autoclave batch reactor. The

maximum bio-oil yield of 75.55 wt.% was recovered from equally mixed HDPE-PS feedstock pyrolysis at 450°C reaction temperature with 60 minutes of residence time. The influence of equal HDPE-PS mixing ratio was also observed in the elemental composition of pyrolysis oil with maximum carbon content (82.63±1.03wt.%) with reduced oxygen percentage (7.54±0.11 wt.%). The GC-MS analysis of HDPE-PS co-liquefaction crude product has detected many aromatic compounds. The oil was hydrotreated in the presence of a conventional catalyst. The hydrotreatment parameters varied at fixed hydrogen pressure and catalyst to enhance the selectivity of saturated cyclic compounds, an essential component of aviation fuel. With the reaction temperature of 300°C, the residence time of 2 hours and 1.5wt.% catalyst loading, the saturated cyclic compounds in PS hydrotreated crude could be maximized. The hydrotreatment of HDPE pyrolysis crude could not achieve a similar saturation effect. However, the hydrotreatment of an equal mixture of HDPE and PS plastics-derived pyrolysis oil demonstrated a rise in paraffin and saturated cyclic compounds.

This research project ended January 31, 2025.

Auburn University – Novel Biotechnology that Converts Agricultural and Municipal Waste into Bioplastics

Alabama is one of the top agricultural producing states in the U.S., with annual agricultural exports exceeding $1 billion. As a result, there is a significant amount of organic waste produced in the state, and Alabama ranks 14th among all states in terms of biogas generation potential from organic waste through anaerobic digestion (AD). These organic wastes represent an underutilized renewable feedstock for biofuel and biochemical production. This project aims at researching and assessing the economic feasibility of converting organic waste into bioplastics.

Specifically, the project will develop and optimize a prototype of a patent-pending biotechnology that enables the conversion of organic wastes into bioplastics, and to assess its technical and economic feasibility at scale through techno-economic analysis (TEA). In the proposed technology, a microalgae-methanotroph coculture will be cultivated in a novel patent-pending circulation coculture biofilm photobioreactor (CCBP) to convert biogas (both methane and carbon dioxide) derived from organic waste into microbial biomass while simultaneously recovering chemicals from AD effluent to produce treated clean water. The produced mixed microbial biomass can be economically processed to produce high-value bioplastics that are in rising demand. The project will advance the progress of the patent-pending biotechnology towards commercialization, which has potential to create many new jobs in the State of Alabama.

During Q2 2025, more coculture biomass was produced using synthetic biogas and real AD digestate from the lab AD. In addition, further improvement was made with the techno-economic analysis (TEA) of CCBP. The TEA study demonstrated the potential economic viability of CCBP. The study identified biomass productivity and operating costs as the most critical factors influencing the performance of CCBP. A journal paper is being prepared from the results of the TEA. The portable AD continues to be monitored. The weather has to warm for the portable AD to produce biogas in large quantities to continue to support the experiments with CCBP.

In the near future, we hope to expand the CCBP technology to convert waste (flue gas and wastewater from aquaculture) into aquafeed.

This research project ended January 31, 2025.

Hudson Alpha Institute for Biotechnology – Next Generation Crops for a Diverse Alabama Agricultural Economy

The Hudson Alpha ADECA/ARDEF project, in collaboration with Auburn University Crop, Soil and Environmental Science and Pathology Departments, and Alabama A&M University (AAMU) Winfred Thomas Agricultural Research Station will develop a pilot pipeline to import and test new crop varieties that could be deployed by Alabama farmers. We will connect the advanced agronomy crop research at Alabama Land Grant Institutions to the advanced plant genetic and genomic science expertise at Hudson Alpha. For two crops, barley and beans, the team will bring in diverse germplasm, plant and evaluate cultivars to advance in additional trials. Barley will be tested as an overwinter crop for a spring harvest in Northern and Southern Alabama and dry beans will be tested as a summer crop in North Alabama.

The team will evaluate disease, environmental, and weed pressure and other important agronomic traits for a crop to be successful in our challenging farming climate. As part of the goals, the partners will focus on increasing economic awareness of local barley and beans, connecting into existing educational and career development frameworks, and partnering with end users for brewing and food applications to increase the value of these Alabama crops. As this project develops, the teams will work with local farmers who are interested in planting alternative crops and engage stakeholders in workshops to discuss the science of next generation crop development to expand partnerships and apply this strategy to more crops useful for Alabama. With this newly developed research and collaborative infrastructure to bring in additional crop options, we can take control of the future of Alabama farming by optimizing the genetics and germplasm for Alabama, train new scientists in advanced plant science, open up new economic development in agriscience, and expand the current impact of local food and beverage industries.

Our major goal for this project was to develop a pipeline to import and test new crops for Alabama, with the end goal to offer these crops to farmers. Major accomplishments under this funding source include: 1) Developed a Farm to Brewery Pipeline for Overwinter Barley 2) Evaluated Dry Bean as a crop for Alabama 3) Developed Awareness in the farming communities of alternative crops for Alabama 4) Developed a barley farm budget and survey for Alabama grown grains and 5) Created genomic resources for southeast barley breeding.

This research project ended July 31, 2025.

University of Alabama in Huntsville – Versatile Training to Provide an Agile, Advanced Manufacturing Workforce in Alabama

The overall goal of the proposed institutional collaboration is to assist in the transition of Alabama from a low-labor-cost manufacturing state to a leader in the research and development of next generation manufacturing sciences. To meet this goal, our primary objective is to *expedite trans-*

disciplinarily, inter-disciplinarily, and multi-disciplinarily training of Alabama for entering the industrial and government workforces and contributing to the implementation and advancement of the emerging manufacturing technology through Additive Manufacturing. Student teams from University of Alabama in Huntsville (UAH) and Calhoun Community College (CCC) have developed a documentation system to track vital information on builds with complete specimen builds in 316L under both Nitrogen and Argon atmospheres. Students' understanding of the documentation requirements is critical to their future employers' efforts to qualify and certify additive manufactured components.

All activities mirror industrial expectations for workers at different educational levels (technician vs engineer). This team builds an appreciation for different skills required in industry. Additional equipment installed at the Calhoun Community College Huntsville campus will expose students to testing methods commonly used in industry standards. Collaborative efforts are continuing by the team of Calhoun Students with UAH students.

This research project ended January 31, 2025.

Auburn University – Polymer Smart Machines

This project aims to research and develop the foundational building blocks of polymechatronics, which will enable the realization of 3D printable polymer smart machines. The research and development include designing, fabricating, modeling, and characterizing piezopolymer versions of traditional mechanical and electrical building blocks such as actuators, sensors, energy harvesters, energy storers, and analog & digital circuit elements. Conventional 3D printed structures do not actuate or compute. However, if successful, the proposed project will lead to the first 3D printable smart machines that can actuate and compute without the need of externally manufactured actuators and circuits. Compared to traditional devices, polymer smart machines are expected to be less expensive, easier to manufacture, biocompatible, recyclable, use less energy, operate over a larger range of temperatures, offer new functionalities, and be more environmentally friendly. Such attributes are expected to enable a wide spectrum of novel mechatronic components and products for consumers.

For this stage of the project, the following effort was contributed. We used the polymer purchased to prepare a piezoelectric polymer thin film. The polymer thin film was prepared using the solution cast technique. The polymer thin film was then electrically poled and characterized. The results showed that the piezoelectric response of the polymer purchased is weaker than piezoelectric polymer P(VDF-TrFE) which is not currently available.

This research project ended January 31, 2024.

University of North Alabama – Surface Plasmon Resonance-based Biosensors

Biosensors are devices that convert a biological response into an electrical signal; and they are increasingly prevalent across multiple industries including (i) the food industry to check and verify the quality of the vegetables, fruits and meat, (ii) medicine and health industry to diagnose biological samples for diseases, ailments etc., and (iii) monitor safety industry to identify harmful

chemicals. The current state of biosensors' sensitivity is often limited to minute concentrations of the molecules/agents under testing, usually in the range of 5 ng/mL. Due to this limitation, the biosensor output may lead to a failed detection and/or recognition that might cause harm to life.

A novel technique will be used to enhance the sensitivity of the biosensors based on the principle of surface plasmon resonance (SPR). Numerical investigations have suggested that this novel technique can improve sensitivity by at least 5-fold, which facilitates easier detection of biomolecules in concentrations. It is not possible to use other biosensors. Upon building and successful testing of the SPR sensor system with regular glucose samples, the plan is to detect cow milk allergy agent and Staphylococcal enterotoxin B (SEB), which are important biomolecule agents in the food industry. The proposed biosensor setup can also be used for medical diagnostics.

The refractive index of an air-dried sample of sugar solution deposited on a glass slide without electrical bias was obtained. This number is used to obtain theoretical values of the SPR angle to compare to the experimental value. The refractive index of the air-dried sample of sugar solution with electrical bias at intervals of 1 V from 1 to 15 V was obtained. These numbers will be used to obtain theoretical SPR values for comparison with experimental values.

This research project ended January 31, 2024.

Auburn University – Novel and Sustainable Feed Binder from Soybean Hulls

The goal of this project is to establish a low cost, high value, and novel compound feed binder from soybean hulls (SBH), a co-product of soybean processing for oil and meal production. The specific objectives of this project are twofold: 1) to scale-up feed binder production to around 1.5 kg/hour and optimize process conditions for production; and 2) to scale-up shrimp feeding trials simulating shrimp farming operations at a commercial shrimp operation in West Alabama. Successful completion of this project will establish a high value and novel compound feed binder platform using 100% soy hulls that are ready for commercial scale productions and applications with significant economic and environmental benefits. It will significantly enhance the competitive advantage of shrimp farmers in Alabama by reducing their feed costs. This will in turn improve employment opportunities in seafood farming and processing sectors, making more local seafood and services available to the citizens of Alabama. In addition, it will also significantly improve water quality by reducing leached nutrients.

We produced two binders: 1) a binder produced on a lab scale with 10% solid content and 2) a new binder produced in our pilot-scale reactor with 50% solid content. We evaluated the binding capacity of these two binders at the Aquatic Animal Nutrition Laboratory at the School of Fisheries, Aquaculture, and Aquatic Sciences, Auburn University. The results showed that both binders have a similar binding capacity: 1) the water stability was similar between diets including either binder, and 2) the growth performance of pacific white shrimp feeding with diets including either binder was also similar. The project is on track with no issues impacting the project's progress, cost, and/or schedule.

This research project ended January 31, 2025.

University of Alabama at Birmingham – Amputation (Multifunctional nanomatrix for percutaneous osteointegrated prostheses)

Approximately 1.6 million people live with an amputation within the U.S., and amputation cases are expected to rise to approximately 3.6 million by 2050. 185,000 people have an amputation each year in the U.S., with a significant increase noted associated with COVID-19 infection. The conventional technology is unable to adapt to the dynamic residual limb as it atrophies over time and swells with heat or weight gain. Percutaneous oseointegrated prostheses (POP) are a promising development for the limb-prosthesis interface involving the direct skeletal attachment of the prosthetic device. Alongside the promising benefits of POP, significant risks are present at the bone-implant interface including superficial and deep infection, inflammation, insufficient osseointegration, lack of vascularization, and implant loosening. The main goal of this project is to develop the multifunctional nanomatrix coating on POP that can be clinically translated for improved osseointegration of prosthetics, and other types of orthopedic and dental implants to help promote healing and prevent infection.

During the Q2 2024 reporting period, our efforts have been multifaceted and geared towards advancing our research. The project has made significant strides in exploring the impact of nitric oxide-releasing nanomatrix coatings on human stromal (mesenchymal) stem cell (hMSCs') osteogenic differentiation, and human amniotic epithelial cell (hAECs') response to the coatings. We have successfully modified a protocol for in vivo implantation in rat models without amputation to reduce post-surgery inflammation.

This research project ended January 31, 2025.

University of Alabama at Birmingham – Pneumococcal Vaccine

Streptococcus pneumoniae is a leading cause of bacterial pneumonia and meningitis, resulting in more than 2 million pneumococcal infections and more than 6,000 deaths each year in the United States. Mortality rates are high especially in very young, elderly, and immuno-compromised individuals. In Alabama, invasive *Streptococcus pneumoniae* represents a special concern to the State's aging population, as well as in the rural and economically deprived communities with limited access to routine health care. The currently available pneumococcal vaccines in clinic, *e.g.*, PPV23 and PCV13, have limitations. For example, PPV23 is not effective in children younger than two years old, the elderly, and immunocompromised individuals; and while PCV13 is effective for children, it has limited serotype coverage (fewer than PPV23) and requires an inconvenient four-dose immunization schedule for infants and young children. Moreover, none of these clinical vaccines provide effective protection against *S. pneumoniae* serotype 3 (ST3), a significant cause of morbidity and mortality worldwide. In this project, we will develop enhanced PPV23 and PCV13 vaccines which can provide increased protection with reduced number of immunizations. The enhancement will be achieved by employing the potent new vaccine adjuvants recently discovered in the Principal Investigator's laboratory at UAB. Success of this project will benefit the citizens of Alabama and have broader positive impacts on global health as well.

As of Q2 2024, we recently evaluated VSA adjuvants and their different combinations and formulations in a bivalent glycoconjugate pneumococcal vaccine candidate synthesized in the PI's

laboratory at UAB and in another bivalent glycoconjugate vaccine candidate obtained from an industrial collaborator. We used clinical PCV13 with or without a VSA adjuvant as positive controls in the immunological assessment. In Q2 of 2024, we completed the immunological analysis of the serum samples. The results confirmed that VSA-1 can be used alone or in combination adjuvant form to enhance immune responses induced by the vaccine, leading to a more potent pneumococcal glycoconjugate vaccine candidate.

This research project ended July 31, 2024.

Overview of 2023 Program Year

Projects Funded Under 2023 Grant Period

Applicant	Amount
University of Alabama at Birmingham – Plasma Technology for New Neurovascular Stent	$316,910.00
University of Alabama at Birmingham – Development of a Novel Bioactive Material for Dental Pulp Treatment	$350,000.00
The University of Alabama – Advanced Membrane Technology for Removal and Degradation of Short- and Long-Chain PFAS from Water	$399,831.00
The University of Alabama – Ultra-High-Performance Concrete (UHPC) with Local Materials	$86,195.00
Auburn University – Iron-Based Contrast Agent for Magnetic Resonance Angiography (MRA)	$184,773.00

University of Alabama at Birmingham – Plasma Technology for New Neurovascular Stent

Stroke is a common disease affecting over 90,000 people annually in the U.S and costs the healthcare system over $33 billion. It represents the leading cause of serious long-term disability and third leading cause of death. While recent advances in stroke intervention have radically improved upon the natural history of the disease, minorities benefit less than the general population, in part due to the higher prevalence of carotid occlusion into the acute stroke setting (COASS). Carotid stenosis is implicated in 20-30% strokes and poses unique therapeutic challenges.

In contrast to cardio-embolic stroke, which responds well to intravenous tissue plasminogen activator (tPA) and mechanical thrombectomy, ruptured atherosclerotic plaque requires stent implantation to achieve effective reperfusion. However, a major obstacle in the field is that stent placement requires dual antiplatelet therapy (DAPT) that predisposes to hemorrhagic conversion of ischemic brain tissue.

The translational relevance of the proposed project lies in resolving this clinical dilemma by developing a blood-compatible surface modification, potentially enabling carotid stent placement without DAPT. The overall goal of this project is to complete a preclinical study of UAB surface-engineered stents in animal models to demonstrate feasibility.

Carotid stenosis is implicated in 20-30% of strokes and poses unique therapeutic challenges. In contrast to cardio-embolic stroke, which responds well to intravenous tissue plasminogen activator (tPA) and mechanical thrombectomy, ruptured atherosclerotic plaque requires stent implantation to achieve effective reperfusion. However, a major obstacle in the field is that stent placement requires dual antiplatelet therapy (DAPT) that predisposes to hemorrhagic conversion of ischemic brain tissue. The translational relevance of the proposed project lies in resolving this clinical dilemma by developing a blood-compatible surface modification, potentially enabling carotid stent placement without DAPT.

During this quarter, the project started working on the particle shredding/ leaching from the coated stent and control in point of FDA requirements and regulations. Also, the project was contacted by an industry for further use of our coating technology to blood clot retrieval aspects. While the interaction with the company was going on, a spinoff company was co-founded, Flexicoat LLC, and registered at Alabama for further growth of our technology into commercial and for further grant applications. In addition, the project was selected as the finalist for Alabama Launchpad competition. Lastly, a journal article was published from the results of the work on "Cold plasma process ensnares fibrin-rich clots in an adhesive web" (JGA Jones, L Nair, V Thomas, Interventional Neuroradiology, 15910199251389067, 2025). We have also submitted the IP to UAB research foundation for filing.

University of Alabama at Birmingham – Development of a Novel Bioactive Material for Dental Pulp Treatment

According to the American Association of Endodontists, 22 million endodontic root canal treatment (RCT) procedures are performed annually in the United States. When a tooth is severely infected or decayed, RCT is recommended to preserve the tooth structure and avoid extractions and artificial replacement (i.e., implants, dentures, etc.). In many cases, RCT is not an available treatment option to some populations due to accessibility and financial burden. In addition, 10-15% of RCTs do not demonstrate long-term success and are present as recurrent infections, which leads to permanent tooth loss. However, the need for RCT could be prevented by early detection of the initial stage of dental caries and treatment with the proper application of biomaterials. Therefore, early diagnosis of dental caries and appropriate treatment using biomaterials are critical for the maintenance of pulp vitality with long-term success and for the prevention of RCT and tooth loss. Thus, direct pulp capping (DPC) is a preferred treatment option which is less invasive, reduces patient discomfort and clinic time, and is less expensive.

Although numerous DPC materials have been used to improve clinical outcomes with moderate clinical success, many characteristics of these DPC materials still need to be improved, such as pulp cellular compatibility, regenerative potential, physical/mechanical properties (i.e., pH control and setting time), and cost-effectiveness. The main goal of this project is to develop a novel bioactive dental pulp capping material (RMCS-NANO) that improves the current treatment regimen and prevents sequential oral disease and infection.

During this quarter, the team made meaningful progress in refining laboratory protocols, completing preclinical data collection, and preparing for further biological analysis. Student researchers received specialized training and presented their work at a university-wide research

forum, receiving positive recognition for their contributions. Collaborative planning with industry partners continued, alongside progress in strategic funding efforts that support long-term goals. These activities highlight the project's ongoing momentum and commitment to advancing dental care through research, education, and innovation.

The University of Alabama – Advanced Membrane Technology for Removal and Degradation of Short- and Long-Chain PFAS from Water

Per-and poly-fluoroalkyl substances (PFAS) are a group of persistent organic compounds of industrial origin that are now ubiquitous in the environment, including drinking water sources. PFAS are a source of great concern due to their harmful impact on ecosystems and human health. Therefore, the development of efficient technologies for their removal from water/wastewater is a worldwide need. To achieve this goal, the research plan of this proposal is focused on a complete understanding of the PFAS adsorption properties of MXenes, followed by rigorous design and fabrication of highly efficient MXene-adsorptive NF (nano-filtration) membranes.

During this quarter, the project focused on advancing the understanding of how MXene materials interact with PFOS and PFBS. Pristine MXene and two functionalized variants, amine-functionalized MXene (NH_2–MXene) and fluorinated MXene (F–MXene), were systematically characterized using electron microscopy, surface spectroscopy, and surface area analysis. In parallel, the mechanisms governing PFAS adsorption were elucidated by integrating surface charge measurements with spectroscopic analyses. The results demonstrated that NH2-MXene primarily captures PFAS through electrostatic attraction and hydrogen bonding between positively charged amine groups and PFAS headgroups, while F-MXene adsorbs PFAS predominantly through hydrophobic and fluorophilic interactions involving the perfluoroalkyl tails. Pristine MXene showed comparatively weaker adsorption due to the absence of these targeted interaction pathways. Overall, these findings provide clear design principles for developing next-generation MXene-based materials for the effective removal of PFAS. Based on these outcomes, a manuscript detailing the results has been prepared and is currently being finalized for submission.

The University of Alabama – Ultra-High-Performance Concrete (UHPC) with Local Materials

The proposed research aims to create an ultra-high-performance concrete (UHPC) mix using local ingredients (obtained from Alabama and nearby states) for use in precast manufacturing settings, with the ultimate goal of lowering the cost of UHPC to between $650 and $1,000 per cubic yard. This will be completed in collaboration with Contech Engineering Solutions LLC, a Birmingham-based precast producer (an industry partner).

The mechanical and structural performance of the generated UHPC mixture will be experimentally evaluated as part of the planned research. Through laboratory testing, the study team will also assess the structural performance of beam and pipe constructions made from this material. We intend to disseminate the accumulated knowledge to local manufacturers and government organizations through personal meetings and webinars, brief online videos, and invitations to observe laboratory experiments.

We have refined the composition and additives in our mixed designs from the previous quarter, focusing specifically on enhancing workability. A large batch was produced to cast tension and shrinkage specimens. We have completed the tension testing and characterized the tension behavior of UHPC. Additionally, we cast test specimens to assess the performance of the reinforcement and prestressing strand, which are scheduled for testing in the upcoming quarter.

During this quarter, we completed the casting of the UHPC specimen and finalized the UHPC mix design using the materials from the local precast producer (our industry partner). The measured compressive strengths confirmed the mix design to meet the UHPC definition. We also submitted an extended abstract (accepted) to present and disseminate this research to broader audience at an international UHPC conference, planned to be held in June 2026 in Iowa, USA.

This research project ended on July 31, 2025.

Auburn University – Iron-Based Contrast Agent for Magnetic Resonance Angiography (MRA)

Contrast-enhanced magnetic resonance imaging is a staple diagnostic procedure for imaging blood vessels. Over 450 million gadolinium-based contrast agent (GBCA) doses have been administered since regulatory approval 30 years ago, to improve image quality. While GBCAs offer excellent MRI properties, they have been associated with numerous side effects. Therefore, there is a strong need for new contrast agents able to provide enhanced imaging capabilities without resulting in long-term accumulation and dangerous side effects. In addition, because GBCAs are toxic and are designed to be rapidly cleared through kidney filtration, the imaging window is short and provides sub-optimal imaging of the vascular system.

Compared to currently utilized contrast agents, our envisioned product has the potential to disrupt the MRA contrast agent markets because of its improved safety profile and enhanced imaging of the vascular system. The product will initially be marketed to radiologists and medical institutions that perform MRA, for application in diagnosing deep venous thrombosis, which affects up to 900,000 people each year in the U.S., vascular malformations, and pediatric imaging. The envisioned contrast agent can also be used in other applications, such as peripheral arterial disease (PAD) and renal imaging, allowing improved imaging of vascular structures while reducing the risk of long-term side effects.

A major aspect of this project is to validate the safety and performance of an iron-based MRI contrast agent. Demonstrating these aspects of the minimum viable product requires the use of animal studies, but initial preliminary work will be conducted using in vitro models. This will allow for the agent to be well characterized prior to the initiation of animal studies. The focus for the past quarter was to evaluate simple in vitro models that would allow for continuous measurement of nanoparticle permeability. The PhD student is also learning to synthesize, modify and characterize nanoparticles for use in the study.

This research project ended October 31, 2024.

Overview of 2024 Program Year

Projects Funded Under 2024 Grant Period

Applicant	Amount
Hudson Alpha Institute for Biotechnology – TIMBER: Turning Information into Meaningful Benefit and Economic Return	$383,268.00
Southern Research Institute – Station 41 Venture Studio	$335,712.00
The University of Alabama – Multidirectional Yield Strength Design of Hot-Band X70 Steel for New Pipelines in Energy Media Transport	$246,060.00

Hudson Alpha Institute for Biotechnology – TIMBER: Turning Information into Meaningful Benefit and Economic Return

The TIMBER project ("Turning Information into Meaningful Benefit & Economic Returns") combines two of Alabama's greatest assets - the biotechnology field and the forestry sector - for a greater return for all. Hudson Alpha's sequencing and analysis tool, Khufu, uses genetic data to provide genotyping results at a fraction of the typical cost. This proven method provides accurate genomic solutions for plant improvement. TIMBER will deploy and test Khufu for the timber industry, enabling Alabama's landowners, foresters, and manufacturers to use genetics to reduce risk, invest wisely, and secure a competitive advantage over those without this cutting-edge technology.

Hudson Alpha will coordinate and facilitate this R&D project and work closely with various collaborators. Together, these partners will seek to answer two key questions: What added value can genomic sequencing provide for the timber industry? At which stage in the life cycle of a timber tract does whole genome sequencing provide the most value? TIMBER aims to show that genome sequencing can be a biological surveillance tool in the timber industry and offer an extraordinary layer of information to transform decision-making in the supply chain. This project can enhance the industry's ability to verify species at a large scale accurately, identify timber assets with key genetic traits, market superior products to buyers, and mitigate financial risk over the long time required to harvest and produce forestry products.

Hudson Alpha is continuing to work with Alabama companies to discover how genetics can be a meaningful benefit and show an economic return to the Alabama Timber Industry. We were able to successfully re-sequence the sample DNA from our pilot one project. Our team met with a group of conservation experts in Crenshaw County to discuss the project in more detail and work with potential new pilots to determine if there is a way of use for conservation efforts of pine. New decks were created to work specifically with businesses with our new data to begin creating meaningful discussions around the pine genome and selective breeding practices to support business problems in a positive manner. We hope to begin working with university partners in Q2.

During this quarter, the TIMBER grant project successfully completed key milestones by engaging with private-sector industry partners to establish partnerships and obtain sector-specific insights,

while also collecting and evaluating feedback from landowners and manufacturers regarding the timing and value of genetic testing and its potential implications for future industry practices.

Southern Research Institute – Station 41 Venture Studio

Southern Research's Station 41 biotechnology commercialization hub aims to address two primary opportunities in the State of Alabama: 1) increasing investment and venture capital deal flow to match Alabama's research prowess and 2) improving healthcare outcomes related to cancers with unmet needs through therapeutics that will be discovered and developed in the State. The Station 41 Venture Studio will address these problems by enhancing commercialization outcomes and catalyzing private-sector investment toward a therapeutic program that will address a critical unmet need with particular relevance to Alabama patients, in this case, colorectal cancer.

The project team will undertake activities that involve a combination of commercialization and scientific research activities, which will all take place on Southern Research's campus located in downtown Birmingham. The Station 41 commercialization team will conduct an ecosystem analysis and create a matrix that will be used to rank potential commercial partners and investors by their strength of overlapping with our areas of expertise. This deliverable will serve as a guideline to Southern Research and other instate partners to identify and engage with partners who could invest in Alabama's nation-leading R&D ecosystem.

The team will also create target product profiles, a critical industry tool to guide therapeutic development, for other SR internal programs that address critical unmet needs in Alabama. The team's scientific research activities will include the continued development of a wholly new therapeutic program, a lipid nanoparticle (LNP) formulation that encapsulates an mRNA encoding a modified version of the alpha-9-helix of the Bax protein. Southern Research's scientists will optimize the formulation of the lipid nanoparticle to target colorectal cancer tumors and conduct vital proof-of-concept studies necessary to advance the product into the clinic. The aim of the project team will be to ultimately expand access to this therapeutic program to Alabama patients by initiating clinical studies with a wide range of partners across the state.

During this reporting period, Station 41 focused on completing data analysis, disseminating findings, and preparing for project close-out. For Research Program #1, the ecosystem mapping deliverables were finalized and leveraged at a national conference, where the commercialization pitch deck and ecosystem insights were presented to potential partners and stakeholders. This activity provided external visibility and reinforced Stations 41's strategy for advancing oncology and immune-oncology programs. For Research Program #2, the team completed analysis of the preclinical and transcriptomic data generated in earlier studies, confirming the potential of both the LNP-mRNA platform and the small-molecule PD-1 inhibitor. These results were presented at a national conference to obtain external feedback, which will help inform translational planning and next-phase opportunities.

The research project ended on October 31, 2025.

The University of Alabama – Multidirectional Yield Strength Design of Hot-Band X70 Steel for New Pipelines in Energy Media Transport

This proposal focuses on online pipe steel research and development (R&D) in collaboration with The University of Alabama (UA), AM/NS in Calvert, AL, and ArcelorMittal Global R&D in East Chicago. The primary objective is to address the emerging market demand for the transportation of CO2 (carbon dioxide) and H2 (hydrogen), which require advancements in line pipe steel technology. The project addresses the new additional safety requirement requested in pipeline projects for adhering to a longitudinal (L) Yield Strength maximum in a pipe made from a hot band. It addresses it by varying the processing of the hot band in a traditional API alloy design in 18 variations. The study will focus on controlling anisotropic yield strength in hot bands along L and T directions. The established manufacturing leads to a high differential in L and T directions. The project will vary hot band manufacturing process parameters to change and study the directional differentials by exceeding established approaches. The (hot band) source and industrial partner will be AM/NS Calvert in Alabama. AM/NS has one of the most advanced and capable Hot Strip Mills in North America, commissioned in 2010 for API line pipe, and since then has developed long-standing expertise supported by the mother company AM. Microstructural characterization and mechanical testing will be conducted at UA. A part or all of this data will be inputted into a model of predicting pipe properties, which ArcelorMittal Global R&D, East Chicago, will carry out. Correlations of the model input data into microstructure and processing conditions will finally provide technological gain and know-how progress.

During this quarter, one coordination meeting was held in November between UA and AM Calvert to assess overall project progress. UA focused on comparative analysis of microstructural features in skelp and corresponding plate samples using optical microscopy, SEM-EDS, and SEM-EBSD. Relevant literature was reviewed to identify appropriate testing standards, and a plan was developed for machining samples for tension–compression testing. The graduate student continued hands-on training in processing, microstructural characterization, and mechanical testing, completed formal training on five major instruments, and continued preparation of a review paper on the Bauschinger effect in steels.

AM Calvert and AM Global R&D East Chicago completed their Q4 activities by producing seven coils representing seven of the nine planned DOE variations under industrial hot strip mill constraints. Mechanical testing across multiple pipe-making stages and directions revealed significant variation-dependent differences, highlighting opportunities to control pipe properties through hot band processing. Parallel skelp samples were provided to UA for advanced characterization and deformation behavior studies.

Overview of 2025 Program Year

Projects Funded Under 2025 Grant Period

Applicant	Amount
Hudson Alpha Institute for Biotechnology – Building Tomorrow: Developing Bio-based Construction Materials for a Sustainable Future	$325,000.00
Auburn University – Data Mining for Enhanced Real-Time Bidding in Alabama's Online Display Advertising Industry	$104,898.00
The University of Alabama – Experimental Investigation of 3D-Printed Concrete Wall forms with UHPC for Modern Resilient Construction	$100,745.00
Southern Research Institute – Optimization of Model to Predict Mitochondrial Protectors and Promoters	$174,684.00
Southern Research Institute – Development of Hydrogel-Based Wound Healing Devices	$124,961.00
The University of Alabama – From Waste to Wealth: Unlocking Alabama's Coal Ash Potential	$231,361.00
The University of Alabama – Advanced Separation Technology for the Recovery of Rare Earth Elements and Critical Minerals from Coal Ash Waste	$440,000.00
The University of Alabama – Smartguard: Adaptive Ultra-High Performance Concrete Panels for Modular Construction and Extreme Event Protection	$236,135.00

Hudson Alpha Institute for Biotechnology – Building Tomorrow: Developing Bio-based Construction Materials for a Sustainable Future

Advances in bio-based materials technologies offer incredible possibilities to utilize Alabama's substantial agricultural and forestry resources in sustainable, carbon-sequestering construction materials. The manufacturing of building construction materials is responsible for more than 10% of global CO2 emissions annually. If the United States is to meet its commitment to onshore manufacturing, alternative construction materials from US resources must be developed, demonstrated, and commercialized to complement current products. Through initiatives at Hudson Alpha, like Hudson Alpha Wiregrass and the National Science Foundation Greening the Southeast project, and those at Auburn University, such as its Mass Timber Collaborative and the Sustainable Bio-Based Materials Lab, the project partners are capitalizing knowledge from a combination of strong expertise across multiple areas to move toward new frontiers in biogenic construction materials innovation. The partners have received grant funding from the US Department of Agriculture, the US Forest Service (USFS), and the National Science Foundation to support related research in bio-based materials development and innovation. The proposed project seeks to demonstrate these innovations to home builders and others in the Architecture Engineering and Construction (AEC) industry by designing and constructing a mobile demonstration pavilion. The pavilion would be transported to important trade and industry events throughout the American Southeast, boosting workforce development efforts in construction and building materials research and development.

Led by Hudson Alpha Institute for Biotechnology in collaboration with Auburn University, the project includes industry partners such as SmartLam North America, Russell Lands Inc., and Sierra Pacific Windows and academic partners like the University of Tennessee and the USFS Forest Products Laboratory. The project will cost $650,000, and Hudson Alpha will provide $325,000, representing the full 50% match. The work will be completed primarily on Auburn's campus by students and faculty researchers. The research and design of the mobile pavilion will be accomplished by students in a seminar course in the Department of Architecture, and its construction will be part of a service-learning course in the Department of Building Science. The project will link student learning to industry outreach and Alabama economic development. The resulting demonstration unit will be utilized across Alabama to engage industry and citizens.

This project has the potential to enhance the industry's output by creating new applications for Alabama's forest and agricultural resources. By investing in the proposed mobile demonstration pavilion, the ARDEF can support novel research and outreach that benefits Alabama businesses and industry, student education and university research, and employment opportunities at multiple skill levels.

During this quarter, the project successfully completed the implementation of the Building Science (BSCI) Seminar Syllabus . BSCI students began construction of the pavilion after receiving the complete structural assessment from Harvest Engineering. The floor and wall systems of the pavilion have been installed. Procurement of cladding and interior materials is underway, and the remaining construction tasks will be completed in Spring 2026, when Prof. Alan Bugg offers a 3-credit course.

Auburn University – Data Mining for Enhanced Real-Time Bidding in Alabama's Online Display Advertising Industry

Auburn University's (AU) data scientists with collaborators at Wright Media LLC, a web and mobile-based recruiting solutions company, will develop data mining techniques for enhanced real-time bidding in Alabama online advertising industry. The overall goal is to bridge the gap between Alabama's data science workforce and the region's digital marketing needs, we propose a novel infrastructure to apply leading-edge data mining technology to enhance digital marketing efficiency through the industry partnership with the Wright Media LLC – an Alabama digital marketing leader for the transportation industry. Our team will achieve three goals. The first goal focuses on harnessing advanced data mining techniques to refine advertising strategies. The second goal is pivotal in fostering Alabama's SMEs to grow in the digital age. This goal aims to significantly improve the relevance and impact of digital advertisements for consumers.

The project will offer numerous benefits to various Alabama industry sectors. These benefits include improved targeting, increased return on investment, enhanced user experience, optimized advertisement spending, real-time insights, better market understanding, personalized advertising, and improved analytics and reporting. With our project's data mining capabilities, the initiative will streamline the job matching process. These advanced tools analyze user data to better align job seekers with suitable employment opportunities. For Alabama residents, this means more accurate job recommendations and a higher likelihood of finding positions that match their skills

and career goals. Improved job matching not only enhances the chances of securing employment but also reduces the time spent searching for jobs.

During this quarter, the team focused on advancing company enrichment, analytics, and outreach capabilities across the platform. We completed the integration work with Apollo.io, which now allows us to enrich the company object with industry and size attributes, growth indicators, employee counts, estimated revenue, and related website and social media data. This work has significantly improved the completeness and utility of company-level data and established a strong foundation for downstream analytics and engagement workflows.

In addition, we implemented and validated a comprehensive analytics engine that supports multi-factor lead scoring, hiring velocity calculations, growth trend analysis, department diversity scoring, and automated lead tier classification. Building on these insights, the team also completed the core components of the contact discovery and outreach system, enabling reliable contact generation, validation, deliverability scoring, and multi-channel outreach with dynamic personalization and optimization. System testing confirmed that the enrichment, analytics, and outreach components are fully functional and work together as intended..

The University of Alabama – Experimental Investigation of 3D-Printed Concrete Wall forms with UHPC for Modern Resilient Construction

This project aims to provide affordable, sustainable, resilient housing through innovative construction methods, addressing modern demands, labor shortages, and natural disasters, while minimizing damage and ensuring rapid recovery. This project, led by professors from the University of Alabama's Department of Civil Engineering and supported by industry partners Build Additive LLC and the American Concrete Institute Foundation, will investigate the use of ultra-high-performance concrete (UHPC) and 3D printing technologies. The industry partner, Build Additive LLC, based in Troy AL, specializes in manufacturing 3D-printed concrete elements.

The primary goal of this project is to combine 3D-printed concrete wall forms with UHPC to develop resilient building systems. This research will characterize the structural performance of these systems under mechanical loads, with specific objectives including the characterization of fresh and hardened properties of 3D-printed concrete, investigation of mix design impact on printability and buildability, determination of critical engineering parameters, and evaluation of structural performance under lateral loads.

The project will benefit small- and medium-sized enterprises in Alabama's construction and materials manufacturing sectors by enhancing competitiveness through advanced construction techniques. It will create employment opportunities, foster innovation, and improve the quality of life for residents by providing safer, more resilient, and sustainable buildings. Additionally, the collaboration with industry partners will facilitate knowledge transfer and practical application of research findings, ensuring local businesses remain at the forefront of industry developments. This initiative will ultimately lead to a higher standard of living with better designed buildings and infrastructure that meet the evolving needs of the community.

During this quarter, the team progressed the literature review to approximately 60% completion, synthesizing findings across hardened-wall load paths, pumpability, buildability, non-destructive evaluation methods, and numerical simulation approaches. Interim conclusions are guiding the project's technical direction, including promising frameworks for representing fresh-mix behavior and preferred strategies for load transfer in hardened printed walls. More trial prints were completed to validate the CAD-to-print workflow and familiarize the team with printer operation. The team also conducted initial Vicat needle testing to measure setting time of a rapid-set mix used for trial prints and evaluated the influence of water content to inform printing time windows. Printing activities experienced temporary downtime due to a malfunctioning manual mixing pump; a replacement pump order is in progress, and no cost impacts are anticipated at this time. The team anticipate a delay in the overall schedule.

Southern Research Institute – Optimization of Model to Predict Mitochondrial Protectors and Promoters

The University of Alabama at Birmingham (UAB), Yuva Biosciences (YuvaBio) is on a mission to address the root cause of aging and mitochondrial dysfunction and promote Youthfulness for Life™. Often referred to as the "powerhouse of the cell," mitochondrial health and activity decline with age. This phenomenon is implicated in numerous age-related pathologies, including neurodegenerative and cardiovascular disorders, diabetes, obesity, and cancer. In 2018, YuvaBio's Cofounder and Chief Scientific Officer, Dr. Keshav Singh, contributed to this understanding by experimentally demonstrating that mitochondrial dysfunction also drives the most notable signs of aging—hair loss and skin wrinkles. This groundbreaking study made global headlines and prompted the question: What if products could be made that help reverse mitochondrial decline and mitigate the undesirable effects that follow?

YuvaBio aims to collaborate with Southern Research (SR). This alliance aims to significantly enhance the capabilities of MitoGPT, creating a next-generation AI system dubbed the Frontier Model. It will be trained on data generated from conducting a series of high-throughput screens on a previously developed assay that measures mitochondrial DNA content (mtDNA). Using compounds from SR's library, the team will measure the amount of mtDNA before and after treatment. The higher the increase, the more promising the candidate is in improving mitochondrial health and function.

The impact of these activities will be widespread, yielding substantial economic and scientific benefits throughout the state of Alabama. This innovative system has the potential to attract new investments, foster job creation in high-tech sectors, and solidify the state's position as an emerging hub for biotechnology and AI research. Furthermore, the ripple effects will cascade across various industries in Alabama, from chemical companies to research institutions and commercial real estate, thereby contributing to overall growth for the region.

During this quarter, activities have been limited until an agreement with YUVA is finalized.

Southern Research Institute – Development of Hydrogel-Based Wound Healing Devices

Grant terminated August 16, 2025.

The University of Alabama – From Waste to Wealth: Unlocking Alabama's Coal Ash Potential

The goal of this project is to create an environmentally and economically feasible process to harvest these metals from coal ash. Furthermore, the solid waste produced from this extraction process, which is rich in silicate, can be used as a supplementary cementitious material (SCM) to replace ordinary Portland cement in concrete. Compared with the virgin coal ash, this waste possesses much higher pozzolanic reactivity due to drastically increased surface area induced by the extraction of metals. Significant socioeconomic and environmental benefits can be generated by this research. Economically, it will stimulate local production of critical minerals essential to various targeted industries and produce valuable SCM, highly sought after by the concrete industry. The project is expected to create numerous direct and indirect knowledge-based and support jobs in these industries. Environmentally, this study addresses a major challenge in Alabama: the safe disposal of fly ash. If commercialized, the proposed technology will provide Alabama with a competitive advantage in attracting targeted industries, as outlined in the Accelerate Alabama Strategic Economic Development Plan.

During this quarter, the goal was to recover iron and aluminum from coal fly ash with an emphasis on aluminum and the remaining solid residue. Analytical work was completed and we discovered that the aluminum rich fraction had more calcium than desired. We were able to remove the excess calcium with a simple water wash. After the calcium was removed, we were able to calcine the material to convert the aluminum chloride material into aluminum oxides (alumina). This alumina was analyzed by XRD and determined to me a more amorphous alumina instead of crystalline alumina.

We analyzed the coal ash pre-extraction and post extraction using SEM at the University of Alabama for metals. We confirmed that the acid extraction does a significant job of 80% element extraction. The pozzolanic performance of the residual ash has also been drastically enhanced for its suitability as a supplementary cementitious material (SCM) by a novel mechanochemical activation process.

The University of Alabama – Advanced Separation Technology for the Recovery of Rare Earth Elements and Critical Minerals from Coal Ash Waste

The State of Alabama is known for its historical mining capabilities and is emerging as a major player in electric vehicle manufacturing, particularly in the lithium-battery sector. This project aims to connect these two aspects of the state by developing technologies that enhance mining efficiency for lithium battery manufacturing. The goal of this project is to develop advanced separation technology for the selective recovery of rare earth elements (REE) and critical minerals (CM), such as lithium, nickel, zinc, etc., from coal ash wastewater. These recovered elements, in pure and concentrated forms, can be used to manufacture valuable products like lithium batteries and alloys. Additionally, addressing the coal ash waste stream, a significant environmental challenge in Alabama due to the presence of heavy metals such as arsenic, is a critical aspect of this project. The proposed advanced separation process will simultaneously and selectively remove these hazardous elements from coal ash waste. The vision of this project is to develop advanced membranes that selectively recover REE/CM, including valuable elements, such as lithium, and

hazardous elements, such as arsenic, from coal ash. The successful completion of this project will benefit Alabama's economy by enhancing the effectiveness of the mining process and harvesting valuable resources. It will also improve the health of Alabama's citizens, particularly those living near coal ash waste dumps, by removing hazardous materials from their water systems.

This quarter's report evaluated MXene sheets, an advanced 2D nanomaterial, for the recovery of rare earth elements (REEs) from acidic solutions representative of industrial leachates. Adsorption experiments compared the performance of MXene with superfine activated carbon under realistic, low-concentration, acidic conditions (pH 2). Both materials demonstrated effective REE uptake, with particularly strong affinity for heavy rare earth elements such as dysprosium and neodymium, even in mixed-element systems.

Results indicate that MXene performs competitively with conventional adsorbents, offering additional advantages, including stability under harsh acidic conditions and enhanced interaction with positively charged rare-earth ions. These findings establish important performance benchmarks and support the potential of MXene-based materials for efficient and scalable recovery of rare earth elements.

The University of Alabama – Smartguard: Adaptive Ultra-High Performance Concrete Panels for Modular Construction and Extreme Event Protection

This project aims to address several pressing challenges in the construction industry. The project will develop an innovative modular structural wall system combining UHPC and metamaterials to improve building resilience against extreme weather events. The system will utilize smart structural wall panels consisting of dual layers of thin UHPC panels connected with polymeric mechanical metamaterial shear connectors. These panels are designed to be lightweight, easily assembled, and capable of withstanding high impacts, such as those from tornadoes and hurricanes.

The project will benefit a wide range of stakeholders, including industry partners such as GATE Precast Company and CorTuf UHPC, who bring their expertise in precast concrete systems and UHPC materials. Local communities, especially those in rural Alabama, will gain from the availability of affordable, resilient housing. The construction industry will benefit from the introduction of advanced materials and methods that mitigate labor shortages. Academic institutions will have the opportunity to engage in cutting-edge research and provide educational experiences for students.

The research will primarily take place at the University of Alabama's large-scale structures lab, with additional activities at GATE Precast Company's manufacturing facility. The anticipated broader impacts include improved infrastructure resilience in Alabama, job creation, and enhanced economic and social well-being for local communities. The smart panel system developed through this project has the potential to be utilized by various industries, promoting safer and more efficient construction practices nationwide. By addressing the critical need for resilient and affordable housing, this project positions Alabama as a leader in innovative construction solutions, capable of responding to both local and national challenges.

During this quarter, the project advanced early experimental capabilities and technical planning to support development of a modular UHPC wall system incorporating mechanical metamaterials for resilient, lightweight, ready-to-assemble structures. The team conducted debris impact testing on small-scale UHPC panels (2 ft × 4 ft and 4 ft × 4 ft) primarily as a training and shakedown effort, enabling student researchers to become proficient with the impact testing equipment, instrumentation, and procedures. In parallel, the team expanded the knowledge base by identifying and reviewing relevant experimental ballistic/impact studies on thick UHPC panels to inform test planning and performance expectations. To bridge from training-scale testing to project-relevant thin-panel behavior, the team initiated the design of a drop-test apparatus intended to quantify the impact response of thin UHPC panels prior to producing and testing large-scale specimens. In addition, progress was made on metamaterials development through experimental investigation of multiple 3D-printed metamaterial architectures, with mechanical testing used to characterize deformation mechanisms and energy dissipation behavior.