

2026 – 2027 TRIA Projects

PI: Professor Brian Sidlauskas, Ecology and Evolutionary Biology

Title: Advancing the taxonomy of Central African freshwater fishes using 3D skeletal scans and more.

The SID Lab (Systematics, Ichthyology, and Diversification) in the Department of Ecology of Evolutionary Biology seeks an undergraduate researcher to assist PI Brian Sidlauskas with ongoing studies of the diversity and taxonomy of freshwater fishes in Central Africa. In their primary project, the student will collect anatomical data to support the redescription of a fish species described originally from a single specimen and once thought to be highly endemic and endangered, but which recent surveys have revealed to be much more widely distributed. The student will use cutting-edge microCT technology to produce 3D skeletal models, and develop skills in more traditional approaches such as microscopy, photography, and measurement of preserved fish specimens. We also anticipate opportunities to assist graduate students with similar projects, to present results at a regional or national meeting, and to co-author a scientific manuscript.

PI: Professor Michael Naguib, Physics and Engineering Physics

Title: Novel Energy Materials

The growing demand for reliable energy conversion and storage systems is driven by the rapid advancement of renewable energy technologies and the exponential increase in portable electronic devices. Consequently, the development of novel materials for energy conversion and storage has become critically important. Our research group is dedicated to exploring Novel Energy Materials as a central theme. We focus on the design and synthesis of new 2D nanomaterials for next-generation energy storage systems, including batteries beyond Li-ion technology, supercapacitors, and electrocatalysis. In addition to discovering and creating innovative materials, we are also committed to developing cost-effective materials for commercially available electrochemical energy storage systems, such as Li-ion batteries and supercapacitors. These efforts aim to contribute to environmentally sustainable and economically viable energy solutions.

PI: Professor Fenglei He, Cell and Molecular Biology

Title: Genetic Control of Craniofacial Development

Craniofacial defect is one of most common birth malformations. Among this category, midfacial defect, including cleft lip and/or palate, is on the top list. However, its etiologies remain largely unknown. Our long-term interest is to **understand the fundamental mechanisms underlying craniofacial development, and how genetic mutation disrupts this process**, by using a combinatorial approach of in vivo and in vitro models. Undergraduate students are welcome to join our team efforts to address critical questions in craniofacial development and malformation. They will be trained with basic experimental

techniques of developmental biology and molecular biology, including DNA electrophoresis, genotyping of mouse models, embryos dissection, sample processing, immunohistochemistry, skeletal preparations and other essential skills.

PI: Professor Daniel Straus, Chemistry

Title: Development of Nanocrystalline Magnetic Materials

Magnetic materials play a crucial role in many common devices, such as data storage devices and motors, and are also at the core of future technologies, such as magnetic quantum computers and circuit elements that are capable of both storing and processing data. The tunability of conventional magnetic materials is quite limited. Since atoms of a given element have stable oxidation states and corresponding ionic radii, it is rare that an element can be substituted to tune the magnetic properties without also drastically altering the material's structure and electronic properties. Thus, there is an opportunity to create new broadly tunable building blocks that can be used to predictably design and synthesize tailored magnetic materials. The overall research objective for this project is to harness the size- and composition-tunable properties of atomically precise nanocrystals to construct designer magnetic materials with well-defined crystal structures and magnetic properties. Atomically precise nanocrystals provide alternate structural units that can be used like atoms to build materials, but unlike atoms, their size and composition can be more precisely tailored, potentially allowing for the development of new magnetic materials.

A student working on this project would gain experience with the chemical synthesis of atomically precise magnetic nanocrystals, the crystallization of the synthesized nanocrystals into materials with long-range order, as well as structural and magnetic characterization of the nanocrystal-based materials.

PI: Professor Daniel Straus, Chemistry

Title: AI-Enhanced Crystal Engineering

A long-standing goal in chemistry and nanoscience is to predict and synthesize materials that have specific crystal structures and are designed for applications including catalysis, electronics, spintronics, and sensing. However, it is nearly impossible to predict crystal structures, even for small high-symmetry molecules and extended inorganic materials. The goal of this project is to use artificial intelligence/machine learning techniques to develop a model for the prediction of crystal structures.

The ideal student for this project would have experience working with Python and have taken an AP/IB high school chemistry course. A student working on this project would gain experience in datamining scientific data repositories; developing and validating machine learning models; and, depending on interest, testing the model by synthesizing predicted materials.

PI: Professor Thomas Decarlo, Earth and Environmental Science

Title: Evaluating Oyster Reef Restoration with Lasers on Drones

Reef structures provide immense value to society by protecting shorelines from wave exposure and erosion. In Louisiana, oyster reefs historically played key roles in Gulf ecosystems by protecting marshes from waves, dampening erosion, and creating rigid habitat. Although most of the natural oyster reefs along the northern Gulf Coast have been lost, several groups such as The Nature Conservancy and the Coalition to Restore Coastal Louisiana have begun building restored reefs from a variety of materials, some including oyster shells recycled from New Orleans restaurants. We are actively working with restoration groups to map changes in elevation of the restored reefs and surrounding marshes with drone-based lasers, a technology called Light Detection and Ranging (LiDAR). This student opportunity will include training in drone piloting and fieldwork in coastal Louisiana. Data collection and analysis will focus on testing whether recently constructed reefs protect marsh habitat from wave-induced erosion.

PI: Professor Emily Farrer, Ecology and Evolutionary Biology

Title: Climate Change Effects on Plant-Fungal Interactions in Coastal Marshes

Thousands of microbial species live inside plant tissues and in the soil. We have very little understanding of what these microbes do (are they beneficial or pathogenic?) and how they might be affected by climate change. This project aims to study the composition and function of fungal microbiomes that live in plant roots and soil in coastal marshes in Louisiana. Because of climate change, coastal marshes are experiencing salinity stress, as saline water moves inland due to sea level rise and increasing hurricanes and storms. We are surveying marshes across SE Louisiana and performing experiments testing how elevated salinity affects plant-fungal interactions. We culture the fungi (grow them on petri plates) and use metagenomic sequencing (DNA extractions, PCR) to characterize the composition of the fungal microbiomes. We also inoculate seeds and plants with different fungal strains to determine whether the fungi are beneficial or pathogenic to the plant. Overall, this work has implications for how wetland systems will change in the future. Furthermore, if we identify fungi that are beneficial to plants and tolerant of salinity, these strains could be developed for use in restoration practice.

PI: Professor Katie Ferris, Ecology and Evolutionary Biology

Title: Speciation Genetics

The Ferris lab studies the genetic basis of speciation and adaptation in a group of West Coast wildflowers, the yellow Monkeyflowers. We use a combination of genomic sequencing, genetic mapping, and lab and field experiments to understand how different Monkeyflower species have adapted to harsh rocky habitats. One exciting project in the lab is to phenotypically characterize and determine the genetic basis of a genetic incompatibility between the fern-leaved Monkeyflower and its close relatives. Understanding the genetic mechanisms of reproductive isolation gives us important

information on how new species are formed and the origin of biodiversity, which is a primary objective in evolutionary biology. We have previously identified a crossing barrier where very few seeds are produced when the fern-leaved Monkeyflower is crossed to two closely related species: the cut-leaf and seep Monkeyflower. This leads us to believe that when the fern-leaved Monkeyflower is involved in a cross there is a pollen-pistil incompatibility that prevents fertilization of the ovule and production of hybrid seed. We would like an undergraduate researcher to characterize the pollen-pistil incompatibility using microscopy and other fertilization phenotyping techniques. Once the phenotype is characterized the student would be involved in mapping the loci involved in this genetic incompatibility using quantitative trait locus mapping. Participating in research in the Ferris lab involves growing Monkeyflowers and measuring ecologically important traits like leaf shape or flowering time, performing genetic crosses in the greenhouse, doing molecular lab work for genomic sequencing, and performing manipulative field experiments in Yosemite National Park, CA.

PI: Professor Katie Ferris, Ecology and Evolutionary Biology

Title: Parallel Evolution in Leaf Shape

The Ferris lab studies the genetic basis of speciation and adaptation in a group of West Coast wildflowers, the yellow Monkeyflowers. We use a combination of genomic sequencing, genetic mapping, and lab and field experiments to understand how different Monkeyflower species have adapted to harsh rocky habitats. One main project in the lab is looking at the genetic basis of parallel evolution of leaf shape across Monkeyflower species. One of the central questions in evolutionary biology is whether evolution is predictable at the molecular level. This has been explored in several genetically simple traits such as stickleback fish body armor and animal pigmentation. Little is understood about the extent of parallel genetic evolution in polygenic phenotypes. We have found parallel leaf shape evolution across several Monkeyflower species native to rocky outcrop habitats. However, we do not know whether the same genetic loci underlie leaf shape evolution in each species. To test whether leaf shape has evolved from standing variation in an ancestral population or new mutation across research, our research currently focusses on finding the individual genes involved in leaf shape evolution in three species: the cut-leaf Monkeyflower, the fern-leaved Monkeyflower, and the seep Monkeyflower. To identify the individual loci controlling leaf shape evolution across species, we are using molecular genetic mapping techniques (GWAS and QTL mapping) in both laboratory-controlled crosses and natural hybrid Monkeyflower populations. **Characterizing individual loci and mutations will allow us to assess whether a complex trait has evolved due to independent genetic changes or selection on standing variation in an ancestral population and how predictable evolution is at the molecular level both within and between species.** Participating in research in the Ferris lab involves growing Monkeyflowers and measuring ecologically important traits like leaf shape or flowering time, performing genetic crosses in the greenhouse, doing molecular lab work for genomic sequencing, and performing manipulative field experiments in Yosemite National Park, CA.

PI: Professor Matt Escarra, Physics and Engineering Physics

Title: Solar Cells and Light Emitters from Ultra-Thin Nanomaterials

Just as electronics have been miniaturized into densely packaged chips, the future of photonics will include more optical materials, devices, and systems at the chip scale. Our lab is investigating a pixelated optical modulator using phase change materials, such as vanadium dioxide, fabricated at the micrometer and nanometer scale and integrated into optical devices. This project will include opportunities to support the development of these new optical materials and devices and to assess their performance as we move towards practical photonic integrated circuits.

PI: Professor Scott Grayson, Chemistry

Title: Synthesis of Exact Masses for Chemical Calibration of Biological Products.

Our group has completed high molecular weight compounds (from $m/z= 1000$ to 60,000 Da) for calibrations standards which have only one peak for their mass spectrometry. This is from a simple chemical reaction that approximately doubles its molecular weight for each repetition. Our research group will expand these for other unique polymers, including increasing these for higher molecular weights, controlling the mass defect with each macromolecule, and confining the isotopic distribution for every calibrant.

PI: Yanxu Zhang, Earth and Environmental Sciences

Title: Breaking the Gold-Mercury Poverty Trap

Gold is often seen as a symbol of wealth and a “safe-haven” asset, and its price has nearly tripled over the past decade as global economic uncertainty has grown. Today, about 15–25% of the world’s gold is produced through artisanal and small-scale gold mining (ASGM), which supports the livelihoods of more than 15 million people, especially in developing regions. However, many ASGM operations rely on mercury, a highly toxic metal that easily binds to gold and is released into the environment during processing. This makes ASGM the largest source of human-caused mercury pollution worldwide. Mercury exposure can damage the brain, affect child development, and increase the risk of heart disease, leading to long-term health and economic losses that can trap communities in poverty. In this research project, we use tools from environmental science, data science, and Earth system modeling to understand how gold prices, employment, and mining activity drive mercury pollution, quantify its health and economic impacts, and test solutions that could break this “gold–mercury–poverty” cycle. Students involved in this project will gain hands-on experience working with real-world datasets, computational models, and interdisciplinary research questions with global relevance. If you are curious about how science, data, and technology can help solve pressing environmental and societal challenges, we warmly invite you to join our team.

PI: Shuaihua Gao, Chemical and Biomolecular Engineering

Title: Mapping Druggable Conformational States of the Estrogen Receptor through Biophysical Analysis and AI-Guided Protein Therapeutic Design

The Gao Lab conducts research at the intersection of chemistry, biology, and engineering, with a particular focus on Protein Discovery and Engineering for medical, pharmaceutical, and chemical applications. As part of the TRIA program, students will investigate estrogen receptor conformational dynamics using biophysical approaches and apply AI-guided protein design principles to develop protein-based binders or modulators with therapeutic potential.

Estrogen receptors play central roles in hormone signaling and are key therapeutic targets in breast cancer. However, many clinically relevant resistance mechanisms arise from dynamic conformational changes and noncanonical binding interfaces that are poorly addressed by traditional small-molecule approaches. A deeper understanding of ER structural dynamics is therefore critical for next-generation therapeutic development.

In this research, students will apply advanced biophysical tools to map conformational states, ligand-induced structural rearrangements, and transient interaction surfaces of the estrogen receptor that represent previously unexploited druggable sites. These experimental insights will be combined with AI-based protein design principles to engineer protein therapeutics—such as binders or modulators—that selectively target defined receptor conformations with high specificity and tunable functional outcomes. By integrating experimental measurements with machine-learning-driven design strategies, this project aims to establish a rational pipeline for developing protein medicines that overcome limitations of conventional endocrine therapies.

Through this work, students will gain hands-on experience in experimental design and execution, structure–function analysis, biophysical data interpretation, and AI-assisted therapeutic design, learning how experimental and computational approaches synergize in modern drug development. The project emphasizes hypothesis-driven research, translational relevance, and quantitative reasoning, preparing students to contribute to emerging areas at the interface of biophysics, artificial intelligence, and precision medicine.

PI: Professor Jiang Wei, Physics and Engineering Physics

Title: Two-Dimensional Superconductors for Single-Photon Detection

Two-dimensional superconductors, materials only a few atoms thick, exhibit unusual electronic properties that make them promising candidates for next-generation single-photon detectors for quantum communication, astronomy, and low-light imaging. Our group is developing prototype devices that show sharp superconducting transitions and sensitive electrical switching behavior that may correspond to single-photon-level signals. A TRIA student will learn the basics of superconductivity, take part in simple cryogenic measurements on prefabricated samples, and help analyze resistance–temperature data and noise-switching events. No prior lab experience is expected. The goal is to provide an accessible, hands-on introduction to quantum materials, measurement techniques, and scientific data analysis.

PI: Professor Shusheng Wang, Cellular and Molecular Biology

Title: Mechanisms and Therapeutics of Degenerative Eye Diseases

Research in the Wang lab has been focused on the intersections of noncoding RNAs, vascular biology and retinal degeneration. Our research is highly relevant to degenerative retinal diseases including age-related macular degeneration (AMD). AMD is the leading cause of blindness in the elderly, affecting ~8.7% percent of the worldwide population. It has both wet and dry forms. Late-stage dry AMD is characterized by degeneration and loss of retinal pigment epithelial (RPE) cells, while wet AMD is characterized by choroidal neovascularization. The projects in the lab involve studying the AMD-related biological processes, including angiogenesis, fibrosis, cell death and cellular senescence, with the goal of finding novel therapeutics for AMD.

PI: Professor Ibrahim Demir, River-Coastal Science and Engineering

Title: Robotics for Disaster Relief

Have you ever imagined a robot that doesn't just sit on a desk, but actually walks, climbs, and thinks its way through a disaster zone to save lives? That is the mission of Rescue Robotics. We use advanced "robot dogs", agile, four-legged machines, to navigate places where it's too dangerous for humans to go. Our project isn't about having all the answers or finishing a task; it's about exploration and discovery. We are looking for curious students who want to pull back the curtain on how these machines actually work. You'll learn how to "speak" to a robot through code, how sensors allow them to "see" through rubble, and how technology can become a hero in times of crisis. Whether you've never seen a line of code or you're just a fan of futuristic tech, come join us to learn how we're building a safer world, one step at a time!

PI: Professor Ibrahim Demir, River-Coastal Science and Engineering

Title: How We Code New Worlds

Imagine being able to step inside a video game, walk through a digital twin of a historical city, or see virtual blueprints floating right in front of you while you work. This is the world of Spatial Computing (VR/AR), the technology that is blurring the line between the physical and digital worlds. Our project is a playground for students who want to explore the "how" behind the magic. We use cutting-edge gear like the Apple Vision Pro and Meta Quest not just to play, but to understand how to design and code experiences that feel real. You don't need any prior experience in design or programming; we are here to learn together. If you're curious about how to build immersive worlds or how these headsets track your hands in thin air, come join us! We're not just looking for "doers", we're looking for thinkers who want to learn how to create the future of human connection.

PI: Professor Ibrahim Demirr, River-Coastal Science and Engineering

Title: Where Code Meets the Real World

Ever wonder how a self-driving car "sees" or how a smart camera detects an emergency in real-time? That is the world of Edge Computing, the art of bringing the "brains" of a computer directly to where the action happens, rather than waiting for a distant cloud server to respond. Our project is looking for curious students who want to explore this frontier using industry-standard tools like NVIDIA's high-performance hardware and Spark for massive data processing. You don't need to be an expert or have a background in engineering yet; we are a community focused on learning. If you want to understand how the next generation of smart technology is actually built and see how code interacts with the real world, we'd love to have you join us for the journey!