PROJECT DESCRIPTION OF RESEARCH MENTORED BY SPRING 2024 FYRE MENTORS

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(1) Dr. Lara Souza, Associate Professor of Plant Biology

Drought impacts on ecosystems, specifically the Southern Great Plains, can have detrimental impact on system productivity and overall function. Understanding species-specific responses to drought can provide a mechanistic basis to changes in productivity and overall ecosystem function. Leaf level spectral and morphological measurements inform us of shifts in plant function across varying environmental conditions. The FYRE student would take spectral and morphological measurements of plant species that co-exist in our field drought experiment to provide an understanding of species level differences in function that can be driving canopy level responses.

(2) Dr. Abigail Moore, Assistant Professor of Plant Biology

The research projects would involve herbarium specimens, which are pressed plant specimens collected from 1895 to now, that are housed in the Bebb Herbarium on campus or images of specimens from other herbaria. Using herbarium specimens, we can look for variation in plant species through space and time and can also look at how plant communities have changed over time. The research project would involve gathering data from physical specimens or online to answer these types of questions. R will likely be used for data analysis.

(3) David Ebert, Professor of Electrical and Computer Engineering

Project 1: SMART Machine Learning to Classify Misinformation and Disinformation Project

The Data Institute for Societal Challenges (DISC) is seeking one graduate student to work on developing machine learning algorithms to classify social media data into Misinformation and Disinformation. The results of this project will be integrated into an existing visual analytics system called SMART. SMART is a visual analytics project that helps data analysts, and first responders identify and track emergencies through social media.

The student(s) will work on developing and finetuning machine learning and transformer models to classify the textual data from Tweets or social media posts as misinformation or disinformation. The results will then be integrated into SMART with the goal of a) classifying Tweets as misinformation or disinformation, b) tracking the spread of misinformation through social media, and c) providing interactive visualizations of the data classification process. Additional responsibilities will include attending regularly scheduled team meetings.
Candidates with an interest in natural language processing (NLP) and machine learning techniques are strongly encouraged to apply.

Desired qualifications: Strong programming skills in Python, NLP, ML.

Project 2: International Syndromic Surveillance Project
The Data Institute for Societal Challenges (DISC) is seeking one or more graduate students to assist in an International Syndromic Surveillance Project. This project will evaluate the feasibility of a real-time, electronic, syndromic surveillance and decision-making system to provide (i) base data needed for accurate situational surveillance, virus spread status, and measurement of mitigation actions, and (ii) support for timely, data-, model-, and expertise-driven problem-solving. The student(s) will conduct machine learning research and assist in extending a web-based visual analytics system that characterizes disease spreading patterns and supports users in conducting an in-depth analysis of the spread of COVID-19. This interface, titled PanViz 2.0, incorporates multiple statistical epidemiological models (e.g., SIR and SEIR) to quantify and predict disease spreading patterns. This application uses novel visualization approaches to allow users to dynamically refine an epidemic model's parameters, compare the predictions of multiple models, and conduct what-if analysis to assess the impact of

different mitigation strategies. Additional responsibilities will include manuscript preparation and attending regularly scheduled team meetings. Candidates with proficiency in Spanish and willing to learn how to program interactive visual tools are strongly encouraged to apply.

Desired qualifications: Strong programming skills in Python, JavaScript, HTML, CSS, and preferably D3 and the React framework.

Project 3: Data Science for Sustainable Agriculture Project

The Data Institute for Societal Challenges (DISC) is seeking one or more graduate students to assist in applying machine learning and artificial intelligence techniques to agricultural and climate data as a part of an ongoing research effort. Currently, available models for quantifying the impacts of agricultural management practices on environmental quality are diverse. Few, if any, represent detailed physical processes, and some assimilate field and remotely sensed data products. Unfortunately, these models are time-consuming and computationally intensive to tune and run simulations. AI can potentially transform earth science models into more nimble, robust decision support tools. The student(s) will conduct research in machine learning and artificial intelligence to model the relationship between soil health, growing conditions, and corresponding weather dynamics of various experimental studies in the fields. Additional responsibilities will include manuscript preparation and attending regularly scheduled team meetings. Candidates interested in machine learning, data science are strongly encouraged to apply.

Desired qualifications: Strong programming skills in Python, Java, foundations of data science, HTML, and CSS.

More Projects on Data Science, Machine Learning, and Artificial Intelligence are available at the DISC (Data Institute for Societal Challenges).

(4) Dr. Farrokh Mistree, Professor of Aerospace and Mechanical Engineering

Research Field: Systems design and fabrication
Description: Designing Smart, Low-Cost, Modular Greenhouses using Waste Material: Dr. Ashok Das is a Social Entrepreneur in India - https://sunmoksha.com/. We are interested in designing a smart, low-cost, modular greenhouse for commercial use by small and marginal farmers in India and the US.

Conventional greenhouse farming requires high investment; hence its use is limited to crops that have high commercial value and sustainable market demand. Small and marginal farmers cannot afford the use of greenhouses. Thus, there is a need to design and deploy smart, low-cost modular, and cost-efficient greenhouses. We hypothesize that the use of local waste materials (e.g., plastic packets, bottles, mosquito nets, leaves, bricks, rags, etc.) in construction and simplification of the construction can reduce costs.

Expectations: In this project, the learners will focus on the design, manufacture and deployment of a smart greenhouse for small and marginal farmers in India and developing countries. Over time, the outcomes of this study may be presented in peer-reviewed conferences or journals. There is potential for the findings to be extended to an undergraduate Honor’s thesis.

Skills and techniques students will have opportunity to develop: The learners will have the opportunity to learn about sensors, machine learning models in agriculture, mass and heat transfer, and elements of entrepreneurship.

(5) Dr. Shuozhi Xu, Assistant Professor of Aerospace and Mechanical Engineering

Ductile metal fractures have traditionally been attributed to the growth of voids. With an increasing strain, the metal's deformation is no longer reversible, and the voids expand more rapidly. As the strain increases further, neighboring voids interact and coalesce into larger ones, eventually leading to crack propagation within the metal. However, the initial stage of void growth is still not well understood. In this project, we will employ atomistic simulations to examine the growth of nanovoids in several pure metals and alloys. A series of void sizes will be considered, so as to analyze the size effect on void growth. An open-source atomistic simulation software will be utilized by the student, who is also expected to do some programming to analyze the simulation data. At the end of the project, if the student were interested, he/she can write a manuscript that is to be submitted to a scientific journal.

(6) Dr. Deborah Moore-Russo, Professor of Mathematics

Dr. Moore-Russo studies the multiple ways a single mathematical concept is conceptualized, represented, visualized, and communicated. She recognizes that multiple resources characterize human interaction, communication, and meaning making and considers how physical and digital tools influence learning. As an extension of this, she also studies how using digital tools and incorporating reflection impact teachers and students and the ways they conceptualize, perceive, and portray mathematics as a dynamic, engaging discipline that goes beyond memorization of rules and equations. *(Studying Mathematics Tutoring Practices*)

(7) Dr. Hyunho Noh, Assistant Professor of Chemistry and Biochemistry

With the ever-growing need to develop catalysts that can utilize renewable energy sources to generate chemical fuels, development of efficient heterogeneous catalysts that can perform these reactions is critical. My group focuses on understanding the exact chemistry occurring at the surfaces of many candidate catalysts to establish the fundamental design principles. Students will utilize a subclass of a state-of-the-art materials known as metal−organic frameworks (MOFs), which structurally mimic the reported bulk metal oxide-based catalysts. These include, but are not limited to, Ti- and Ce-based MOFs. Notably, the crystallinity of MOFs enables structural determination down to the atomic level using a host of spectroscopic and diffractive characterization techniques. Furthermore, using electrochemistry and in-situ spectroscopy as primary tools, students will experimentally measure key thermodynamic and kinetic parameters relevant to catalysis. These measurements quantitatively establish how the local structure of the catalyst and the surrounding microenvironment impact the overall catalytic performance, and will become cornerstone in design principles for the next-generation catalysts. Through these projects, students can not only gain extensive hands-on research experience but also on how fundamental chemical principles, many of which are covered in introductory chemistry, can be applied to state-of-the-art materials to make a significant impact on renewable energy-related research.

(8) Dr. Donna Nelson, Professor of Chemistry and Biochemistry

Collection, study, and analysis of news reports in which inappropriate activities, mostly by administrators and faculty, adversely impact faculty, students, departments, and other units. Consequences can be unfavorable publicity, loss of students and / or faculty, budget shortfalls, reputation loss, hiring issues, etc. The activities and interactions will be sorted, depending upon whether the interaction reported in the news occurs between two students, a student and a faculty member, two faculty members, a student and an administrator, a faculty member and an administrator, etc. The incidents will also be sorted depending upon the type of inappropriate activities, such as sexual harassment, false claims made by one individual about another, withholding privileges without cause, etc. The student will analyze how these are reported in the news and how they are received by the public. The study and resulting report, will help faculty and students understand what is happening in their units and at other universities.

(9) Dr. Susan Schroeder, Associate Professor of Chemistry and Biochemistry

The long-term scientific goal in the Schroeder lab is to understand RNA structure and function well enough to predict its three-dimensional structure. The novel functions and dynamic structures of viral RNA open doors to better understand the fundamental physical interactions that determine RNA structure, function, and energetics. The Schroeder lab research focuses on three areas: satellite tobacco mosaic virus RNA (STMV); prohead RNA (pRNA); and RNA thermodynamic parameters for better RNA interference (RNAi) therapeutics. We are developing better ways to determine STMV RNA structures inside virus particles using crystallography data, chemical probing data, and computational predictions. The experimental and computational methods developed to study STMV RNA will be applied to other viral RNAs, such as Hepatitis B pregenomic RNA and MS2 bacteriophage RNA, which have well-defined in vitro assembly conditions for studies of RNA folding and virus assembly. pRNA is an essential component of a viral packaging motor and self-assembles into RNA nanoparticles. The Schroeder lab explores pRNA tertiary structure and dynamics using a variety of biophysical techniques, including NMR spectroscopy, crystallography, gel shift assays, and ultrafast femtosecond fluorescent spectroscopy. *(RNA Structure and Function in Virus-Host Interactions)*

(10) Dr. Sarah George, Assistant Professor of Geoscience

Large river systems in big mountain belts are one of the main processes that modify Earth's surface; rivers can entirely erode mountains and control the distribution of species since they act as major biogeographic barriers. By studying the sediment transported in modern and ancient river systems we can glean important insights into climate processes and how large mountain systems are built.

FYRE students will work on either modern or ancient samples from rivers in the Andes Mountains of Colombia or from the Canadian Rocky Mountains. Students will have an opportunity to travel to Tucson, Arizona in Spring 2023 to work in a world-class geochronology lab to date mineral grains from samples using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry. All students will use a Scanning Electron Microscope to image mineral grains. Interested students may also be asked to join for field work in the Canadian Rocky Mountains in Summer 2023. Students will get exposure to software that is a requirement for many Geoscience-related jobs including geospatial software (QGIS) and basic plotting in a programming language (R, python, or MATLAB).

(11) Dr. Lewis Borck, Assistant Professor of Native American Studies

As a scholar in Native American Studies with a background in sociology, anthropology, archaeology, and chemistry, I use these methods to examine the historic and ongoing erasure of Indigenous histories and presents through memorialization of the material archive (our stuff). A student on this project would be working on spatial mapping of Indigenous presence and visibility at OU.

(12) Brian Grady, Professor of Sustainable Chemical, Biological and Materials Engineering

A recent paper from our group indicates that the heat of wetting can be used to measure contact angle as a function of temperature, as long as the change with temperature of certain things are constant. In this work, the student will measure the heat of wetting and also measure the contact angle of powders at different temperatures, and see if the contact angle measured corresponds to that predicted from the heat of wetting. A bomb calorimeter (Setaram C-80) will be used to measure the heat of wetting; this procedure is well established. The contact angle will be measured using the Washburn method. We have a device to measure the contact angle, but have never used it for this purpose, so the student will work with Dr. Grady to develop a standard method for this device. Also, Dr. Grady will be the one who supervises the student.

(13) Dr. Hanping Ding, Assistant Professor of Aerospace and Mechanical Engineering

The students will work in the laboratory to study some topics on energy conversion or storage, such as fuel cell, water electrolyzer, battery. They will be able to learn how to synthesize materials, fabricate fuel cell or battery, and test the performances. The students will be able to participate in their own selected topics or assist our graduate students. Their work activities will be guided by graduate student and professor on the hand-on experiments.

(14) Dr. Keng-Lou (James) Hung, Assistant Professor of Biology

The Hung Lab works on native pollinator conservation, with a focus on native bees. FYRE students may choose from one of several projects that will take place in the Spring, including operating microscopes to take images of diagnostic characters of native bees to help create a resource for bee identification, surveying early-spring pollinators and how they use floral resources from native and invasive plants, monitoring “bee hotels” set out throughout Norman for colonization, and documenting natural history of bee-parasites, to name a few. The student may also design their own project if it fits within the scope of the lab’s research. Each student will be paired with a graduate student mentor, who will provide hands-on training in addition to mentorship from the professor.

(15) Dr. Stefan Wilhelm, Associate Professor of Stepheson School of Biomedical Engineering

The Wilhelm Lab research is focused on nanomedicine, i.e. using nanoparticles for drug delivery and diagnostics. Students in our biomedical nano-engineering laboratory learn the synthesis and characterization of nanoparticles for biomedical applications, such as small molecule and nucleic acid delivery for cancer and infectious diseases, super-resolution microscopy of cells and tissues, and molecular diagnostics. The ultimate goal of our research program is to translate nanotechnologies into the clinic to create safer, more effective, and more efficient therapeutics and diagnostics.

(16) Dr. Iman Ghamarian, Assistant Professor of Aerospace and Mechanical Engineering

We are seeking motivated and curious students to join us on projects related to data science and machine learning with applications in engineering. Your participation in this research will offer you hands-on experience in cutting-edge methodologies and the chance to work on real-world engineering problems.

What We Require:

Programming Skills: A basic knowledge of programming in Python is required, as most of the project work involves coding and data analysis.
Curiosity and Commitment: You must be willing to learn, explore new ideas, and dedicate time to the project.

What You Will Gain:

Research Experience: You'll gain valuable insights into how machine learning can be applied to solve complex engineering issues.

Potential Publication Opportunity: Depending upon the quality of the conducted project, the results may be published in a peer-reviewed journal, an accomplishment that can significantly boost your academic profile.

Mentorship and Networking: You will work closely with experienced researchers who can provide guidance, support, and connections in both academia and industry.

(17) Dr. Je-Hyun Yoon, Associate Professor of Oncology Science (OUHSC)

Dr. Yoon's main research interest is understanding the "RNP Code", that is, the composition and function of RNA-binding proteins bound to RNAs, both coding and noncoding. He has contributed to efforts to characterize the assembly, composition, and function of ribonucleoprotein (RNP) particles, the influence of long noncoding (lnc)RNAs in translation and ubiquitin-mediated proteolysis, and the mechanisms that determine lncRNA abundance in the cell. He is interested in elucidating the rules that govern the assembly of RBPs into RNA-containing functional complexes, the influence of signaling events that regulate RNPs, and the impact of specific RBPs and RNAs on RNP activity and ensuing gene regulation. He is specifically interested in studying the consequences of RNPs on cellular events such as proliferation, survival, senescence, aging and age-associated human diseases such as cancer.

(18) Dr. Lauren Ethridge, Assistant Professor of Psychology

The Brain and Biomarker Laboratory (BABL), under the direction of Dr. Lauren Ethridge, is a multidisciplinary, translational neuroscience laboratory focusing on applications of basic science to clinical outcomes, particularly in neurodevelopmental disorders.

The BABL group centers on the use of dense-array EEG as a translational tool for learning more about brain function in neurodevelopmental disorders. The ultimate goal of our research is to establish non-invasive biological markers for changes in brain function that not only elucidate neural and molecular pathways affected by disorders such as Autism Spectrum Disorder (ASD) and but also serve as aids for early identification, early predictors for response to individualized treatment protocols, and reliable indicators of treatment effects.

(19) Dr. Yuanning Feng, Assistant Professor of Chemistry and Biochemistry

I graduated an Honor Degree in Chemistry seven years ago. I am interested in mentoring students in Honors College. My group have many projects for FYRE students that I can support. We mainly focus on organic synthesis, which is one of the fundamental in chemistry and natural sciences. I also research on supramolecular chemistry, which is one of the frontier discipline in the field. Projects include the synthesis of artificial molecular machines, mechanically interlocked molecules, self-replicators, supramolecular polymers and fluorescent dyes. Those can be applied in physics, material science and biological engineering. More information can be found here: https://www.ou.edu/cas/chemistry/people/faculty/yuanning-feng

(20) Dr. Qinggong Tang, Assistant Professor of Stepheson School of Biomedical Engineering

There is a worldwide shortage of kidneys for transplantation due mainly to the fact that there is no reliable means to determine the viability of kidneys available for transplant. We will develop a novel imaging platform that can better predict the post-transplantation renal function, thus promoting the allocation of marginal donor kidneys and decreasing failed kidney transplants. Such an accurate and non-invasive assessment of kidney viability will enable selection and use of high-quality kidneys from high-risk donors, which are currently under-utilized.

The students will help with designing the testing experiment using ex-vivo human kidney for data acquisition. Students will have the chance to get experience in experimental design, clinical experience on kidney transplant, machine-learning-based computer-aided diagnosis software development, pathology, and medical system design.

(21) Dr. Shreya Vemuganti, Assistant Professor of Civil Engineering and Environmental Science

This study discusses the use of 3D printing technology in developing pseudo-ductile multi-angle FRP laminated composites. The unique capabilities of 3D printing were utilized to vary fiber orientation angles, the thickness of layers, and stacking sequence to produce several novel designs. The FRP composite designs were evaluated regarding stiffness, strength, and ductility. The results highlight the significance of using low and high fiber angle orientations to obtain proper strength and failure strain and thus maximize ductility. This investigation also introduces a new approach in FRP composite manufacturing by producing mixed fiber-angled composite layers to obtain moderate behavior with respect to layers with discrete fiber orientation. We demonstrate the nonlinear behavior and progressive failure of 3D printed FRP. We also suggest the design of combinatorically angled 3D printed Glass Fiber Reinforced Polymer (GFRP) composites using optimization algorithms to carefully select design parameters such as the fiber angle, stacking sequence, and fiber layer thickness to allow suitable load distribution within the 3D printed FRP composite leading to ductile failure.

(22) Dr. Sree Deepthi Muthukrishnan, Assistant Professor of Oncology Science (OUHSC)

The Muthukrishnan laboratory at the Department of Oncological sciences investigates the cellular and molecular basis of adult brain tumors with a specific focus on glioblastoma (GBM) to develop effective pre-clinical models for therapeutic targeting. GBM is a lethal and aggressive form of primary adult brain tumor with an extremely poor prognosis. It is highly invasive, extensively vascularized, and immunologically "cold tumor" that is resistant to standard, anti-angiogenic and molecular targeted therapies. The mechanisms that contribute to GBM resistance, invasiveness and immunosuppression remain largely unknown. Research in the laboratory is focused on tackling these problems using a combination of patient-derived in vitro cell culture models, mouse GBM models and cutting-edge technologies such as bulk and single-cell transcriptomics and epigenomics to identify potential therapeutics to improve patient outcomes. Specific projects include a) elucidating the interplay of cellular metabolism, DNA repair and epigenetics in mediating therapeutic resistance, b) the mechanisms by which the tumor microvasculature contributes to GBM growth, migration, and immunosuppression and c) the functions of histone acetyltransferases in mediating phenotypic plasticity and resistance in GBM. For more details on prior research, please refer Nature communications 2022, https://doi.org/10.1038/s41467-022-33943-0, Cell Reports 2022 10.1016/j.celrep.2022.111511). The Muthukrishnan lab is a very friendly, collaborative, and an inclusive place that is committed to mentoring and training students to develop technical research and presentation skills and provide guidance on potential career paths in science and research.

(23) Dr. Blaine Mooers, Associate Professor of Biochemistry and Molecular Biology (OUHSC)

Larger crystals for more accurate structure-based drug design

The crystallization of proteins, nucleic acids, and their complexes with drug molecules is an essential first step when doing a structure determination project with X-ray crystallography. Over the past three decades, other labs have put much effort put into developing of crystal screening experiments. These screening experiments often yield crystals that are too small to give optimal results in diffraction studies. The size of the crystal used in the diffraction experiment matters because larger crystals tend to diffract X-rays to higher resolution. Higher resolution data lead to more accurate structures. Accuracy matters in structure-based drug design, where the structure of protein-drug complexes are used to redesign the drug molecule for improved binding to the protein. The current methods of growing large crystals are time-consuming, frequently unsuccessful, and wasteful of the expensive biomolecular sample, especially those containing drug molecules in low supply. Improved methods for growing larger crystals would enable new science and advance medicine.

My lab has been working with advanced experimental designs (computer generated response surface designs) to efficiently grow large crystals of biomolecules for which the screening work has already been done. We recently found that modifications of a leading edge response surface design that has promise of yielding reproducible results while consuming less material. This Fyre project involves extending this work to test its generalizability.

This project involves basic biochemistry laboratory skills including preparing buffers and solutions. The project include making images of the crystals with a microscope and measuring the lengths of crystals. This project requires the recording of observations in spreadsheet and the running of R and Python statistical software scripts to analyze the data. However, no programming experience is required.
Larger crystals for more accurate structure-based drug design

(24) Dr. Kamiya Mehla, Associate Professor of Oncology Science (OUHSC)

Pancreatic tumors are immune-quiescent (“cold microenvironment”). Multiple tumor cell intrinsic and extrinsic factors shape tumor immune microenvironment that culminates into nonexistent frequency as well as dysfunction of anti-tumor immune cells. My lab is interested in elucidating the signaling mechanisms that contribute to tumor immunosuppression and refractive response to immunotherapies.

(25) Dr. Sangpil Yoon, Assistant Professor of Electrical and Computer Engineering

Yoon lab (Ultrasound Molecular Imaging and Targeted Therapy Laboratory) develops ultrasound molecular contrast agents using gas vesicles for deep tissue imaging and drug delivery for early diagnosis and therapy of critical diseases like cancer and diabetes. FYRE students will have training on molecular cloning and will be participate on the development of drug delivery and imaging contrast agents with graduate students. We are looking for people with diverse background and open for collaboration with others. We provide diverse opportunities for research, personal career development, and fun experience in the lab.

(26) Dr. Christina Bourne, Associate Professor of Chemistry and Biochemistry

The underpinnings of all biochemistry rely on the structures of the macromolecules, and how these are impacted by interactions with each other and with small molecules. The overall theme of research in the Bourne lab is deciphering structure-function relationships to understand biochemical mechanisms. Projects range from bacterial studies to host-pathogen interactions to mammalian cell lipid homeostasis. Students on our team use a variety of methods to approach these questions, including recombinant protein expression and purification, in vitro and microbiological assays, X-ray crystallography, and cryoelectron microscopy single particle analysis. We seek to maintain a vibrant and diverse scientific community with free exchange of ideas, and welcome students with varied backgrounds and career objectives.

(27) Dr. Zhibo Yang, Associate Professor of Chemistry and Biochemistry

Novel Mass Spectrometry (MS) Bioanalysis

Mass spectrometry (MS) is a powerful molecular analysis technique to detect and identify a broad range of molecules at very low concentrations. New advances in modern MS methods have allowed this technique to be used in emerging areas in chemistry, biology, pharmaceutical and medical studies. We are developing novel MS-based techniques for modern bioanalysis. There are two major areas for undergraduate student research in our group.

(1) Single cell MS analysis.
In traditional biological studies, many cells with different types of status are collected and destroyed to prepare cell lysate, and therefore only averaged results can be obtained. Single cell analysis enables us to assess the biology of each cell and allows for different sub-populations to be identified and characterized. For example, drug-resistant cells are regarded as the key for cancer treatment, but these rare cells exist among heterogeneous populations. Single cell MS methods can study these cells to enhance diagnosis and treatment of cancer.

(2) MS Imaging of biological tissues.
In biological tissues, different types of cells are organized to play biological functions. In traditional experiments, tissues are generally homogenized prior to molecular analysis, and therefore, the spatial information of cells is inevitably lost. As a novel technique, MS imaging allows for the measurement of the spatial distribution and relative abundances of biomolecules in tissues. For example, we can use MS imaging techniques to measure the molecular distributions on brain slices for AD (Alzheimer's disease) studies.

(28) Dr. Adi Joshi, Assistant Professor of Pharmaceutical Sciences (OUHSC)

Discovering novel therapeutics against Non-alcoholic fatty liver disease @ Joshi Laboratory

Dr. Joshi is an Assistant Professor in the Department of Pharmaceutical Sciences and a Member of Harold Hamm Diabetes Center. He has coauthored numerous highly cited journal publications, conference abstracts and book chapters. His research is funded by National Institute of Diabetes and Digestive and Kidney Diseases (National Institutes of Health) and Presbyterian Health Foundation.
Research by our group is focused on mechanistically understanding the pharmacological and toxicological role of the Aryl hydrocarbon Receptor (AhR) in liver and to design novel therapeutic strategies against plethora of hepatic diseases using AhR as a target. AhR, a ligand activated transcription factor, is a mediator of xenobiotic toxicity, best recognized for conveying the deleterious human health effects following exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD, dioxin) and related environmental contaminants. Canonically, TCDD activation of the AhR results in potent upregulation of the key target gene, cytochrome P450 1A1 (encoded by Cyp1a1). We have recently identified a tryptophan catabolite, cinnabarinic acid as an endogenous AhR agonist responsible for expression of AhR target gene, stanniocalcin 2 (Stc2). This finding is noteworthy for two reasons. First, cinnabarinic acid-induced AhR-mediated Stc2 induction confers hepatoprotection against alcoholic and non-alcoholic fatty liver disease. Secondly, Stc2 induction exhibits agonist specificity, meaning that cinnabarinic acid but not TCDD, induce Stc2 expression. Moreover, cinnabarinic acid in contrast to TCDD, does not trigger Cyp1a1 expression and does not regulate xenobiotic metabolism. Therefore, these two AhR target genes exhibit mutually exclusive agonist-specific transcriptional responsiveness with distinct physiological consequences.

My current research is focused on: 1) developing cinnabarinic acid (and other AhR agonists) as potential pre-clinical therapeutic lead compound(s) against non-alcoholic fatty liver disease, 2) using transgenic mouse models and by utilizing contemporary single nuclei gene expression + ATAC-seq (and ChIP-seq) methodologies – decipher molecular pathways by which CA-induced AhR-Stc2 signaling protects against hepatotoxicity, 3) Utilize mass spectrometry based approach to identify molecular basis for the agonist specific differential gene regulation. Specifically, identify agonist-specific histone modifications, readers-writers-erasers of those modifications and role of chromatin architecture in agonist-specific dichotomy.

Our research employs cutting-edge cellular, molecular and biochemical methodologies, use in vitro hepatic organoid and in vivo models as well as utilizes innovative technologies such as hepatic organoid models, next-generation sequencing, cross-linking chromatin immunoprecipitation coupled mass spectrometry and CRISPR mediated genome editing. My long term-objectives are to mechanistically study repertoire of AhR target genes in the context of liver and metabolic diseases and develop a translational approach to AhR biology by identifying and characterizing therapeutically useful endogenous AhR agonists to ameliorate hepatic diseases.

To check out more about his research please visit https://www.joshilaboratory.org/

(29) Dr. Yitong Dong, Assistant Professor of Chemistry and Biochemistry

The research interests of Dong's group include developing and synthesizing novel nanomaterials and elucidating their photophysical and electronic properties for photonics, energy, and photocatalysis applications. We focus on developing and synthesizing new QDs with exquisite control of size, shape, and surface and studying their optical and electronic properties at the single particle level. Our group also aims to exploit the advanced QD material to enable cutting-edge photonics devices such as ultra-fast single photon sources.

(30) Dr. Bayram Saparov, Associate Professor of Chemistry and Biochemistry

In recent years, we have prepared several new families of high-efficiency photo-luminescent materials. These materials emit tunable light with efficiencies up to 100%, which is remarkable as most compounds do not luminesce at room temperature. In addition, our materials are based on inexpensive element copper, and can be processed at room temperature using simple solution processing. These characteristics make our materials candidates for a variety of applications including LED bulbs, and in sensors and detectors.

In this project, the students will work on improving the environmental stability of our copper(I) halides. Despite their outstanding light emission properties, our current copper(I) halides degrade quickly due to oxidation. The student will make targeted chemical modifications to our materials to improve their stability.

(31) Dr. John Clegg, Assistant Professor of Stepheson School of Biomedical Engineering

The Neuro-Immuno-Engineering Collective (Clegg Lab) explores hydrogel and innate immune cell-based therapeutics for the treatment of neurological diseases and traumatic injuries. Our approach is to develop application-specific therapeutics, and to evaluate their efficacy using both biomimetic tissue devices (i.e. engineered biological barriers or organs on chips) and animal models. Our current efforts are focused in the following areas:

(i) Hierarchical synthesis and assembly of soft biomaterials for the sustained release of immunomodulators.
(ii) Development and application of engineered brain-tissue barrier models.
(iii) Evaluation of macrophage cell-based therapeutics that are delivered in tandem with an immunomodulatory scaffold.
(iii) Translation of these therapeutics to treat brain inflammation (multiple sclerosis, traumatic injury, secondary brain damage) and brain cancer.

The FYRE student(s) that join our laboratory will assist a graduate student or postdoctoral fellow in one or more of these areas. You will learn hydrogel synthesis, characterization, and biological evaluation (primarily immortalized cell cultures). Long term projects, beyond the scope of the FYRE program, can include additional biological work (primary human or mouse cells, in vivo work in rodents).

(32) Dr. Reza Foudazi, Associate Professor of Sustainable Chemical, Biological and Materials Engineering

he current research activities in SMaRT group are self-assembly of amphiphilic molecules, templating approach for synthesis of porous polymers, and rheology of soft matter, with the long-term goal of producing responsive multifunctional materials for sustainability and environmental applications. Example projects are:
1. *Stimuli-responsive ultrafiltration membranes:* ultrafiltration membranes are used for water treatment, protein purification, viral filtration, etc. Currently, the available membranes have a fixed pore size, and thus a limited selectivity. Additionally, a lot of solvent is needed for making membranes which is harmful to the environment. In this research, we produce membranes that have better separation performance compared to conventional membranes and are also responsive to temperature and pH.
2. *PFAS removal from water resources:* PFAS are Per- and Polyfluoroalkyl Substances, known as forever chemicals as they do not break down in the environment. In the U.S., PFAS contaminated water supplies are found in 49 states. PFAS have severe health effects to the wildlife, human, and environment. In this research, we are developing an efficient system for PFAS removal from drinking water.
3. *Porous polymers for environmental applications:* We synthesize multifunctional porous polymers through emulsion- and foam-templating methods. The obtained porous polymers are used for different applications, such as agriculture in outer space, microfiltration membranes, and adsorbents for heavy metal removal.

(33) Dr. Dimitrios Papavassiliou, Professor of Sustainable Chemical, Biological and Materials Engineering

Project 1: What happens to blood proteins when blood flows through cardiovascular implants?

When suspensions of long molecules (e.g., proteins) move through medical equipment, their molecular structure changes because of hydrodynamics stresses acting on them. Such molecular changes can result in changes in the functionality of the proteins, for example a protein known as Von Willebrand factor can lose its activity to make blood clots. We use molecular level simulations to understand the changes that a long molecule can undergo when it gets to flow through carefully controlled flow environments. The two extreme conditions are shear flows (where shear stresses are exerted on the molecules) and elongational flows (where normal forces act on the molecules). We want to see what are the conditions that lead to significant changes in the way the molecules are structured and to develop guidelines for the design of medical devices. Skills to be developed include working with high-end computers, presenting research results and thinking critically about open-ended problems.

Project 2: How do nano-plastics behave when they end up in the ground?

Nanoplastics can be a health and environmental hazard. We use computations in porous media to investigate the details of nanoplastic aggregation and how the structure of the porous medium and the nanoparticle properties affect the propagation of nanoplastics in the soil. Skills to be developed include programming, use of supercomputers and critical thinking.

(34) Dr. Yingtao Liu, Associate Professor of Aerospace and Mechanical Engineering

Dr. Yingtao Liu in AME seeks to select a single student to spearhead advancements in 3D printing of polymers and composites, focusing on optimizing the printing processes. This endeavor will provide the chosen student with an immersive experience in the intricate world of additive manufacturing, fostering collaboration with seasoned researchers and hands-on engagement with cutting-edge technology. As the chosen student delves into refining 3D printing techniques, they will inevitably expand their skill set, broaden their knowledge horizons, and set forth on a trajectory towards a promising career in this rapidly evolving domain. This program not only transcends traditional classroom learning but also empowers students to actively contribute to the future landscape of additive manufacturing.

(35) Dr. Marshall Cheney, Associate Professor of Health and Exercise Science

In the spring we will be analyzing interviews from participants in smoking cessation studies. Participants are interviewed at the end of the intervention and gathers data about their experiences with the intervention and how to improve it. The student research assistant will help check the transcriptions for accuracy then work with our team to analyze the data and provide a report to the full study team.

(36) Dr. Cesar Ruiz, Assistant Professor of Industrial and Systems Engineering

Discovery of new high-performance and lightweight alloys is key for ensuring the success of the US clean manufacturing objectives. Alloy mechanical properties are characterized by either expensive simulations or extensive physical experiments. This project seeks to develop novel machine learning techniques methodologies for predicting the mechanical properties of new alloys based on simulation and experimental data from similar alloys.

(37) Dr. Carolyn Ibberson, Assistant Professor of Microbiology

Our research centers around understanding bacterial physiology and behavior in situ during chronic human infection, with a focus on elucidating the mechanistic links between co-infecting microbes and disease severity. Our work is at the cutting edge of assessing bacterial physiology in human infection, and leverages classic microbiological techniques in combination with -omics approaches to ask foundational questions about how the prominent pathogen, Staphylococcus aureus, causes disease and persists in human infection. Further, we work to determine the molecular mechanisms of microbe-microbe interaction in infection sites with interdisciplinary approaches. Central questions in my lab are:

1) What mechanisms allow S. aureus to establish and persist in chronic infection?
2) How do other community members impact S. aureus physiology in polymicrobial infection?
3) What is the role of spatial structure in mediating interactions between microbes in chronic infection?

(38) Dr. Laura Stein, Assistant Professor of Biology

Project Topics:
1) Brain responses to aggression, feeding, and social situations in guppies
2) How parental stress influences social behavior in three-spine stickleback fish
3) Why some individuals are more influenced by stress than others in guppies

(39) Dr. Doerte Blume, Professor of Center for Quantum Physics and Technology

FYRE students will experience theoretical atomic, molecular, and optics research. The project will involve reading of literature as well as analytical and numerical work. There exists the possibility of using/learning a programming language and/or working with symbolic software packages such as Mathematica. The research will explore aspects of manipulating atoms in the cold and ultra cold regime, using quantum optics techniques. There might be an opportunity to continue research through the summer 2024.

(40) Dr. Han Yuan, Associate Professor of Stephenson School of Biomedical Engineering

There are two possible research projects in Dr. Han Yuan's lab: 1) Functional near-infrared spectroscopy (fNIRS) is a promising, noninvasive neuroimaging technology that measures hemodynamic responses in the brain using infrared light. The technology provides answers to current medical restrictions for patients with medical electronic implants that are often incompatible with other neuroimaging methods such as fMRI. This research project will attempt to use fNIRS to measure the brain response to transcranial magnetic stimulation (TMS) which is an FDA approved treatment for depression and other diseases. The novel multimodal imaging of fNIRS and TMS may be able to improve the efficiency of treatment. 2) The 2nd project is about the analytics of functional magnetic resonance image (fMRI) data acquired in the human brain. fMRI provides unique opportunity to measure neural activity at fine spatial resolution in the human and is the most widely used modality to obtain information. The imaging modality also has important clinical applications in the planning of neurosurgery. In the project, the student will learn about the fMRI analytics using AFNI (https://cbmm.mit.edu/afni), and also programming with shell scripts and medical image processing. After learning the basics of fMRI analytics, the student may be able to work on a research dataset in patients.

(41) Dr. Jie Gao, Assistant Professor of Sustainable Chemical, Biological and Materials Engineering

The goal of this project is to enhance the educational experience of students enrolled in the chemical engineering undergraduate Unit Operation Laboratory course through the creation of an innovative and engaging pedagogy. This initiative aims to provide students with a dynamic and immersive learning environment that reinforces core concepts of chemical engineering unit operations while fostering teamwork, critical thinking, and problem-solving skills.

(42) Dr. Jeremy Mikhail Kellawan, Associate Professor of Health & Exercise Science

Dr. Kellawan's work largely focused on mechanisms that control blood flow in skeletal muscle and cerebral circulations during exercise and environmental stress in humans. His work is designed to understand the physiological mechanisms that limit cardiovascular support of the brain and skeletal muscle with the aim of developing treatments and strategies to improve human health and performance.

(43) Dr. Sepideh Razavi, Assistant Professor of Sustainable Chemical, Biological and Materials Engineering

The Razavi Lab conducts research on the behavior of complex fluids near surfaces and interfaces. These interfacial systems, consisting of surfactants, nanoparticles, and polymers, play a crucial role in various industrial and technological processes such as agrochemical delivery, coatings, and processing of protein solutions. Despite their importance, many aspects of the interactions between solution components, with other fluids, and at material interfaces remain unknown. The primary focus of our research is to gain a fundamental understanding and ultimately predict the thermodynamic, transport, and deformation properties of complex fluidic systems. We aim to expand the current knowledge of interfacial systems involving isotropic particles and extend it to technologically relevant particles with engineered surface heterogeneity and anisotropy. Our research findings contribute to the development of sustainable soft materials and the engineering of solutions for complex interfaces encountered in challenges related to "water and energy sustainability".

Lab Website: http://srazavilab.com/

(44) Dr. Mauricio Carvallo, Associate Professor of Psychology

My current research focuses primarily on three main lines of research. First, I am interested in examining the antecedents and consequences of a "culture of honor" ideology. We can define "culture of honor" as a belief system that emphasizes the need to maintain one's reputation with respect to others. My graduate students and I have investigated, for example, how the endorsement of a culture of honor ideology is related to mental health stigma and preventive screening behavior. Second, I am interested in exploring factors that influence different health outcomes such as disease preventive screenings uptake, utilization of health services, and the adoption of unhealthy or risky health behaviors. Finally, I am also interested in exploring how stereotypes and prejudice affect people's views of different minority group members.

(45) Dr. Yijie Jiang, Assistant Professor of Aerospace and Mechanical Engineering

3D printed structural integrity:

In recent years, 3D printing has become a powerful manufacturing technique that can product highly customizable parts with many applications from medical to structural components. Regardless of the applications, the high and consistent quality (such as mechanical strength) of 3D printed parts is desired. Extrusion-based 3D printing operates via a programming language known as G-code, which guides the movement of nozzles and extrusion of the materials. With emerging applications of 3D printing in wireless control and batch production, the concern of cyber security raises as well. The hacking of 3D printing via modification of G-code may lead to interior defects and weak material properties. In this work, I investigate the strategies to modify the 3D printing G-code in such a way to compromise the structural integrity in an un-detectable manner, including preserving the outer appearance and bulk density. Ultimately, by studying how to weaken 3D prints, this research hopes to learn a protective strategy enhancing the cyber security and manufacturing high quality 3D printed parts.

(46) Dr. Bihui Zhu, Assistant Professor of Physics and Astronomy

The research project will focus on theoretically studying quantum dynamics in many-body systems. The studies will be closely related to applications on current quantum platforms, including quantum computing, simulation and sensing. Students getting involved will gain knowledge on the frontiers of relevant research topics as well as experiences with useful computational and analytical methods.

(47) Dr. Justin Metcalf, Assistant Professor of Electrical and Computer Engineering

There are two potential projects. The first project will involve developing materials that mimic biological tissues to a radar. In other words, they respond the same as blood, skin, bone, etc. would to the radar. However, they are made from a mix of a silicone base and powdered metals. The student will work on mixing the materials, learning to characterize them using our lab equipment, and using 3D printers to develop 3D molds of various parts of the human head. There are no needed or expected skills for this project.

(48) Dr. Valentin Rybenkov, Professor of Chemistry & Biochemistry

The emergence and spread of antibiotic resistant pathogenic bacteria present a rapidly expanding threat to public health. A plausible strategy to overcome this threat involves the development of drugs against new bacterial targets. This project seeks to develop antibacterial agents against a previously unchallenged cellular pathway, chromosome maintenance. The project builds upon the recently created series of compounds that inhibit condensins and seeks to characterize the target. Condensins play a central role in chromosome organization, an essential cellular function, and are required for cell viability and pathogenicity in a diverse range of organisms. Condensin inhibitors proved efficacious in vivo for the control of drug resistant Escherichia coli. The project seeks to characterize the mechanism of inhibition of condensins on structural, mechanistic and genetic levels. The project will create a platform for anti-condensin drug development and characterize bacterial resistance mechanisms to the inhibition of chromosome maintenance.

(49) Dr. Heather McCarthy, Associate Professor of Plant Biology

Dr. McCarthy's research interests include: plant physiological ecology, global change, urban ecology, ecohydrology and elevated carbon dioxide (CO_2) effects on forest ecosystems. Her research addresses how trees and forests respond to environmental changes, and, conversely how can they be managed to moderate environmental changes. This research draws on physiological and ecosystem ecology to explore how tree and forest-scale water and carbon cycle processes respond to global change factors, including changes in water availability, extreme weather events, elevated atmospheric CO_2, and urbanization. Recent projects include measuring elevated CO_2 effects on southern pine forest productivity, and quantifying tradeoffs between water use and carbon uptake in the urban forests of Los Angeles.

(50) Dr. PK Imbrie, Professor of Aerospace and Mechanical Engineering

Research focuses:

Experimental mechanics
Piezospectroscopic techniques
Epistemologies, assessment, and modeling of student learning, student success, student team effectiveness, and global competencies.

(51) Dr. Wesley Honeycutt, Research Associate of OU-AQTLab

My current projects with resources include:

- Remote sensing of atmospheric trace gases using a solar tracking spectrometer to measure total column concentrations of things like CO, CO_2, and CH_4 at interesting sites.
- Systems engineering using design principles for policy development by social entities based on physical observations.
- Detecting trace gas in urban canyons using multiple in situ sensors in collaboration with a professor in Architecture. (2 previous FYRE students did this)

My work is transdisciplinary in nature, so any interest is welcome. Currently, I can think of interesting projects for undergrads with interest in:

- Trace gas sensing
- Micro- and mesoscale meteorology
- Geometric projections
- Electrical engineering --- Power supply and actuators
- Electrical engineering --- Logic-level conversion

All projects TBD: research needs will change by the time student selection is in and I always adapt the project for student needs.