PUMA-STEM Summer 2022 Faculty Research Descriptions

Biology:

Name of Mentor: Jim Fackenthal, Ph.D.
Institution: Benedictine University
Department: Biological Sciences

Students in the Fackenthal group study regulation of tumor suppressor genes at the level of alternate mRNA splicing. Students will use cancer and non-cancer derived tissue culture cells to learn basic cell culture techniques, end-point and quantitative RT-PCR, ELISA, and flow cytometry. We explore the effects of DNA damage repair pathways and epigenetic genomic modifications on regulation of alternative splicing, cancer risk models, and therapy outcome predictions.

Research could be in-person or remote at Benedictine University.

Name of Mentor: Leigh Anne Harden, Ph.D.
Institution: Benedictine University
Department: Biological Sciences

The Harden Lab conducts integrative ecological research on reptiles and amphibians (herps). Our lab's central research questions revolve around of how these organisms function and interact with their increasingly modified environment, by studying them on a physiological, behavioral, and spatial/temporal level. We use field-intensive (e.g. aquatic surveys) and laboratory-based (e.g. ELISAs, microscopy) approaches to investigate how abiotic factors influence the physiology, behavior, and habitat preferences of herps, with applications to their conservation and management.

Summer research projects will involve intensive outdoor fieldwork 5 days/week of trapping turtles in local wetlands to investigate their species diversity, population structure and demography. Students will have the ability to develop their own side projects of interest within this larger project. Much of this fieldwork may be done in hot, muggy, and buggy conditions, so a hardiness in this kind of weather is a must. Attention to detail is important for high quality science. Curiosity and an ability to troubleshoot will contribute substance as well as enjoyment to our shared work experience!

Research would be in-person lab and field research at Benedictine University.

Name of Mentor: Tiara Perez Morales, Ph.D.
Institution: Benedictine University
Department: Biological Sciences

Undergraduate students in the Perez Morales lab research cell-cell communication or quorum sensing pathways present in *Lactobacillus sp.,* a commensal microorganism of the gastrointestinal tract. Our focus is to determine how these quorum sensing pathways affect *Lactobacillus sp.* social behavior *in vitro.* Currently, our research projects

provide students with knowledge in general microbiology techniques, bacterial genetics, cloning, 96-well transcriptional and phenotypic assays, RNA preparation, RT-PCR and qRT-PCR.

Research would be in-person at Benedictine University.

Name of Mentor: Jayashree Sarathy, Ph.D.
Institution: Benedictine University
Department: Biological Sciences

The Sarathy lab works on two main projects involving how bile salts affect the physiology of colon cells. In the first project, a student will work with colon cancer cell line and study the effect of various primary and secondary bile acids on paracellular permeability (in-person).
The second project will work on a case study to highlight the importance of having an epithelial barrier and how bile acids in excess can compromise this barrier as seen in patients with inflammatory bowel disease (remote). Research could be in-person or remote at Benedictine University.

Research would be in-person at Benedictine University.

Name of Mentor: Christopher Anderson, Ph.D.
Institution: Dominican University
Department: Biological Sciences

Ecology and Evolution: The Anderson lab's research interests include ecology, evolution, and behavior found in natural systems. Our primary study subjects are insects in the order Odonata (dragonflies and damselflies). Our field sites have included locations in the Forest Preserve District of DuPage County (Illinois) and at the Sinsinawa Mound Center (Wisconsin). Our studies have included biodiversity surveys, documenting internal and external parasite prevalence & intensity, and experimental investigations of reproductive and territorial behavior. While primarily field based, our research group's laboratory approaches have included population genetic studies (e.g. microsatellite development and analysis), laboratory dissections, and image analysis.

Name of Mentor: Zomary Flores-Cruz, Ph.D.
Institution: Dominican University
Department: Biological Sciences

Microbiology: Both pathogenic and beneficial microbes utilize similar molecular "toolkits" to colonize and interact with their respective hosts. Likewise, eukaryotic hosts engage identical responses to both beneficial and pathogenic partners. Although beneficial microbes are necessary for host development, biology and health, most research has focused on pathogenic interactions. The Flores-Cruz lab's research interests lie in understanding how beneficial host-microbe interactions are established and maintained. Currently, we examine the role reactive oxygen species (ROS) play in the beneficial *Vibrio fischeri*-Hawaiian Bobtail squid model system. Undergraduate students in the Flores-Cruz laboratory generate mutant strains in different oxidative stress response genes to determine their role in ROS stress response and symbiotic fitness. To test the role in oxidative stress response, mutant strains are exposed to different ROS and compare growth and survival to the wild-type strain. In addition, biochemical tests are performed to quantify oxidative damage and ROS generation and consumption.

Name of Mentor: Irina Calin-Jageman, Ph.D. & Robert Calin-Jageman, Ph.D.
Institution: Dominican University
Department: Biological Sciences & Psychology

Behavioral Neuroscience: The Calin-Jageman lab's research interests focus on the regulation of gene expression in the central nervous system. Understanding the biological mechanisms of memory is an important goal in neuroscience and fundamental to understanding how nervous systems adapt behavior to novel conditions. Specifically, we study the transcriptional changes that accompany the maintenance and decay of long-term memory in the simple marine mollusk, *Aplysia californica*. Our research program integrates multiple methodologies, including bioinformatics, cell culture, molecular biology, and biochemistry.

Name of Mentor: Scott Kreher, Ph.D.
Institution: Dominican University
Department: Genetics/Biological Sciences

The Kreher lab's research is focused on the genetic basis of behavior. Our specific research goal is to investigate the molecular, genetic and cellular basis of the sense of smell, using the fruit fly, Drosophilia melanogaster, as a model system. The sense of smell, or olfaction, is crucial for animals to find food, avoid predators and to find potential mates. Understanding the sense of smell is a fundamental question in neuroscience, as it relates to the mechanisms by which stimuli are coded by the sensory nervous system. It is especially worthwhile to investigate the basis of olfaction in insects, since pest insects use their sense of smell to find crops and blood-feeding insects use their sense of smell to find crops and blood-feeding use their sense of smell to find their hosts. We use various approaches in our research, such as classical genetics, molecular biology and behavioral analysis.

Name of Mentor: Paul Arriola
Institution: Elmhurst University
Department: Biology

i. **Please share a description of the research project the student will work on.**
I am continuing to work on the impact of drought stress on the reproductive output in amaranth. During the summer I may be collecting data on seed production. The work will involve harvesting seeds from amaranth plants grown in the greenhouse to gain estimates of female fecundity and then germinating the harvested seed in order to determine the viability of the seed produced.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
I would only require a student who does not mind working in the greenhouse when it is warm. It is important that I have a student willing to commit to the project and even be willing to work on the occasional Saturday or Sunday. There are no specific lab skills needed except for a willingness to learn and enter data into an excel spreadsheet reliably.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
This project would require to be in person. I would assume all COVID related precautions to be observed, (fully vaccinated, masks, etc.)

Name of Mentor: Kyle Bennett, Ph.D.
Institution: Elmhurst University
Department: Biology

i. **Please share a description of the research project the student will work on.**
We will be installing a prairie garden and monitoring native pollinator usage over the establishment of the planting

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Ability to lift 30 lbs, work on hands and knees in soil, comfort being outside in unpredictable weather.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
This will be in-person at the study site at Elmhurst University.

Name of Mentor: Amy Hebert, Ph.D.
Institution: Elmhurst University
Department: Biology

i. **Please share a description of the research project the student will work on.**
In our lab we are exploring the role of inflammation and how it can affect learning and memory. We use the model organism C. elegans, which is a small nematode, to examine how exposure to inflammation changes various aspects of learning and memory such as gene expression, cell abundance, and synaptic function. Our hope is that exploring the impact of inflammation on learning and memory, it can further our understanding of how neurodegenerative diseases work.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Basic lab skills, at least intro level BIO courses

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
Mostly in person at the beginning of the summer but data analysis may be done remotely

Name of Mentor: Kelly Mikenas, Ph.D.
Institution: Elmhurst University
Department: Biology/Environmental Studies

i. **Please share a description of the research project the student will work on.**
Green technologies, such as green roofs, can help to support local plants and animals that have lost their habitats due to agriculture and urbanization. However, it can be difficult to establish plants on green roofs because they tend to be very hot, dry, and windy. Elmhurst University installed a 4000 square foot green roof on top of its student center (Frick Hall) in the Fall of 2019. The plants installed on the green roof are non-native succulent species but a selection of local native species with the potential to survive in harsh conditions was added as an experiment in the spring of 2021. Research in 2022 will aim to identify the native plant species that have survived the first winter and document changes in population size. Data obtained from a weather station on the green roof will be used to help explain variability in plant survival and growth.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
The student must be comfortable working outdoors and in a variety of climatic conditions. Data collection for this project will take place outdoors and is somewhat physically-demanding. The student may need to pick up and carry heavy trays filled with soil and plants and carry supplies up and down a 3-story ladder. Data collection can be dirty and conditions on the roof can get very hot during the summer months. Insects, including honey bees will likely be present.
Familiarity with the Microsoft office suite, particularly Excel, is needed as is a computer with an internet connection off campus to work on remote data analysis.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
Research will be conducted in person and online. The student should plan on tending to plants and collecting data on campus 1-3 days per week. Data collection will occur both in a garden and on a green roof. Data interpretation and analysis will occur virtually. The student should be self-motivated and able to work independently as well as part of a team.

Name of Mentor: Mallory Havens, Ph.D.
Institution: Lewis University
Department: Biology

i. **Please share a description of the research project the student will work on.**
The long-term objective of this project is to reduce the production of reactive oxygen species (ROS) in Alzheimer's brains using ligands that slow electron transfer between heavy metals and the amyloid beta (A□) peptide to reduce neurotoxicity and slow or eliminate disease progression. We established in our preliminary work that copper chelation can reduce ROS production and A□ aggregation *in vitro*. Furthermore, we successfully increased lifespan of an Alzheimer's model organism following copper chelation. To accomplish our long-term objective, the **goal** of this proposal is to elucidate the underlying mechanism of increased average lifespan of our Alzheimer's disease model organism following copper chelation. We **hypothesize** that the increased average lifespan in our model organism is due to decreased ROS production, therefore, decreased A□ aggregation and/or expression. To test this hypothesis and prepare to move into a mammalian system, we propose the following specific aims. **Specific Aim 1** is to detect the level of ROS produced in the mitochondria of *C. elegans*. **Specific Aim 2** is to determine if our copper chelating compounds cause a reduction in Aβ expression and/or aggregation *in vivo*. Finally, **Specific Aim 3** is to generate dose curves, examine amyloid

beta aggregation, and examine the toxicity of our copper chelating ligands in a mammalian system using cultured mouse neurons expressing the human amyloid precursor protein. Together, these aims will provide mechanistic insight into how our copper chelating compounds work *in vivo* and will lay the groundwork for future experiments using rodent models with the compounds.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

The student should have taken a hands-on Biology or Chemistry lab at the college level.

Name of Mentor: Jerry Kavouras, Ph.D.
Institution: Lewis University
Department: Biology

i. Please share a description of the research project the student will work on.

The complex web of ecological interactions in which hosts and their parasites are embedded has the potential to substantially alter patterns of infection. Mesocosms provide a manageable method for isolating and examining the effects of multiple species, in order to explore the importance of direct and indirect effects for parasite transmission in a multi-species planktonic system. Daphnia dentifera, or water fleas, are microcrustaceans which serve as indicator species and are involved in a variety of food web interactions. Metschnikowia bicuspidata is a fungus that is an endoparasite to D. dentifera. The invasive Dreissena sp. (D. polymorpha and D. bugensis), is a bivalve mollusk and voracious filter-feeder in aquatic habitats that can change the species composition of plankton communities. The objective of this project is to examine the potential for indirect effects by Dreissena on the host-parasite relationship between Daphnia and Metschnikowia. The presence of Dreissena in habitats may alter disease dynamics in Daphnia through competition for algal resources, and/or as serial diluters by consuming fungal spores. The specific aims for this summer project are: (a) to determine if Dreissena can reduce the prevalence of infection in Daphnia by removing spores from the mesocosm which decreases the chance for infection and (b) to determine if Dreissena can increase the prevalence of infection in Daphnia due to stress caused by competition for algae. Mesocosm experiments will be performed during the summer to determine if Dreissena exerts indirect effects in this system.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

The applicant should have completed one year of General Biology with labs.

Name of Mentor: Steve Johnston
Institution: North Central College
Department: Biology

i. Please share a description of the research project the student will work on.

Our research group is investigating the function of the *COX10* gene, which is essential for the function of mitochondria. Defects in this gene are associated with Leigh Syndrome in humans. We will be moving various human *COX10* alleles into yeast cells and measuring how well they function. In addition, we will attempt to identify other genes that can overcome the metabolic defects associated with loss of *COX10* function.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

Students should have completed at least two semesters of college-level biology and chemistry classes. Perhaps more importantly, students should be curious about how cells function and should willing to ask lots of questions.

Name of Mentor: Michael T. Stefanik, Ph.D.
Institution: North Central College
Department: Neuroscience

i. Please share a description of the research project the student will work on.

My lab is interested in understanding the neurobiological basis for the progressive intensification of craving for drugs of abuse following prolonged periods of abstinence. This intensification (or "incubation") is seen in both human and animal models for multiple drugs of abuse including cocaine, methamphetamine, heroin, and nicotine. However, it been understudied for oxycodone, the most widely prescribed prescription opioid painkiller. In my lab, we train rats to self-administer the drug in an operant chamber, and then utilize a variety of behavior, pharmacological, and biochemical techniques to examine the molecular changes that take place in the brain's reward system. Current projects in the lab center around examining changes in excitatory signaling in the brain that are shown for other drugs to play a role in relapse to drug seeking. Specifically, do the brain's major family of excitatory neurotransmitter receptors (AMPA receptors) change in a similar fashion following oxycodone self administration and abstinence to what is observed for other addictive substances? Our previous studies have shown that neural activity patterns in key reward-related brain regions are altered following oxycodone self-administration and forced abstinence. The next question we are asking is where these regions project to. Given the complex interactions between multiple brain regions in driving relapse, we will utilize cutting-edge viral tracing methods combined immunohistochemical techniques to gain a better understanding of circuit-wide alterations in neuronal communication that underlie incubated oxycodone seeking. All students are instructed in how to handle, care for and train the rats in the self administration procedure. Then, depending on their personal interests/course background, they then are assigned a variety of molecular/biochemical studies to examine the consequences of drug exposure on the brain. Techniques they can be trained in include immunohistochemistry, Western blotting, immunoprecipitation, non-canonical metabolic labeling (BONCAT, FUNCAT), proximity ligation assays (PLA), viral pathway tracing, and in vivo optogenetics. These techniques are a combination of fundamental neuroscience lab skills and cutting-edge tools to examine brain structure and function. Together, this broad training that spans behavior to biochemistry and molecular biology positions students well to succeed in graduate or professional schooling in the future.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Students must have completed at least an introductory-level neuroscience or equivalent psychobiology course in order to be considered for a position. Students without this prerequisite will not be considered. Additional course work in biology, chemistry, and neuroscience are strongly encouraged. A willingness and ability

Chemistry:

Name of Mentor: Stefan Stefanoski, Ph.D.
Institution: Benedictine University
Department: Physical Sciences

Project 1: This project involves testing of batteries for electric (EV) or hybrid-electric (HEV) vehicles. Although the testing of batteries is on a laboratory-scale, the project is intended to mimic the activities of engineers in companies and national laboratories designing batteries for EVs. Properties such as battery capacity, voltage and current during charging and discharging, are investigated. The effects of temperature and mechanical stresses on the performance of the battery are analyzed. Impedance Spectroscopy is employed to measure properties such as internal resistance in order to assess the “state of health” of energy storage systems.

Project 2: Dye-sensitized solar cells (DSSCs)
This is one of the latest promising solar photovoltaic (PV) technologies, focused on the design of solar cells that are light, inexpensive, transparent, and have the potential of achieving desirable efficiencies. The DSSCs are assembled and their electrochemical properties measured. The investigation is aimed toward identifying inexpensive and abundant dyes which allow for an efficient solar-to-electrical energy conversion.

Project 3: Batteries for biomedical applications
Batteries can be used as power sources for motorized wheelchairs, surgical tools, cardiac pacemakers and defibrillators, dynamic prostheses, sensors and monitors for physiological parameters, neurostimulators, devices for pain relief, iontophoresis, electroporation, and related devices for drug administration. Students investigate the types of battery chemistries used for biomedical applications and test their properties by using instrumentals such as potentiostats/galvanostats.

Students should possess basic understanding of concepts related to mechanics and electromagnetism, typically acquired in courses such as College Physics I and II, although a strong passion for science research is more than enough.

Research could be in-person lab at Benedictine University along with virtual consultations.

Name of Mentor: Amartya Chakrabarti, Ph.D.
Institution: Dominican University
Department: Nanotechnology

Nanotechnology deals with development, characterization, and application of nano-dimensional materials in diverse fields including energy, electronics, space, and medicine. Two-dimensional

(2D) nanomaterials are emerging as materials of immense interests due to their unique electrical, thermal, and mechanical properties. Among a variety of 2D nanomaterials, graphene, hexagonal boron nitride, and many transitional metal sulfides are particularly useful in energy applications. Chakrabarti's research is focused on developing methodology to synthesize 2D metal sulfide-based nanomaterials using a hydrothermal route. Hydrothermal synthesis involves high pressure synthesis of crystalline materials in aqueous medium. The influence of incorporating surfactant molecules in the reactant mixture and variation of polarity of the solvent system on product morphology is currently being investigated in Chakrabarti's research laboratories.

Name of Mentor: Álvaro Castillo, Ph.D.
Institution: Elmhurst University
Department: Chemistry & Biochemistry

i. Please share a description of the research project the student will work on.

Creating a 3D Reactivity Map of CO_2

Climate change due to increased levels of CO_2 in the atmosphere is a clear and present danger. Current remediation techniques rely on its capture and storage. If done at the source, the aim is to prevent it from entering the atmosphere. If done away from its origin, the goal is its removal from the atmosphere to be stored elsewhere. Both techniques fail to add value to the resulting CO_2-capturing agent composites. Moreover, they also fail to allow for the recycling of CO_2.

This project aims to create a three-dimensional map that describes the reactivity of CO_2 versus both electron rich (nucleophiles), and electron deficient (electrophiles) species. Such a map could help in the design of better carbon capturing materials and promote the development of alternative remediation methods, that could add value to the processes of carbon capture or carbon sequestration.

The methodology is simple, by using a computer to solve the equations of quantum mechanics, we will calculate the reactivity of CO_2 *vs*. nucleophiles/electrophiles at different locations (distances and angles) around it. We will then use those results to construct the 3D reactivity map.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

Students should have taken general chemistry or equivalent. Preferably students should have taken organic chemistry, but it is not necessary. Facility on handling the frustrations of dealing with computers is a plus.

iii. Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).

This research can be conducted in either fashion (or both), to be decided in consultancy with the interested parties.

Name of Mentor: Duy (Zoey) Hua, Ph.D.
Institution: Elmhurst University
Department: Chemistry and Biochemistry

i. Please share a description of the research project the student will work on.

The aim of this summer project is to standardize protocols for the characterization of interactions between antigen-binding fragment (Fab) of multiple antibodies and protein A or protein G. In order to reach this goal, the student researcher will 1) purify a set of Fab proteins using column chromatography and 2) test multiple experimental conditions to establish appropriate parameters for the study of Fab-protein interaction using immunoprecipitation.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Students will receive training on making buffers, immobilized metal affinity column (IMAC) chromatography, pull-down assay and/or immunoprecipitation assay, and protein gel electrophoresis. However, basic knowledge of biochemistry (first-semester) and laboratory experience (from courses such as general, organic, and bio-chemistry) are required.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
Students will conduct lab work in person, but meetings to discuss research plan and data analysis will be on Zoom.

Name of Mentor: Evan Vanable, Ph.D.
Institution: Elmhurst University
Department: Chemistry & Biochemistry

i. **Please share a description of the research project the student will work on.**
Students would work with me on designing synthese for and making small-molecule natural products, such as Clonorosin B and Rubrolide V. These compounds are natural compounds that have been isolated from plants and shown to have anti-tumor, anti-fungal, and antibacterial properties – which makes their synthesis a priority for me so we can examine them further. Small molecule synthesis is the way organic chemists solve the issue that these complex compounds are only available in tiny quantities at great expense.

This research involves handling many organic compounds, reagents, and solvents. It is very synthesis-oriented – making compounds, problem-solving, checking purity, analyzing using instrumentation like GC-MS and NMR, troubleshooting difficulties with reagents, and using SciFinder to find prior work.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
The student must be familiar with organic chemistry (preferably through a traditional two course sequence) and the simple lab techniques of chemistry. Ideally a student would have a strong enough organic foundation to discuss organic reactions and their mechanisms with me giving a helping hand.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
This is primarily in-person research – we're going to actually be making these compounds. Some days will involve a fair amount of computer work, drawing synthetic plans, looking for reactions in the literature, etc. – but primarily we're going to be in the lab, making compounds, and learning techniques and instrumentation.

Name of Mentor: Joseph Kozminski, Ph.D.
Institution: Lewis University
Department: Physics

i. **Please share a description of the research project the student will work on.**
The main focus of this project is designing, building, and testing a low-cost suite of sensors for monitoring air quality and temperature as a part of a project to map climate impacts in Will County. Currently, the EPA has only two air quality monitoring sites in Will Country, which does not give much weight to air quality inputs to the climate vulnerability index that we are trying to compute at census tract level (census tracts are typically smaller than zip codes). Air quality is an important input since poor air quality can be directly tied to increased rates of respiratory conditions like asthma. Climate change is increasing the number of high temperature, ozone action days during the summer, which also pose a health risk to people with respiratory illness, especially those in areas with more air pollution. This suite of sensors will monitor particulate matter (PM2.5) and nitrogen oxides (NOx), which are both found in diesel exhaust and industrial emissions. It will also monitor temperature to look for heat island effects. We hope to deploy a number of these sensors throughout Will County, especially in residential urban areas along transportation corridors and near heavy industry and warehouses. The student working on this project may also take part in other climate mapping activities and community engagement.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Students should have completed an introductory physics sequence and have some experience with simple electrical circuits and electrical test equipment (e.g. multimeters). Experience with Arduinos (or Raspberry Pi) and/or programming would also be beneficial.

Name of Mentor: Kari L. Stone, Ph.D.
Institution: Lewis University
Department: Chemistry

i. **Please share a description of the research project the student will work on.**
<u>During the summer, we will focus on the development of materials with immobilized antibodies for drug delivery of cancer therapeutics.</u> The work in Dr. Stone's laboratory focuses on greener alternatives to synthetic processes and drug discovery. The Stone laboratory has also been utilizing metal-organic frameworks as potential drug delivery and therapeutics. Successful entries into biocatalytic and drug discovery processes requires both biochemical and materials chemistry skill sets making Dr. Stone's research projects highly collaborative focusing on creating new biocatalysts, drug discovery, and therapeutics. Therefore, she is looking for students with interests in biochemistry, synthetic chemistry, and materials.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**

Students do not have to have a particular skill set, but rather be eager to work in a highly collaborative environment on a project that has real-world applicability.

Name of Mentor: Sharada Buddha Ph.D.
Institution: Saint Xavier University
Department: Chemistry

i. **Please share a description of the research project the student will work on.**
Plants are nature's manufacturers of a variety of chemicals in short time to respond to environmental changes and pressures. Obesity is considered a disease of inflammation. Therefore, Anti-inflammatory effects of the total ethanolic extracts of plants used ethnopharmacologically is the Americas will be studied using the 15-Lipixygenase assay and Cyclooxygenase I and Cyclooxygenase II (COX-1 and COX-2) will be studied.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Preferred organic chemistry knowledge but not mandatory. A curios mind with scientific aptitude and interest in the topic of medicinal properties of natural products. If the student does not have any of the above, but very motivated to learn will also be considered, enthusiasm is a great motivator for learning.

Name of Mentor: Sharada Buddha Ph.D.
Institution: Saint Xavier University
Department: Chemistry

i. **Please share a description of the research project the student will work on.**
Effect of emerging persistent chemicals in the environment on human health by studying their effects on enzyme Protein Tyrosine Phosphatase 1 beta (PTP1b) which is implicated as a target in many pathways particularly with various cancers like breast cancer and prostate cancer with different outcomes for each type. The project will be studying the effects of Bisphenol-A, Chlorhexidine and Triclosan and their degradation products on the enzyme (PTP1b). The degradation products of Triclosan were identified by a summer research student of the PUMA-STEM, in 2020 by literature research (due to COVID and lack of access to laboratory) and has continued laboratory research in the following years using controlled photoreactors and analytical methods of Gas chromatography and mass spectrometry, liquid chromatography and infra-red spectroscopy.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Preferred organic chemistry knowledge but not mandatory. A curios mind with scientific aptitude and interest in the topic of "Environment and Human Health". If the student does not have any of the above, but very motivated to learn will also be considered, enthusiasm is a great motivator for learning.

Name of Mentor: Meilin Huang, Ph.D.
Institution: Saint Xavier University
Department: Chemistry

i. **Please share a description of the research project the student will work on.**

Cooperation is crucial for success. We study the emergence and evolution of cooperation in the classroom. Depending on the student's background and interests it may involve network data collection, visualization, analysis, as well as developing mechanistic understanding of how team assembly mechanisms lead to different cooperative network patterns and student performance through a model of autocatalytic networks which has implications on the origins of life.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

Students with interest or experience in one or more of the following areas will have advantage: data science, social network analysis, Python programming, mathematical modeling, evolution of cooperation.

In the past, I have worked with students in-person, completely online, or hybrid, depending on circumstances and preference. They all worked out well.

Engineering, Computer and Mathematical Sciences:

Name of Mentor: Marion Weedermann, Ph.D.
Institution: Dominican University
Department: Mathematics

Prof. Weedermann's research is in mathematical modeling with difference and differential equations. Her work reaches from establishing models to analyzing models using a variety of approaches (through computer simulations, stability analysis, sensitivity analysis). Current research interests include but are not limited to modeling the spread of the Asian carp population as well as degradation of organic waste material. Questions of interest are established in consultation and many other types of topics can be explored through modeling. Prof. Weedermann is also working on questions related to differential equations with randomly varying parameters and fundamental questions about time-varying global sensitivity analysis of differential equations. Students should have taken courses in linear algebra and differential equations to participate in this research.

Name of Mentor: Dean Jensen, Ed.D.
Institution: Elmhurst University
Department: Computer Science & Information Systems

i. Please share a description of the research project the student will work on.

Exploration of WordPress and GravityForms as a Viable Low-Code Platform

The world is changing at a fast pace and businesses need to keep up with the times in order to stay ahead of the competition. Software is integral to the way we work, play, learn, and live. As innovation increasingly takes place in the digital world, low-code application development can play a decisive role in driving these transformations. Low-code platforms enable software development with little to no manual programming

required, instead these platforms use a visual model where users can drag-and-drop components into logical sequences to create functional applications.

This research project will explore whether or not the WordPress content management system and the form-building plugin GravityForms could be utilized as a viable low-code development platform for the creation of back-end, line-of-business applications.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

Students should be technically inclined and interested in application development, specifically those applications that focus on the use of electronic forms with digital workflow, but do not necessarily have to have previous computer programming experience.

iii. Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).

This research can be conducted both online and in-person, and I am open to collaborating on it either way.

Name of Mentor: Sam Abuomar, Ph.D.
Institution: Lewis University
Department: Engineering, Computing, and Mathematical Sciences

i. Please share a description of the research project the student will work on.

In this project, data mining techniques will be employed to validate their efficacy in acquiring information about the physical properties of oceans, and/or bio-physical and mechanical properties of different materials such as nanocomposites polymers and preclinical/ clinical brain samples, from data derived from designed experimental studies. The dataset(s) that will be studied consist of different formulation and processing factors as inputs and different responses as outputs. The data analytics algorithms and techniques include visual assessment of clustering tendency (VAT), self-organizing maps (SOMs), and convolutional neural networks (CNNs). VAT algorithm can be used to help discover if there are clusters (groups) in a given dataset. SOMs will be used to extract the input(s) of the most significant effect on the output responses. CNNs will be applied on the dataset to estimate the associations between different dimensions and input parameters with some of the dynamic responses in the dataset under certain conditions. Most importantly, the student should be able to use the results from data mining as either a proof of concept of previous theoretical studies related to the studied dataset(s) or as a new knowledge that has not been discovered a priori. This work will highlight the significance and utility of data mining in the context of informatics and knowledge discovery.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

Accepted student(s)is/are preferred to have basic computer programming skills. The student is free to use any programming environments (platforms) of his/her choice such as Python, R, Java, C++,...etc.

Name of Mentor: Amanda Harsy, Ph.D.
Institution: Lewis University
Department: Math as part of Engineering, Computing, and Mathematical Sciences

i. **Please share a description of the research project the student will work on.**

Applying Linear Algebra to Sports Analytics

Answering "who is #1" and predicting the final ranking of sports teams can be a challenging task and using straight win percentage can be misleading at times. Among the many mathematically inspired sports ranking systems, linear algebra methods like Markov Chains and the Massey and Colley methods are among the most elegant and simple. These systems involve setting up and solving a matrix system. While at their most basic level, these methods are useful for sports rankings, unfortunately, they are not particularly strong at predicting future outcomes of games. One way to improve these methods for ranking and predicting future outcomes is by introducing weights to these systems. This research involves collecting sports data and adding and testing features and weights to modified linear algebra and probability-based models. The student researcher has the freedom to choose their own sport and research questions and past students have explored questions dealing with hockey, baseball, softball, and golf.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**

This research also often involves writing programs to construct huge systems of equations, so some programming experience is helpful, but by no means necessary.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**

Last year I met with students once a week in person and 2-3 times a week remotely through zoom/discord and used Overleaf to help my student research teams collaborate. It worked really well. I expect this research will be done with a mix of in-person and remote meetings. There are many opportunities for student researchers to present their work at LSAMP and Math conferences. My last PUMA STEM researcher presented at the fall LSAMP conference and will be presenting at a math conference in Seattle in January.

Name of Mentor: Amanda Harsy, Ph.D.
Institution: Lewis University
Department: Math as part of Engineering, Computing, and Mathematical Sciences

i. **Please share a description of the research project the student will work on.**

Project 2: Mathematical Modeling of DNA Self-Assembly

Self-assembly is a term used to describe the process of a collection of components combining to form an organized structure without external direction. By modeling complexes with discrete graphs, efficient self-assembly of nanostructures becomes a mathematical puzzle which can be solved using methods from undergraduate mathematics. This research will apply techniques from graph theory and algebra to various graph families to help design optimally created nanostructures. The

unique properties of double-stranded DNA molecules make DNA a valuable structural material with which to form nanostructures, and the field of DNA nanotechnology is largely based on this premise. These nanostructures have wide-ranging applications, such as containers for the transport and release of nano-cargos, as templates for the controlled growth of nano-objects, and in drug-delivery methods for cancer treatment.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

This research can be introduced to students with little mathematical background. It involves basic graph theory and depending on the student's background and interests may also involve programming, computer graphics, art, biology, and geometry.

iii. Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).

Last year I met with students 3 times a week remotely through discord and used discord and Overleaf to help my student research teams collaborate. It worked really well. I will be open to doing something similar this upcoming summer or meeting with students with a mix of in person and remove meetings. There are many opportunities for students who conduct this research to present their research at LSAMP and Math Conferences. My researcher from 2021 is presenting her work in Seattle in January.

Name of Mentor: Amanda Harsy, Ph.D.
Institution: Lewis University
Department: Math as part of Engineering, Computing, and Mathematical Sciences

i. Please share a description of the research project the student will work on.

Project 3: Analyzing the Impact of Alternative Assessments on Student Anxiety and Attitudes about Mathematics and Learning

As educators, it is important to recognize that our assessment methods affect student attitudes. If we want students to learn from their mistakes and counteract a fixed-mindset of learning, perhaps we should look at what we incentivize in the classroom. One way that professors are attempting to counteract math anxiety, poor STEM retention, and a fixed-mindset of learning is through using and researching alternate assessment models. In several of these models like "growth-based grading," “standards-based grading,” and “mastery grading,” students are given problems in which they can only receive full credit for the problem after they demonstrate mastery of the concept being tested. Each test includes similar questions over the same concepts from previous tests which allows students who have not mastered an idea to retest and reevaluate old concepts. In this research we analyze qualitative and quantitative data from classes using these alternate grading methods and compare it to classes using more traditional assessments.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

This research involves some statistical analysis and data analytics and is appropriate for students who have taken a statistics class or data analytics class. Students involved in this research must complete an online CITI training which provides foundational training in human subjects research and includes the historical development of human subject protections, ethical issues, and current regulatory and guidance information.

Name of Mentor: Brittany Stephenson, Ph.D.
Institution: Lewis University
Department: Engineering, Computing, and Mathematical Sciences

i. **Please share a description of the research project the student will work on.**
Infectious disease models can provide detailed insight into the transmission dynamics of pathogens and, thereby, facilitate the evaluation of disease surveillance, control strategies, and their effectiveness. With the onset of the COVID-19 pandemic, disease modeling and its impact have been brought into the forefront. Using mathematical models, together with appropriate parameter values, we can simulate outbreaks in order to predict emerging behaviors, assess the impact of intervention strategies, and support decisions for disease control. Mathematical models come in a variety of forms; for example, they can be either deterministic or stochastic and either discrete or continuous. Oftentimes several different forms are used to model the same disease, where each model type may focus on a distinct aspect of disease spread. In this project, students will work on developing and/or improving an existing model of the spread of COVID-19, *Clostridioides difficile* infection, or another infectious disease of their choosing. After the model is developed, students will run simulations and use the resulting output to draw conclusions about how best to prevent the spread of the disease.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Interested students will need to possess the mathematical maturity to analyze and/or create mathematical models, so the student should have at least completed Calculus I. Differential equations, Calculus II, and/or mathematical modeling experience would be an added bonus but is not necessary for success with this project.

This project will involve coding. Much of the work will involve understanding and modifying existing code, and there will be less of an emphasis on writing code from scratch unless the student has a desire to do so. Therefore, a student with little coding experience could succeed as long as he or she is willing to work hard and put in the necessary time.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
This project can be completed online through Zoom meetings and/or in-person meetings.

Name of Mentor: Cara Sulyok, Ph.D.
Institution: Lewis University
Department: Engineering, Computing, and Mathematical Sciences

i. **Please share a description of the research project the student will work on.**
Mathematical modeling and analysis is a useful technique to describe dynamics happening within events and allows one to address questions and test hypotheses that may be not be feasible to study in reality. This project uses a mathematical model to quantify the role that environmental pathways play in the transmission of disease in healthcare settings.

Clostridioides difficile (*C. difficile*) is one of the most frequently identified healthcare-acquired infections in United States hospitals. Colonized patients, both symptomatic and asymptomatic, shed *C. difficile* endospores that can survive for long periods on surfaces outside the host and are resistant to many commonly-used disinfectants. Transmission pathways can include contact with endospores on fomites, objects likely to carry infection. This project investigates the relative contribution of environmental pathways to *C. difficile* transmission in healthcare settings.

Students will work to improve a model of the spread of *C. difficile* or extend the existing model to another disease. Models may either be a system of ordinary differential equations or stochastic algorithms. Students will simulate the model and use the results to examine the role surfaces with varying touch frequencies contribute to patient colonization in healthcare settings. Using model analysis, work can be completed to identify the best method to reduce disease spread.

ii. Please share any necessary qualifications or skills students should have for your research project, if any.

Students should have taken at least Calculus I. Students' background and interests may involve applied mathematics, mathematical modeling, programming, biology, and epidemiology. Students do not need any background in mathematical modeling or programming to begin work on this project.

iii. Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).

I would plan to meet with my research student three to five times per week over the course of the research period. Ideally, these meetings with occur in person, but depending on student needs, I would be willing to host the meetings completely online or a combination of in person and online. Students would be expected to make progress between faculty mentor meetings.

I was involved in a similar research program as an undergraduate and found regular meetings with my faculty mentor invaluable. By checking in with my research mentor daily, it helped me remain on track to successfully complete my research goals by the end of the summer program. I aim to provide the same experience for my research students.

Name of Mentor: Piotr Szczurek, Ph.D.
Institution: Lewis University
Department: Engineering, Computing, and Mathematical Sciences (ECaMS)

i. Please share a description of the research project the student will work on.

TITLE: Analyzing the Influence of Reddit Posts on the Volatility of the Stock Market

In this project, students will analyze data gathered from the Reddit platform and stock market APIs in order to determine how reddit posts can influence the stock market volatility. This project has been inspired by the GameStop (GME) event, in which posts done by reddit users on r/wallstreetbets seemingly increased the stock price of GME significantly beyond what the company is worth. The stock price eventually fell and then increased again. This effect has been noticed in a number of other companies, such as Hertz or AMC, which are now referred to as "meme stocks". The goal of this project is to quantify the effect that reddit users have, and to determine whether volatility in stocks can be predicted from observing reddit forums. Currently, at Lewis University, our Data

Science and Artificial Intelligence Lab (DataSAIL) has implemented a database system to gather, process, and query data from reddit and a stock market API. The student would be tasked with performing a survey of existing approaches to this problem, querying the database to retrieve needed data, compute descriptive statistics using a software package or programming API, and develop and compare predictive models (using existing software). The project will involve some programming and some statistical analysis.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Students should have some programming experience (Python is preferred). Prior coursework in probability, statistics, or data science is recommended.

iii. **Please provide information on how you plan to conduct research over the summer with a research student (online, in person, or both).**
This project can be completed online through Zoom meetings.

Name of Mentor: Dr. Fadi Wedyan
Institution: Lewis University
Department: Computer and Mathematical Sciences

i. **Please share a description of the research project the student will work on.**
The concept of using design patterns is popular and encouraged by the academia. In software engineering, it became part of related courses in educational institutes. This trend gave developers the necessary understanding to use design patterns when they recognize a problem where a pattern solution applies. The expectation, consequently, would be that design patterns instances can be found everywhere.

Experimental software engineering is a part of software engineering that focuses on experiments involving software systems (software products, processes, and resources). The purpose of these experiments is to collect data that can be used as the basis of theories about the processes involved in software engineering (theory backed by data is a fundamental tenet of the scientific method).

In empirical studies that evaluate design pattern, which are performed mainly for measuring their effect on software quality, researchers usually evaluate two types of software. The first type includes software with documented instances of design patterns. For example. the P-Mart repository5 contains nine systems with metadata about the instances of design patterns. The P-Mart repository contains popular software that are used in studying design patterns such as JHotDraw, eclipse, and JUnit. By using software with documented patterns, researchers do not have to detect or mine the software for instances of the studied patterns. Moreover, it allows comparison of results from different studies. The second type include software with no information about used design patterns other than comments in the source code that developers might had provided. Here, researchers need to use pattern mining tools to locate instances of design patterns.

Despite having these evaluation studies, the majority of them do not target programs used in the industry. In this project, we aim at performing an empirical study to evaluate the popularity of design patterns, by which, we mean which design patterns are used frequently to solve pattern intended problem. Moreover, we investigate in which software components design patterns are used more, whether the size of software is related to

the use of design patterns, and whether the domain of the software has an influence on design patterns usage.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Accepted student(s) should have good programming experience (Java programming will be required for the project). Student should also have the ability to learn how to use software engineering tools for mining design patterns, or develop scripts for mining using Python or R.

Name of Mentor: Imad Al Saeed, Ph.D.
Institution: Saint Xavier University
Department: Computer Science

i. **Please share a description of the research project the student will work on.**
With the current rise of cybersecurity attacks, business and individual data has been breached more than ever before. Phishing attack is one of the most common types of social media attack aimed to steal users' sensitive information. This attack normally happened when an attacked tricked a victim into an email, instant messages, or text messages that contains a link which can lead to installing a malicious software on their computers may lead to harm their computers or reveal sensitive information. The main goal of this research is to investigate various scenarios of the phishing attack, simulate them using Kali Linux software, and find effective and efficient ways avoid them and prevent them from happening.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
No specific qualifications or skills will be required.

Name of Mentor: James Vanderhyde, Ph.D.
Institution: Saint Xavier University
Department: Computer Science

i. **Please share a description of the research project the student will work on.**
Three-D virtual worlds are easily accessible with new hardware technology for virtual reality. VR allows a user to move and view in 3D. This creates the opportunity for exploring new possibilities for education in computer science, science, and math. We will use the Unity game engine to design and build an app for Oculus Quest that science novices can use to explore new topics. We will also test and add features to existing VR environments used for STEM learning.

ii. **Please share any necessary qualifications or skills students should have for your research project, if any.**
Some programming skill will be helpful, but the faculty mentor will help.