



The UNIVERSITY *of* OKLAHOMA

FYRE

First-year Research Experience

**Mentor List and Research Catalog
2024–2025**

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Table of Contents by Mentor – Biological Sciences (Biology, Microbiology, Plant Biology)

McCarthy, Heather

My lab studies how trees and other plants respond to environmental stress, including global change factors, like drought, increased temperatures, and urbanization. Our work takes place in field sites, greenhouses, and sometimes the lab. We have several ongoing projects that students might be interested in working with us on: Switchgrass anatomy – Switchgrass is a potential future biofuel source, but the efficiency of conversion to fuel depends on cell characteristics and chemical composition. We are interested in assessing possible differences in anatomy of plants with reduced lignin composition for plants grown under water stressed conditions. Urban forest condition and composition – Urban vegetation provides many ecosystem services, but urban conditions (increased temperatures, sometimes decreased water) can be stressful for plants, especially in Oklahoma. We have long term monitoring of growth and survival of public trees in the OKC/Norman area. Bur oak genetic diversity – Oaks very commonly hybridize with other species, possibility introducing new traits that may be useful in a changing climate. We have established 3 “common” garden environments using bur oak seedlings from across a temperature gradient, where we can investigate differences in adaptive traits such as drought resistance.

[Growth and Survival Rates of Norman Parks Trees Over the Past 10 Years](#)

Stein, Laura

[The Impact of Dietary Niche Variation in Three Pupfish Species on 11KetoTestosterone Levels and Behavior in Periods of Low Resources](#)

Woodruff, Gavin – <https://gcwoodruff.github.io>

The Fig Worm Lab at the University of Oklahoma aims to understand the genetic basis of phenotypic diversity across multiple scales of biological organization. We are driven by these questions: • How does genetic change lead to change in developmental processes? • How does developmental variation promote morphological variation? • What are the processes that generate and maintain genetic diversity in the first place? We currently have ongoing projects in: • The evolution and genetic basis of body size • The evolution and genetic basis of developmental rate • The evolution of transposable elements and genomic organization • Nematode diversity and ecology • Host-microbe interactions • Gene copy number variation • Phenotypic plasticity and polyphenism Our projects often involve nematode husbandry and genetic crosses, as well as PCR and gel electrophoresis. We also offer opportunities in genomics/computational biology. Please don't hesitate to reach out if you have further questions (gcwoodruff@ou.edu). Here is our website: https://gcwoodruff.github.io/research_interests.html

[Dominance of Nok4 Gene: Body Size Expression in F1 Prodigy of NKZ35xWOU12 Cross](#)

Hung, Keng-Lou James – <https://hungpollinatorlab.weebly.com/>

We have several projects ongoing that revolve around studying plant-pollinator interactions and pollinator conservation. Students may have the opportunity to work on analyzing pollen samples (including setting up artificial intelligence systems for pollen identification), curating and identifying pollinator specimens, and rearing native plants and wild bees (that do not generally sting humans).

[Examining Bee Visitation Patterns in Oklahoma through Flower and Bee Pollen Samples](#)

Table of Contents by Mentor – Biological Sciences (Biology, Microbiology, Plant Biology)

Becker, Daniel

[Genetic Diversity of *Bartonella* in Vampire Bats from Belize](#)

Yoon, Je-Hyun – <http://www.molecularultrasound.com>

Synthetic biology - CRISPR screening, contrast agents; Imaging / signal processing - ultrasound imaging manipulation; Transducer fab- single element transducer fab

[Measuring RNA Stability with 5-EU and its Implications](#)

Ethridge, Lauren – <https://babl.oucreate.com/>

Research in the lab is highly collaborative, with a large network of investigators across the country. Current research includes: EEG as a translational, treatment sensitive, biomarker in rare genetic disorders associated with autism and intellectual disability, including Fragile X Syndrome and Phelan-McDermid Syndrome Sensory processing disorders Characteristics of EEG activity related to variation in ASD symptoms across the full spectrum Neural correlates of child well-being and adverse childhood experiences

[Examining How Parent-Child Interaction Therapy Enhances Parent and Child Outcomes in Families with Child Maltreatment
Studying the Effects of Free Play on the Wellbeing of 1st-5th Graders](#)

Mooers, Blaine – <https://medicine.ouhsc.edu/academic-departments/biochemistry-and-physiology/faculty/blaine-hm-mooers-phd>

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 in a structure determination project with X-ray crystallography. Over the past three decades, many labs have put much effort into developing crystal screening experiments. These screening experiments usually 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 large crystals would enable new science and advance medicine. My lab is developing advanced experimental designs that are more efficient and effective than the standard practice. This Fyre project involves extending this work to test its generalizability. This project involves basic biochemistry laboratory skills, including preparing buffers and solutions and the setting up of crystallization experiments. The project includes making images of the crystals with a microscope and measuring the lengths of crystals. The project requires the recording of observations in spreadsheets and the running of R and Python statistical software scripts to analyze the data. However, the student does not need any programming experience.

[Experimental Designs to Grow Larger Crystals of RNA](#)

Fornelli, Luca

[Saccharomyces cerevisiae Culturing, Spheroplasting, and Lysing for Top-Down Proteomic Analysis](#)

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Schroeder, Susan – <https://www.ou.edu/cas/mpbio/people/faculty/schroeder>

RNA viruses are master manipulators of gene expression. The Schroeder lab explores the role of RNA structure in regulating gene expression in virus-host interactions. We are particularly interested in the ways that viruses can sometimes be beneficial to their host and collaborate for survival during environmental stress. We study Tobacco Mosaic Virus in tomatoes and the effects of drought, influenza virus in human lung cells and the effects of smoking, and Sindbis virus in human cells and the effects of nucleotide modifications. Undergraduate researchers in the Schroeder lab gain practical lab skills in plant care and cultivation, plant infection techniques, RNA sample preparation from plant tissue, PCR, gel electrophoresis, bioinformatics analysis, and nanopore sequence analysis.

[Investigating the Role of Heparin for Sustained Drug Release via Hydrogel](#)

Katharine Marske – <https://kamarske.org/research>

I am looking for a student who is interested in using ecological models of species' geographical ranges, or where in space they occur, to explore questions in ecology and evolution. The research would be data/computationally focused and would involve finding data on where species have been detected (e.g., from museum specimens or public sightings) and using these to model the species' ranges past, present and future ranges using climate data.

Julie Van De Weghe – <https://www.juliecvdw.com/>

My laboratory is focused on cilia and cilia-related diseases. We incorporate human genetics, genome engineering, live-cell microscopy, super resolution microscopy, and real time signaling assays in our studies. We work with human cells and the green algae, *Chlamydomonas reinhardtii*. Prospective undergraduate students will be paired with a senior doctoral student or postdoctoral fellow. Depending on the students' interests, we will formulate an appropriate project for the semester.

Lanier, Hayley – <http://lanierlab.org>

My lab studies how mammalian population are responding to changing climates and habitats. This can include shifts related to organismal distributions (e.g., ranges) and adaptation of existing populations. Currently, we're interested in understanding the distribution of cryptic (i.e., difficult to identify) species, and we're hoping to use both morphological (i.e., skeletal features and hair) and molecular (i.e., DNA) tools to identify several difficult species from Oklahoma prairies. Understanding both the range limits and relative abundance of these species will help us understand how each is responding to climatic and habitat changes.

Huang, Liangliang – SCBME

Qin, Wei – <http://www.qinweilab.com>

I have two projects seeking undergraduate assistance. The first, recently funded by the NSF Biological Oceanography program, focuses on the effects of ocean warming on trace metal utilization by marine nitrogen cycle microorganisms. The second project, recently funded by the Department of Energy, investigates the interactive effects of warming and altered precipitation on soil nitrogen cycle microorganisms. Students will participate in lab research alongside graduate students and postdocs on either project. They will learn how to prepare growth media, cultivate enrichment and pure microbial cultures, measure nutrients and cell abundance, collect field samples, and gain basic bioinformatics skills. There may also be an opportunity to participate in a one-month scientific cruise from Seattle to Hawaii next summer.

Table of Contents by Mentor – Biological Sciences (Biology, Microbiology, Plant Biology)

Xiao, Xiangming – <https://www.ceom.ou.edu>

My research group analyzes time series images from various satellites to (1) identify and track land use and land cover changes, e.g., urban, road, surface water, forest, grassland, and croplands, and generate land cover maps; (2) measure leaf phenology and floral (flowering) phenology of plants; (3) identify fire, tree logging, and plant diseases, (4) identify plant species and biodiversity. We also measure carbon/water/energy fluxes using micrometeorological methods and analyze and model carbon and water fluxes of various terrestrial ecosystems. In addition, I teach Environmental Remote Sensing course (PBIO 4733 and GIS 4733) in spring 2025, thus students can take the course to learn remote sensing technology and data analyses.

Gu, Tingting

Research statement: Microplastics (MPs) are polymeric contaminants ranging in size from 1-5000 microns. They originate from the physical and chemical decay of polymers used in every aspect of modern life. Over the past 70y, the estimated total mass of plastics produced is > 9.1 billion tons. MPs have been found throughout the hydrosphere, atmosphere, and soil. Moreover, MPs are detected in living organisms, including humans, who ingest and inhale MPs present in food, beverages, water, and air. MPs are a pervasive, persistent, and highly heterogeneous contaminant varying in size, morphology, and chemical composition. MPs can absorb organic chemicals, heavy metals, bacteria, and viruses, thereby making MPs a transport vector for these contaminants. It is also known that these physical, chemical, and microbial parameters can cause MPs to detrimentally target specific ecological or biochemical processes. To assess MP risks to the extent where prevention and remediation efforts can be designed and implemented, the MP research communities need to address two challenging issues. The first challenge is MP detection. The lack of standardized extraction methods for MPs in complex samples and the need for a high-throughput analytical method for quantitative characterization of MP concentration, size, morphology, and composition. To address this challenge, Dr. Gu is currently developing a new high-throughput, cost-effective method with proper QA and QC standards for MP detection and monitoring. The second challenge is understanding the mechanisms and processes of biological effects, transport, and degradation of MP through different environments. Gu's lab is currently studying the effects and transportation of MPs in soils, particularly through biosolid application. This is a collaborative work with Dr. Mark Nanny from the Civil Engineering and Environmental Science at OU.

Cai, Jiyang – <https://medicine.ouhsc.edu/academic-departments/biochemistry-and-physiology/faculty/jiyang-cai-phd>

Our lab investigates immune cell interactions in the back of the eye, primarily using mouse models of eye diseases. We offer training for students in foundational eye research techniques, including in vivo eye examinations, microdissection, and tissue preparation. Students will also have the opportunity to contribute to our ongoing projects, which are detailed on our website.

Ketchum, Heather

Arthropod vector-borne diseases have more than tripled between 2004 and 2016. More than 60% of these cases were tickborne. In Oklahoma, 90% of our vector borne diseases are caused by ticks. Since most tickborne diseases are caused by tick bites, reducing exposure is the best defense against tickborne diseases. There are only six EPA registered insect repellents recommended by the Center for Disease Control. Of those, N,N-diethyl-3-methyl benzamide (DEET) a synthetic chemical is the most commonly used however, its effectiveness varies across species, the duration of efficacy is no more than six hours, and there are concerns among the public about toxic effects. Other recommended natural or synthetic repellents have repellent properties and while they may repel ticks their duration of effectiveness is limited to one to two hours. With the lack of effective repellents and increase in tickborne diseases there is an increased interest in investigating novel natural products for tick repellency. The objective of the current study is to evaluate the repellent activity of two natural products for control against cayenne ticks.

Table of Contents by Mentor – Biomedical Engineering

Clegg, John – <https://www.ou.edu/coe/sbme/people/clegg>

The Clegg laboratory studies biomaterials for induction of therapeutic immune response or reprogramming of the immune response (e.g., re-directing immune cells from inflammatory activity to more tolerogenic or regenerative states). We are particularly interested in applying immune-instructive biomaterials as new treatments for neurotrauma, inflammatory brain injury, and stroke. In the FYRE project, the student will either (1) synthesize immune-instructive nanomaterials, studying how macrophages incubated with those nanoparticles change their expression of cell surface / intracellular antigens or secretome. (2) Development of scaffolds for therapeutic macrophage delivery, which sustain a therapeutic phenotype in adoptively transferred cells even in the presence of oppositely-polarizing soluble cytokines. All projects will include elements of the following technical skills: polymer synthesis, cell culture, flow cytometry, microscopy, as well as the following other skills: data/image analysis, statistics, technical writing, and poster preparation.

[Investigating the Role of Heparin for Sustained Drug Release via Hydrogel](#)
[Using Dynamic Light Scattering to Test Nanoparticle Samples: Measuring Cell Size and Zeta Potential](#)

Tang, Quinggong – <http://tanglab.oucreate.com/>

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 on 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.

[Evaluation of Repurposing Anti-Parasite Drugs for Ovarian Cancer from Cell to Animal Level Using Optical Coherence Tomography](#)

Wilhelm, Stefan – <https://www.wilhelm-lab.com/>

The Wilhelm Lab in the Stephenson School of Biomedical Engineering focuses on the medical application of nanotechnology to diagnose and treat diseases, including cancer and infectious diseases. As a member of the Wilhelm Lab, students will learn nanoparticle synthesis, characterization, and surface engineering methods to fabricate nanomaterials, such as gold and lipid-based nanoparticles, for biomedical applications in nanomedicine. These applications typically involve cell studies with various cell lines under sterile culture conditions. Research goals include the study of so called nano-bio interactions, and evaluating the safety and efficacy of nanotechnology-based system for drug delivery and diagnostics. Students will engage with experienced undergraduate students, graduate students, and postdocs in the Wilhelm Lab. State-of-the-art equipment will be used to conduct and perform the proposed research. Students will further have an opportunity to develop their oral and written presentation skills and participate in weekly research project update meetings to learn about the full spectrum of nanomedicine research conducted in the Wilhelm Lab.

[Quantitative Analysis of PLGA Nanoparticles Produced by Microfluidic Synthesis](#)
[Manipulating Fluidic Mixing Techniques to Optimize Liposome Synthesis](#)
[Three-Dimensional Super-Resolution Microscopy-Based Imaging of Cancer Spheroids](#)

Table of Contents by Mentor – Biomedical Engineering

Yuan, Han – <https://scholar.google.com/citations?hl=en&user=GCB4m6sAAAAJ>

Functional Magnetic Resonance Imaging (fMRI) provides unique opportunity to measure neural activity at fine spatial resolution in the human brain. The imaging modality has important clinical applications in the planning of neurosurgery. In the FYRE 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. Functional Magnetic Resonance Imaging (fMRI) provides unique opportunity to measure neural activity at fine spatial resolution in the human brain. The imaging modality has important clinical applications in the planning of neurosurgery. In the FYRE 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.

[Multimodal Imaging with Transcranial Magnetic Stimulation in the Human Brain](#)

Table of Contents by Mentor – Chemical Engineering

Foudazi, Reza – <https://foudazi-lab.com/>

There are 2-3 undergrad positions available in Soft Matter Research & Technology (SMaRT) group. The 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. Some examples of available projects are as follows: 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.

[Interfacial Behavior of Aqueous PFAS Solutions During Droplet Pinch-Off](#)

Grady, Brian – <https://coecs.ou.edu/Brian.P.Grady/index.html>

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. Also, Dr. Grady will be the one who supervises the student.

[Effect of Temperature on Contact Angle of Liquids on Particulates](#)

Papavassiliou, Dimitrios – <https://www.ou.edu/coe/scbme/people/faculty/papavassiliou>

The goal is to simulate the photothermal treatment for cancer tumors. The process is as follows: Carbon nanotubes are selectively attached on cancer cells, and a small amount of energy is radiated to them (for example, a laser beam). They get heated up, and as they do so they heat up and kill the tumor cells. The project is computational, using simulation tools. No prior computing experience is required.

[Studying the Stress Experienced by a VWF Protein in Hydrodynamic Flow Using Coarse Grained Simulations](#)

Table of Contents by Mentor – Chemistry

Bourne, Christina – <https://bournelab.oucreate.com/>

Structural biology explains how biochemistry works.

[Purifying Pfu DNA polymerase for Polymerase Chain Reactions](#)

Dong, Yitong – <https://www.donglabou.com/>

The Dong Group's research is focused on colloidal nanocrystal quantum dots, the materials that win the 2023 Nobel Prize in Chemistry. Our projects include development the synthesis of colloidal perovskite quantum dots, understanding their growth mechanisms, surface chemical modifications of perovskite quantum dots, and spectroscopic study of the quantum dots at the single particle level. The goal of our projects is to develop scalable and high-fidelity single photon light sources for the next generation photonic based quantum computing and quantum information sciences. Specifically, we will chemically synthesize lead halide based perovskite quantum dots with sizes tunable from 3 nm to 7 nm. Using an unique thermodynamic equilibrium control synthesis, we are targeting on making perovskite quantum dots with their size and shape precisely controlled at nearly the atomic level. Our powerful single particle fluorescence microscope will be used to study the impact of size and shape of a quantum dots on its single photon emission properties. Our research projects combine chemistry and physics and are highly interdisciplinary. Leveraging our synthesis development, we will also grow organic crystals on the surface of the inorganic perovskite quantum dots to rigidify their surface lattice. We will then understand the effect of lattice rigidity on the single photon emission coherency, promoting the development of quantum emitters.

[Synthesis of manganese-doped cesium lead chloride nanocrystals through the hot-injection method](#)

[Synthesis of Formamidinium Lead Halide Perovskite Nanocrystals on a Liquid-Liquid Interface](#)

[Using Spectroscopy to Understand CsPbBr₃ Quantum Dots as Single Photon Emitters](#)

Feng, Yuanning – <https://yuanningfeng.wixsite.com/website>

On account of the scarcity of molecules with a satisfactory second near-infrared (NIR-II) response, the design of high-performance organic NIR photothermal materials has been limited. Organic photothermal materials have been discovered as some of the most promising photothermal agents with economical cost, improved biocompatibility, and potential biodegradability. Cocrystals are obtained typically by the self-assembly of two alternative molecular building blocks, i.e., an electron-rich donor (D) and an electron-poor acceptor (A). Attributed to the adjustable energy gaps, solvent processability, and easy recyclability as a type of crystalline materials, cocrystals present bright prospects in the fields of field-effect transistors, ferroelectricity materials, dynamic photomechanics, and nonlinear optics. Because the energy absorption and transfer can be adjusted through changing their constituting components, cocrystals have been applied in photothermal conversion. FYRE students will contribute to the synthesis and characterization of donor and acceptor compounds which are small organic molecules.

[Synthesis of a 5-membered Cyclophane](#)

[Supramolecular Antenna Effect in Fluorescent Dyes](#)

[Synthesis of the Pentagonal Cyclophane](#)

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Honeycutt, Wesley & Mistree, Farrokh – <https://www.ou.edu/coe/ame/people/faculty/farrokh-mistree> AND <https://scholar.google.com/citations?user=corYfz4AAAAJ>

UNDERSTAND RESEARCHING BY REFLECTING ON DESIGNING A LOW-COST, SMART COMPOST SYSTEM This project is open to Honors students who have a social conscience and wish to make a difference in the world by researching and sharing their newfound knowledge. Questions for Reflection 1 Do you wish to learn what researching is about? 2 Do you wish to learn how to identify gaps in that which exist and bridge that gap for the betterment of society? 3 Do you enjoy exploring the internet, talking to ChatGPT, Microsoft Copilot, and equivalent to find information? 3. Do you wish to develop your ability to communicate your findings to a range of people? 4. Are you willing to be pushed outside your comfort zone? If the answer to any of the preceding questions is a yes - Wesley T. Honeycutt [honeycutt@ou.edu] and Farrokh Mistree [farrokh.mistree@ou.edu] are interested in mentoring you in Spring 2025. Project Description The design of a low-cost, smart compost system. Composting has the potential to reduce waste and increase the arable soil to farmers in rural India. The challenge is that compost requires certain conditions to convert to soil properly. These conditions may change depending on the composted input be it vegetable matter, meat, paper products, or even bodies. The user interactions with compost also changes based on the conditions: certain composts need turned on different dates. Expectations and Grades You will approach the design in a systematic and organized fashion. You will be required to reflect on what you have done, write Take Aways and transform these Take Aways into lessons that you will use in the future as researchers. We will meet once a week at a time that is mutually convenient to all to discuss your progress. We invite you to attend the weekly meeting of the Systems Realization Laboratory @ OU on Fridays from 9:00AM to 10:30PM. Every week you will turn in a progress report that will be discussed when we meet. Your grade will be based on an End of Semester Report, a Poster, and a Semester Learning Essay.

Honeycutt, Wesley – <https://wesleyhoneycutt.com/>

I am an interdisciplinary researcher with a very broad interest and skill set. I am not strongly affiliated with any single department. My PhD is in chemistry, and I have worked on projects in many fields. I am not a tenure-track faculty member which means I am able to commit time to ensure my student's success. Check my bio for more info: <https://wesleyhoneycutt.com> I am thrilled to work with students from any discipline, and I tailor each FYRE project to the interests of the student(s). Thus far, I have mentored 6 students through the FYRE program and am proud to advocate for each of my students beyond the time we spend together in the lab. All students learn from a holistic perspective: you will be able to do a little of everything on your project by the end. The projects I have ready for Spring 2025 includes: - Work with CO₂ and CH₄ remote sensing data for spatial and temporal analysis. - Engineering design of novel strategies at the device and system level for sustainability challenges. - Electrical engineering hands-on projects to develop new widgets like a rain-sensing actuator. - Dramatic theory applications for training future STEM communicators. - Spatial analysis of migratory birds to novel lighting cues. This list is incomplete and subject to change based on opportunities/resources which I have in the Spring and the interest of the FYRE student.

[Comparison of Retrieval Algorithms for EM27/SUN Spectrometer Data](#)

Noh, Hyunho – <https://www.nohlab-ou.com/>

With the rise in energy demand, it is critical to develop catalysts that can harness solar/wind energy and convert abundant chemicals to value-added feedstocks. While decades of research have developed some promising catalysts, their surface structures are quite complex, precluding an atomic-level understanding of the reaction mechanism. In our lab, we employ metal-organic frameworks (MOFs) as candidate electrocatalysts to examine the reaction mechanisms to generate H₂ from H₂O, CO₂ to fuels, and many others with atomic-level precision. The exact structure of candidate MOFs is known, owing to their crystallinity. Using electrochemistry as a primary tool, students will learn how to experimentally derive catalytically relevant thermodynamics and kinetics and conclude reaction mechanisms. Our lab focuses on MOFs with transition metals and even lanthanides and thus can explore a wide range of elements within the periodic table, otherwise challenging in other fields. The success of this project should instruct chemists and engineers on the exact catalytic motif we need to install to synthesize highly active catalysts and shift the energy and chemical sectors to become more renewable for a sustainable economy.

[Topology-Dependent Proton-Coupled Electron Transfer \(PCET\) Thermochemistry of Ce-based Metal Organic Frameworks](#)

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Rybenjov, Valentin – antibiotics.oucreate.com

The project explores chemical compounds with antibacterial activity that were discovered by Rybenkov group and are presently under development as potential antibiotics with a new mode of action. These compounds act by inhibiting condensins, which play a central role in chromosome organization and segregation. Bacteria can develop resistance to these through a combination of mutations in several genes. The project involves molecular cloning of one of the genes that was implicated in the resistance and investigating the phenotype of the mutant.

[Effect of DNA Binding Agents On Cell Division and Chromosome Segregation](#)

[Impact of DNA-binding compounds on chromosome segregation in *Pseudomonas aeruginosa*](#) **Saparov, Bayram** – <https://saparov-lab.com/>

Synthesis, crystals growth and characterization of brand new materials for lighting, solar energy harvesting and other applications

Rajan, Rahki – <https://www.ou.edu/cas/chemistry/people/faculty/rakhi-rajan>

The students will work on molecular biology and protein expression of components related to the CRISPR-Cas systems. They will also interact with lab members to familiarize with the lab goals of protein engineering to improve the fidelity of CRISPR-based gene editing systems.

Singh, Shanteri

The Singh Lab is interested in combining the power of biochemistry and organic chemistry to provide access to novel organic molecules. We are developing a synthetic biology pipeline for the synthesis and diversification of antibiotics and anti-cancer molecules. The techniques we use in the lab include biochemical characterization of enzymes, enzyme engineering, structural biology, and organic chemistry to access and diversify the structures of pharmaceutically relevant compounds. These efforts form an innovative and powerful platform for drug discovery. Towards these goals, our projects are designed to train students either in biochemistry or organic chemistry techniques.

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Metcalf, Justin

The student will be working in a team to learn how to use a software defined radar to look for birds, bats, and invertebrates. These are radars whose functionality is controlled by open source “blocks”, designed to be easy to use without programming knowledge. Each block provides a radar function, and these blocks are easily modifiable using the Python scripting language. This project is to help with environmental site assessment for current and future offshore wind farms. The student will need to be willing to learn Python and work with software. There will be multiple graduate and undergraduate students working with the student on the team. This project is suitable for a wide variety of majors, particularly computer science, electrical engineering, computer engineering, and biology.

[ADS-B Tracking with GNU Radio: Tracking Planes for Radar Surveillance](#)

Ebert, David – <https://www.ou.edu/disc>

We have numerous projects on data analytics, AI, and interactive visual analysis solving problems in many disciplines and across disciplines.

[Impact of SMART Machine Learning Algorithms in Classifying Social Media Misinformation and Disinformation](#)
[Modeling Carbon Dioxide Fluxes and Evapotranspiration in Grain-Only Wheat Pastures Using Weather and Satellite Data](#)

Aikaterini P. Kyprioti

Depending on the students’ interests, there are different projects that they can work. I have the ability to supervise projects that might be more computationally-driven in solving engineering problems (small uncertainty propagation projects), as well as more heavily involved civil engineering ones, focusing on specific typology of housing like mobile homes and masonry historical buildings. There is also the opportunity for students to gain some experience in software that will be useful later on in their professional career when it comes to structural software and modeling civil infrastructure.

Yijie Jiang

The project will focus on developing a dip coating and electric poling (DCEP) integrated machine. This machine will achieve the automatic and batch processing of sensor specimens to enable novel applications and performance.

Vogel, Jason

Our laboratory completes analysis of wastewater for eight different pathogens that cause infectious disease. This student would integrate into our lab and learn the process of extraction and analysis using RT-qPCR. This information is utilized by health departments across Oklahoma to track infectious disease occurrence and outbreaks at the community level.

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Kittur, Javeed [https://www.researchgate.net/profile/Javeed-](https://www.researchgate.net/profile/Javeed-Kittur/research?ev=prf_act&_tp=eyJjb250ZXhoIjp7ImZpcnNoUGFnZSI6InByb2ZpbGUlLCJwYWdlIjoicHJvZmlsZSI6InBvc2loaW9uIjoicGFnZUhlYWRIciJ9fQ)

[Kittur/research?ev=prf_act&_tp=eyJjb250ZXhoIjp7ImZpcnNoUGFnZSI6InByb2ZpbGUlLCJwYWdlIjoicHJvZmlsZSI6InBvc2loaW9uIjoicGFnZUhlYWRIciJ9fQ](https://www.researchgate.net/profile/Javeed-Kittur/research?ev=prf_act&_tp=eyJjb250ZXhoIjp7ImZpcnNoUGFnZSI6InByb2ZpbGUlLCJwYWdlIjoicHJvZmlsZSI6InBvc2loaW9uIjoicGFnZUhlYWRIciJ9fQ)

In these projects, students will design and implement innovative educational tools involving chatbots and generative AI to enhance engineering education. Project 1 focuses on creating an interactive chatbot to capture and analyze engineering students' emotions throughout the semester, exploring how these emotions impact their sense of belonging, motivation, and persistence. The student will collect both quantitative and qualitative data to assess the chatbot's effectiveness, understand students' experiences, and identify areas for improvement. Project 2 involves developing a generative AI-based instructional setup to teach the engineering design process to freshmen. With minimal guidance, students will self-learn the design process using AI. The effectiveness of this approach will be evaluated through data collection, examining students' learning outcomes and comparing their perceptions of learning with and without AI. Project 3 requires designing a chatbot to moderate role-play activities in a classroom setting, replacing the instructor in this role. The student will gather data to assess the chatbot's success, investigate its impact on students' learning, and compare perceptions of learning with and without the chatbot as a moderator. Each project aims to innovate in educational methods, combining technology and pedagogy to improve student engagement and learning outcomes.

Ghamarian, Iman

AI4Science: Our research group focuses on harnessing the power of machine learning to analyze complex experimental data, with a particular emphasis on image analysis. We develop cutting-edge supervised and unsupervised machine learning techniques to extract meaningful insights from scientific images across various disciplines. Our projects offer an exciting opportunity to apply artificial intelligence to real-world scientific challenges. While a general background in Python programming is required, you'll have the chance to enhance your coding skills and gain hands-on experience with state-of-the-art AI technologies. Join us to explore the intersection of computer science and scientific discovery!

Table of Contents by Mentor – Health Sciences

Kellawan, Mikhail – <https://www.ou.edu/cas/hes/research/research-laboratories/human-circulation-research-lab>

How humans regulate/control blood flow to the Brain and to Muscles during exercise and/or environmental challenges.

[The Effect of EDHF on the Resistance of Sympathetic Vasoconstriction In Healthy Young Adults](#)

Cai, Chanjie – <https://medicine.ouhsc.edu/academic-departments/biochemistry-and-physiology/faculty/jiyang-cai-phd>

Our lab investigates immune cell interactions in the back of the eye, primarily using mouse models of eye diseases. We offer training for students in foundational eye research techniques, including in vivo eye examinations, microdissection, and tissue preparation. Students will also have the opportunity to contribute to our ongoing projects, which are detailed on our website.

[Biophotonic Imaging Utilizing Deep Learning Techniques](#)

[Particle Deposition in 3D Printed Human Lung Model Under Realistic Physiological Conditions](#)

Balasubramanian, Priya – <https://medicine.ouhsc.edu/directory/details/priya-balasubramanian-bvsc-phd>

We have a couple of ongoing projects that the students can pick to work on: 1. Role of lipolysis in calorie-restriction mediated anti-aging benefits: Limiting daily calorie intake is one of the well-established interventions that has been proven to extend lifespan and health span in several species. One of the organs significantly affected by CR is fat tissue. Not only does CR reduce fat mass but it also changes how it functions. CR reprograms fat tissue metabolism to increase lipid breakdown and usage as an adaptive strategy to support whole-body metabolic needs during energy deficiency. These adaptive changes in fat metabolism likely contribute to the anti-aging benefits of CR. Understanding the mechanisms through which CR reprograms fat tissue metabolism and phenotype will inform strategies to maximize the health span in the elderly population. Specifically, we are interested to investigate if the breakdown of stored lipids in the fat tissue is a key initial step required for the metabolic benefits of CR. Further, we want to investigate how the products of lipid breakdown (free fatty acids) regulate functionally different subpopulations of white fat cells in CR. 2. Role of brain lipid droplets in age-related cognitive impairment: In this project, we are focusing how age-related lipid droplet accumulation in endothelial cells of the brain contribute to microvascular dysfunction, impaired cerebral blood flow responses and cognitive impairment.

Lu, Yu

My research focuses on understanding and preventing risk behaviors such as substance use and interpersonal violence. Students joining the Risk Behaviors and Intervention lab will work in teams contributing to studies that examine how these risk behaviors co-occur and progress from adolescence to adulthood and explore social and cultural factors influencing these behaviors. Students will get involved in various research activities including literature review, data analysis, result interpretation, and report writing.

Table of Contents by Mentor – Health Sciences

Cheney, Marshall

Our research team is working with researchers at the OUHSC and the University of Houston to help evaluate smartphone apps developed to help people improve their health. The 5 different apps we are currently evaluating aim to help people reduce/quit smoking, improve their mental health, reduce marijuana use, and increase adherence to HIV medications. Our role is to analyze the qualitative interviews done at the mid point and end of the intervention to see what worked (and did not work) and make recommendations for how to improve the smartphone apps. I try to give students a choice of teams but it will depend on where the teams are in the analysis process at the start of the Spring 2025 semester. The FYRE student will need to complete the Human Subjects online training by December 15th so that we can get IRB approval for the FYRE student participation. Students will receive additional training in qualitative data analysis and be involved with data analysis as a full participating member of the team at the beginning of the Spring 2025 semester. Students are included on professional presentations and manuscripts if they stay with the analysis team until the project is completed (usually an additional semester).

Li, Dan <https://publichealth.ouhsc.edu/About/Directory/details/dan-li-phd-ncc-lsc-nc-k-12>

My research focuses on mental health promotion in economically disadvantaged K-12 schools. One project I plan to initiate is a meta-analysis of factors associated with school absenteeism, particularly examining how COVID-19 may have impacted students' attendance during and after the pandemic.

Mehla, Kamiya <https://medicine.ouhsc.edu/directory/details/dr-kamiya-mehla-phd>

We will assess the role of inflammatory cells in imparting muscle wasting in pancreatic tumor bearing mice by assessing the expression of inflammatory genes using real time PCR and immunostaining.

Yoon, Je-Hyun <https://medicine.ouhsc.edu/directory/details/je-hyun-yoon-phd>

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.

Muthukrishnan, Sree Deepthi <https://medicine.ouhsc.edu/directory/sree-deepthi-muthukrishnan-phd>

The Muthukrishnan laboratory at the Department of Oncology science investigates the cellular and molecular basis of glioblastoma (GBM), an aggressive and lethal primary brain tumor. GBM is highly invasive, extensively vascularized, and 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 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.

Table of Contents by Mentor – Continued

Proietti, Tiziana <https://tizianaproietti.com>

The project is an interdisciplinary research endeavor that bridges the fields of architecture and neuroscience and takes place at the Sense|Base Laboratory based at the University of Oklahoma directed by principal investigator Tiziana Proietti. At Sense|Base we investigate human perception and experience of architectural proportion through methods of science. We ask the following questions: when is architectural proportion perceptible and discriminable to the human eye? How is the perception of proportion affected by perspective distortion? What are the effects of the experience of architectural proportion on human behavior? We consider the realistic conditions in which architectural proportion is experienced by the moving person, and how these conditions were addressed in the prior scientific literature. Then we explore how concepts and methods of the modern science of human behavior and experience can advance our understanding of proportion. To do so, we conduct psychophysical experiments in two distinguished formats: “external observation” and “immersive observation.” In the first approach, the observer is stationary and external to the observed scene, while in the second approach, the observer is either stationary or moving, immersed into the observed scene. Complementary to the psychophysical experiments we are creating a pedagogical model to train students’ perception of proportion. To do so we invent exercises and proportional tools. The research conducted at our laboratory will free studies of architectural proportion from speculative reasoning unsupported by empirical evidence. This novel research will reveal whether and under which spatial conditions architectural proportion affects perception and behavior.

Hamory, Joan <https://jhamory.oucreate.com/>

Dr. Hamory is currently conducting several data collection projects in Eastern and Southern Africa, collecting and analyzing surveys of thousands of adolescents (aged 10-19) to understand the challenges they face at home, at school, at work, and in their communities, and to evaluate interventions that seek to alleviate barriers to their economic empowerment and overall well-being. The overarching research question is to understand “what works” to boost the well-being of adolescents in contexts where educational attainment is low, girls marry and start having children young, and labor market opportunities are limited. Mentees will assist with cleaning and summarizing data for early-stage analysis.

Oxendine, Christy – Educational Leadership and Policy Studies

Lamba, Manika <https://manika-lamba.github.io>

Knowledge-Driven Text Generation: Integrating Neo4j Graph Retrieval with Language Models Project Description Retrieval-augmented generation (RAG) is a technique to search for information based on a user query and provide the results as a reference for generating an AI answer. In contrast, Knowledge Graph Retrieval Augmented Generation (Graph RAG) leverages the structured nature of graph databases, which organize data as nodes and relationships, to enhance the depth and contextuality of retrieved information. In this project, we will first build a knowledge graph interface using Neo4J using different actors from Electronic Theses and Dissertations (ETDs) metadata. Next, we will fine-tune a large language model using the RAG technique to combine structured graph data with vector search through unstructured text to achieve the best of both worlds. Expected Student Research Activities Tasks Involved: 1. Perform literature review to identify recent studies related to the project (technical and usability/query aspects) 2. Building graph schema (nodes representing entities and relationships representing connections between them) for the ETD dataset 3. Using Cypher queries to populate graph data in Neo4J 4. Build a large language model to fine-tune the entire dataset, creating references to all entities and relationships within the source data, which are then used to create an LLM-generated knowledge graph 5. Evaluate the model Prerequisite skills or experience (if any) - Python programming language - Demonstrated experience or interest in designing graph schema - Familiarity with large language models and how they work - Understanding of how to interact with external APIs or interest to learn it.

Table of Contents by Mentor – Continued

Jablonski, Michael

For thousand of years, a focal point of mathematics has been symmetry. Objects with more symmetry are considered most desirable and serve as model objects on which to build scientific theories. This spring, our group will investigate how symmetry occurs naturally in a dynamical system and ways for deforming non-symmetric objects to increase their symmetry. Activities will include: • Studying polygons and polyhedra in 2- and 3-space. • Studying curvature flows. • Proving theorems. • Experimenting with computers to build new examples and suggest theoretical results.

Carvallo, Mauricio

My research explores the influence of culture and minority status on health-related outcomes and attitudes towards the self and others.

Hodges, Caitlin www.caitlinhodges-soil.com

NASA Project: Extreme environments on Earth provide many challenges and opportunities for the development of life. Therefore, these sites may serve as good proxies for environments that support the evolution on life on Mars and other planetary bodies. In this project, we use a fieldsite in Western OK to explore the utility of novel sensors to record the activity of microorganisms in the soil and groundwater. We ultimately aim to develop a set of tools to deploy on other planetary bodies that can efficiently detect environments in which life could thrive. USDA Project: Soils are the largest terrestrial sink of carbon, and respiration by roots and heterotrophic microorganisms is the largest flux of carbon from soils. For this reason, soil respiration is a key component of the global carbon (C) cycle and represents soil's ecosystem services related to regulation of the global climate. However, land use and climate change can shift soil respiration rates and deplete soil C stocks. Further, reactions within the soil system can obscure ecosystem response to global change and confound efforts to characterize soil health. In this project, we will use both field experiments and laboratory incubations to investigate the roles of drought, nitrogen fertilization, and hay harvest in controlling organic and inorganic C cycling in soils.

Wang, Chenghao

McFarquhar, Greg <https://www.ou.edu/ags/meteorology/people/faculty/greg-mcfarquhar>

Cloud Properties over the Arctic: Cold air outbreaks (CAOs) have a big influence on weather patterns, yet their cloud regimes are poorly sampled and understood. The Cold-Air outbreak Experiment in the Sub-Arctic Region (CAESAR) field campaign used the National Science Foundation/National Center for Atmospheric Research (NSF/NCAR) C-130 aircraft to acquire in-situ and remote sensing data of clouds over the Norwegian Sea in February and March 2024. This project will use data collected by the cloud probes on the C-130 during CAESAR to determine the vertical dependence of the microphysical and macrophysical properties of clouds in CAOs, its variability and their dependence on environmental conditions.

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Characterizing interactions between *Rothia dentocariosa* and common human pathogens to determine changes in microbial physiology

Emma Land, Dr. Carolyn Ibberson, Sam Varriale

Department of Microbiology and Plant Biology, University of Oklahoma

Characterizing interactions between *Rothia dentocariosa* and common human pathogens to determine changes in microbial physiology

Emma Land, Dr. Carolyn Ibberson, Sam Varriale
Department of Microbiology and Plant Biology, University of Oklahoma

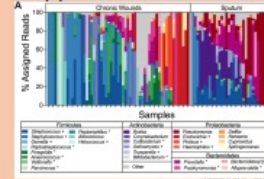


Question

Do interactions between *Rothia Dentocariosa* and ESKAPE pathogens change microbial physiology?

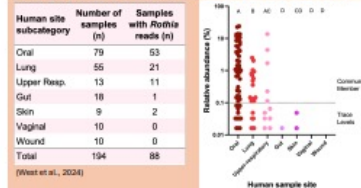
Background

Chronic Infections are a great burden on the healthcare system as treatment is costly. Oftentimes, they are resistant to antibiotics due to the variety in bacterial populations.



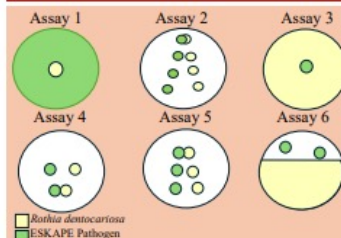
It has been shown that bacterial interactions within a chronic infection can affect a patient's outcome. However, these interactions are not well understood.

Rothia dentocariosa is a non-motile, Gram-positive, and aerobic bacteria. It has been found in the oral cavity of healthy individuals, but it has also been known to cause infections elsewhere in the body.



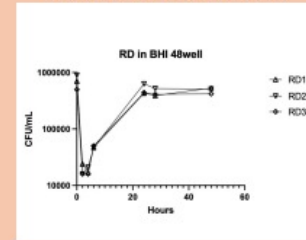
ESKAPE pathogens consist of six pathogens that are the leading cause of hospital-acquired infections. For our purposes, we used a modified panel consisting of *Candida albicans*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Bacillus subtilis*

Methods

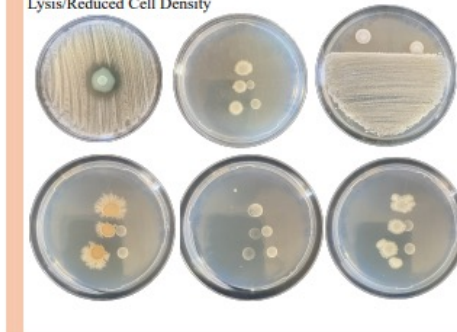


Results

Rothia dentocariosa Growth Curve



Lysis/Reduced Cell Density



Increased Growth



Exploratory Growth



What's Next

We could conduct further analysis by extracting DNA from a growth curve.

We could modify the nutrient concentrations of the media used to plate on and see how this alters the interactions.

- Already done in Assays 5 and 6 (50% and 10% BHI)

We could plate on medias other than BHI to see if modifying the types of nutrients affects the interactions between the bacteria.

- Congo Red
- SCFM2
- CWM



References

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Acknowledgements

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Growth and Survival Rates of Norman Parks Trees Over the Past 10 Years

Alexis Lund and Dr. Heather McCarthy

School of Biological Sciences,
University of Oklahoma, Norman,
Oklahoma, 73019

Growth and Survival Rates of Norman Parks Trees Over the Past 10 Years

Alexis Lund (alexis.m.lund-1@ou.edu) & Dr. Heather McCarthy, School of Biological Sciences, University of Oklahoma, Norman, OK, 73019

Motivations

- Urban forests are necessary for urban heat mitigation, improving air quality, and preserving biodiversity and must be protected¹
- Urban forests are vulnerable to many potential hazards such as storm damage, maintenance injuries sustained from lawn mowers and weed whackers, and disease

Questions

- Is species distribution in parks different between park age groups, and has it changed over time?
- How does the age of the park affect tree growth rates?
- Which tree species have the highest survival rates?

Methods

- 8 different parks were chosen across Norman based on variability in size, founding date, and location
- We measured the diameter of each tree in the park, using diameter tape and measuring at breast height
- Park conditions were noted and compared to data taken in 2014 or 2015
- We then converted the diameter to area and used these areas to calculate what the average cross-sectional tree area (basal area) is in each park now, and what it was 10 years ago
- We compared current average area with past average area in efforts to determine which parks experienced the most growth, and overall, how much growth the parks had experienced
- For comparison, we divided the 8 parks into 2 groups depending on founding date, yielding an older parks group and a newer parks group

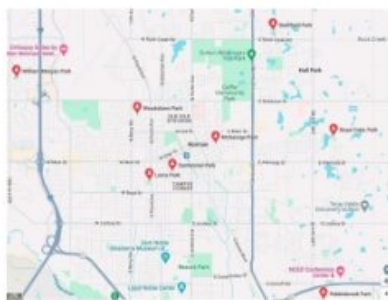


Figure 1. Map of selected parks across Norman

Results

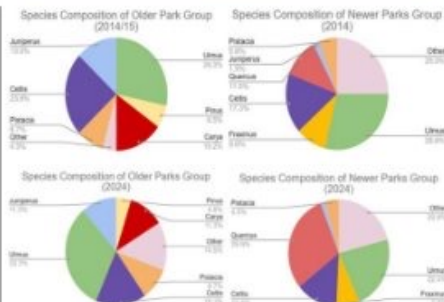


Figure 2. Species Composition Comparison between data taken 10 years ago (top) and data taken this year (bottom)

**Ulmus* (American Elm, Siberian Elm, Chinese Elm), *Fraxinus* (Ash), *Celtis* (Hackberry & Sugarberry), *Quercus* (Black Oak, Shumard Oak, Bur Oak), *Pistacia* (Chinese Pistache), *Juniperus* (Cedar), *Pinus* (Pine), *Carya* (Pecan)

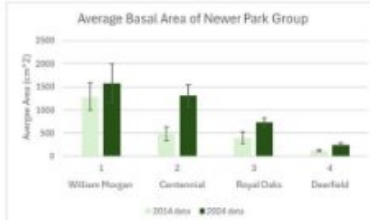
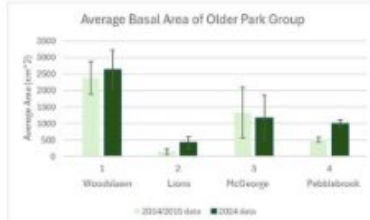


Figure 3. A comparison of average basal area in each park 10 years ago (light green) and this year (dark green).

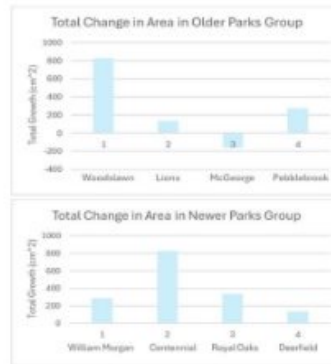


Figure 4. Total change in basal area in parks over the last 10 years

Park Name	Total Trees in 2014/2015	Total Trees in 2024	New Trees Planted	Trees Dead/Cut
Woodblown	12	10	0	2
Lions	12	12	0	0
McGeorge	10	10	1	1
Pottlabeck	27	24	0	3
William Morgan	11	11	0	0
Centennial	8	8	0	0
Royal Oaks	27	46	19	0
Deerfield	7	7	0	0

Figure 5. Tree Totals in Each Park Surveyed

Conclusions

- The growth of trees varies by park and species, but we were able to observe overarching trends
- In the past 10 years, Elm has become the most abundant tree in the "Older Parks Group," taking the place of Berry (Hackberry and Sugar Berry)
- Over the past 10 years in the "Newer Parks Group," Oak has become, by a large margin, the most abundant and commonly planted tree.
- Overall, the "Newer Parks Group" has experienced more growth and maintenance (tree replacement and new trees planted)
- In recent years, Elm has become less frequently planted, likely due to the rise of Dutch Elm disease
- Survival rates of Elm, Oak, and Berry remain the highest

References

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To What Extent Has Climate Change Affected Leafing Times in Oklahoma Oaks?

Joshua Bell, Abigail J. Moore

School of Biological Sciences and Oklahoma Biological Survey



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Introduction

- Phenology, the study of the timing of temporal events such as leafing, budding, and flowering can be used to predict and understand the impacts of climate change on plant species
- Herbaria (dried plant) specimen can be used to track leafing/flowering times from year to year (Panchen et al.)
- Other Oklahoma species have seen earlier flowering times, and significant responses to temperature (Unterschutz et al.)

Specimen Used

- All specimen were sourced from the Robert Bebb Herbarium at OU
- 2539 *Quercus* specimen from Oklahoma were scored
- 187 specimen across 19 species determined to be in early leafing phenophase
- Early leafing is defined as being between the expansion of bud and expansion and separation of young leaves
- Specimen range from 1913-2019, with the majority being collected before 1970
- Precipitation and Temperature Data taken from NOAA National Centers for Environmental Information
- Climate division data are NOAA division of state into 9 distinct regions which collect their own temperature and precipitation data

Questions

- How have oak leafing times been impacted across time in Oklahoma?
- What other factors (temperature, precipitation) could play a role?




Figure 1 (left to right) OKL-251033 *Quercus stellata*, FT. Crawford, Leafing Data (self-captured); *Quercus marilandica* (Naturist, user Ignatzian)

Key Findings

- Significant ($p=.03$) decline in leafing day over time (-0.7d/decade)
- Temperature a significant factor in leafing times for both state mean ($p=1.69e-6$) and climate division mean ($p=1.91e-10$)
- Precipitation a negative but not significant factor in leafing times
- For the four most common species, temperature is a significant factor
- No species showed significant changes in leafing time due to precipitation when p-values were adjusted for number of tests performed ($p<0.004$)

Conclusions

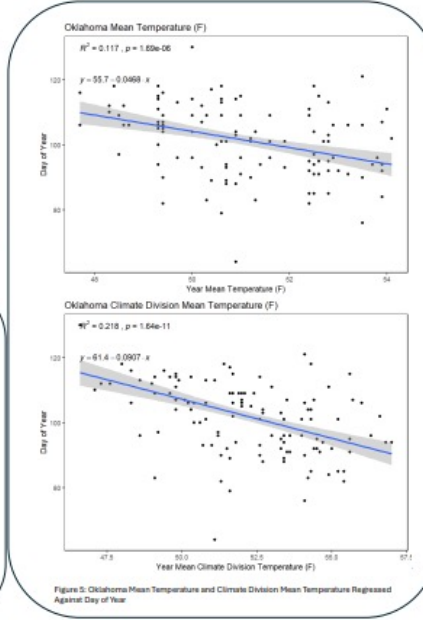
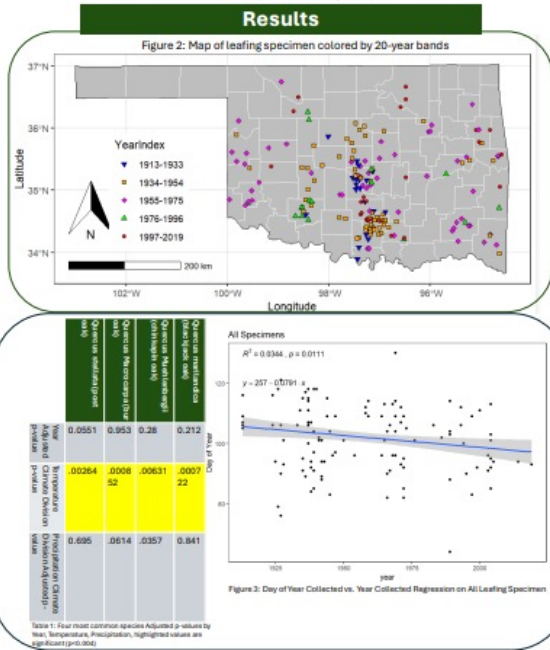
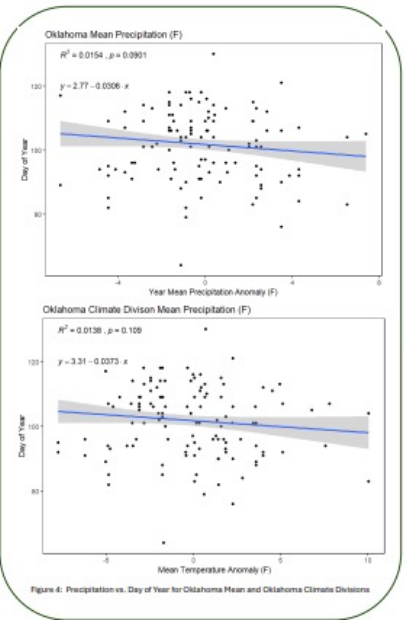
- Oaks have begun leafing earlier over the last century
- Mean Temperature from January-April is best predicting factor of leafing time in Oaks
- January-April Precipitation is less of a significant factor in predicting leafing time
- A global warming trend would lead to earlier leafing
- Experimental studies align with trends found in this survey (Morin et al.)

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Analyzing Changes in Invasive *Triadica sebifera* Phenology Using Herbarium and iNaturalist Samples

Lena Jurik, Abigail J. Moore

School of Biological Sciences, University of Oklahoma



Analyzing Changes in Invasive *Triadica sebifera* Phenology Using Herbarium and iNaturalist Samples

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School of Biological Sciences, University of Oklahoma

Introduction

- Chinese Tallow is an angiosperm native to East Asia.
- The tree was introduced to America in the 1700s for ornamental uses and became widespread in the 1900s as a part of soap production.
- It is now considered to be one of the most invasive species in the American Southeast.
- The tree can produce 100,000 viable seeds in a year and remain reproductively active for 100 years.



Figure 1. iNaturalist image showing *Triadica sebifera* from Pulaski, Arkansas. Hunt, E. (2012). iNaturalist observation: <https://www.inaturalist.org/observations/88978>

- Herbariums are collections of dried plant samples collected and labeled by botanists to be studied in the future.
- Primack et al. (2004) demonstrated that herbarium samples can be used to test phenological change in response to climate change.
- iNaturalist is a citizen science database in which users log image observations that are identified using AI and volunteers.
- iNaturalist has been used by researchers to supplement herbarium data (Iwanycki et al., 2004).



Figure 2. Herbarium Sample showing *Triadica sebifera*. U.S.A., Texas, Nueces County: Swamp, Baton Rouge. Deaver 6729 [ASC [ASC0069609]].

- Flowering for many plant species is starting sooner due to changes in weather patterns related to climate change.
- Earlier blooming times could affect plant-pollinator interactions and could increase total flowering time, potentially increasing the reproductive output.

Methodology

- 935 digital herbarium samples were analyzed from the TORCH database and physical samples in OU's Robert Bebb Herbarium.
- 8511 iNaturalist samples were downloaded from GBIF for the contiguous US and analyzed.
- Samples were categorized as having flowers but no fruit, having flowers and fruit, having no flowers but fruit, and having no fruit or flowers.
- These data were compared on regression lines to year and to average annual temperature from their year on both a national and statewide scale using data downloaded from NOAA.

Results

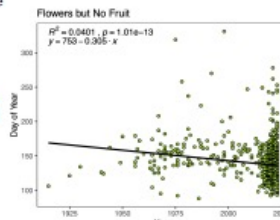


Figure 3. Scatterplot showing day of year of collection vs. year for plants with flowers but no fruit.

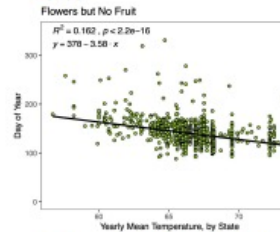


Figure 6. Scatterplot showing day of year of collection vs. yearly mean temperature for collection state for plants with flowers but no fruit.

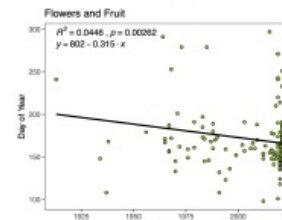


Figure 4. Scatterplot showing day of year of collection vs. year for plants with flowers and fruit.

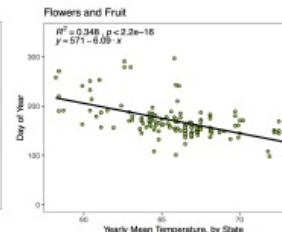


Figure 7. Scatterplot showing day of year of collection vs. yearly mean temperature for collection state for plants with flowers and fruit.

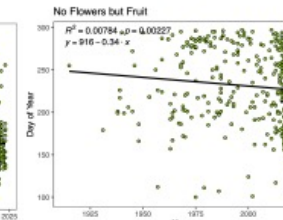


Figure 5. Scatterplot showing day of year of collection vs. year for plants with no flowers but with fruit.

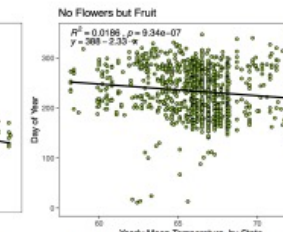


Figure 8. Scatterplot showing day of year of collection vs. yearly mean temperature of collection state for plants with no flowers but with fruit.



Figure 9. Map showing the county centroids of collection for herbarium specimens used.

Independent Variable	Phenophase	Data Types	R ²	p-value	Adjusted p-value
Year	Flowers but No Fruit	Herbarium	0.030	0.15	2.7
Year	Flowers and Fruit	Herbarium	7.9E-03	0.44	7.6
Year	No Flowers but Fruit	Herbarium	0.037	0.21	4.24
Nationwide Annual Mean Temperature	Flowers but No Fruit	Herbarium	1.9E-03	0.54	8.7
Nationwide Annual Mean Temperature	Flowers and Fruit	Herbarium	0.35	2.4E-04	4.4E-04
Nationwide Annual Mean Temperature	No Flowers but Fruit	Herbarium	7.2E-04	0.61	1.1
Statewide Annual Mean Temperature	Flowers but No Fruit	Herbarium	4.0E-04	0.77	1.4
Statewide Annual Mean Temperature	Flowers and Fruit	Herbarium	0.35	4.6E-03	0.08
Statewide Annual Mean Temperature	No Flowers but Fruit	Herbarium	1.2E-03	0.51	9.6
Year	Flowers but No Fruit	Herbarium and iNaturalist	0.040	1.0E-13	1.8E-12
Year	Flowers and Fruit	Herbarium and iNaturalist	0.045	2.6E-03	0.047
Year	No Flowers but Fruit	Herbarium and iNaturalist	7.8E-03	2.3E-03	0.041
Nationwide Annual Mean Temperature	Flowers but No Fruit	Herbarium and iNaturalist	0.023	6.8E-10	1.2E-04
Nationwide Annual Mean Temperature	Flowers and Fruit	Herbarium and iNaturalist	0.086	2.6E-05	4.1E-04
Nationwide Annual Mean Temperature	No Flowers but Fruit	Herbarium and iNaturalist	0.03	4.1E-10	7.4E-07
Statewide Annual Mean Temperature	Flowers but No Fruit	Herbarium and iNaturalist	0.35	<2.3E-16	<4.0E-15
Statewide Annual Mean Temperature	Flowers and Fruit	Herbarium and iNaturalist	0.35	<2.3E-16	<4.0E-15
Statewide Annual Mean Temperature	No Flowers but Fruit	Herbarium and iNaturalist	0.059	9.2E-07	1.7E-05

Table 1. Table showing significance of all statistical tests and Bonferroni adjusted p-values.

Conclusion

- iNaturalist provides large amounts of data in more depth than herbarium samples but only shows relatively recent occurrences and is less likely to show parts like flowers and fruits when present.
- The adjusted p-value for all analyses including both herbarium and iNaturalist specimens was below 0.05, and therefore is considered significant.
- Generally, analysis comparing day of year to yearly mean temperature by state was more significant than comparing to the national annual mean temperature or year.
- Analyses of only herbarium specimens showed significance only in day of year vs annual national mean temperature for flowers and fruit present.
- Difference in significance between herbarium and iNaturalist data indicates that there may be issues with comparing the sample types or could result from the larger sample size of the iNaturalist and herbarium combined data set.
- There is evidence that blooming time is shifting earlier and that it is tied to mean temperature.
- Since all phenophases are shifting earlier, there is no evidence that the flowering period will be extended.
- Further research would be required to determine how plant-pollinator relationships would be impacted by this change in blooming time.
- Future research could also be done to look at the effects of other factors on Chinese Tallow phenology.

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The Impact of Dietary Niche Variation in Three Pupfish Species on 11Keto Testosterone Levels and Behavior in Periods of Low Resources

Isabel Alejandro, Michelle St. John, Laura Stein Dodge

Family of Arts and Sciences School of Biological Sciences University of Oklahoma




The Impact of Dietary Niche Variation in Three Pupfish Species on 11Keto Testosterone Levels and Behavior in Periods of Low Resources

Isabel Alejandro, Michelle St. John, Laura Stein
 Dodge Family of Arts and Sciences School of Biological Sciences
 University of Oklahoma
 Contact: Isabel.m.Alejandro-1@ou.edu




Introduction


- While most organisms are generalist feeders, some organisms specialize on niche foods.
- Origins of these switches and side effects are relatively unknown, but could be a result of periods of low resources and hunger.



C. Desquamator - Scale eater



C. Variiegatus - Algae eater



C. Brontotheroidea - Snail Eater

Located San Salvador Island, Bahamas

- Previous work on pupfish suggests that specialists may exhibit higher levels of behavioral aggression than generalists.
- We are investigating the relationship between hunger and specialization through the lens of behavioral and hormonal analysis of generalist and specialist pupfish.

Period of starvation

➔

Increased aggression

➔

Specialization to new food niche

Methods

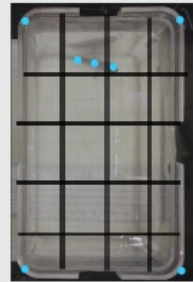
Fasted 12 Hours

Collected 11-KT from water and Placed in Assay Arena

Filmed Behavior for 5 mins

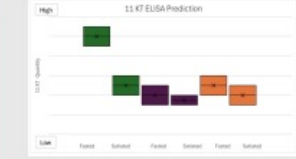
Fed 2 mL of brine shrimp at 5 min and 10 min

Collected Post-Assay 11-KT



- Video assays converted into coordinates through the Deep Lab Cut program and then analyzed using RStudio.²
- Keto-Testosterone levels quantified from the water samples using the 11 k-T ELISA protocol.³

Results



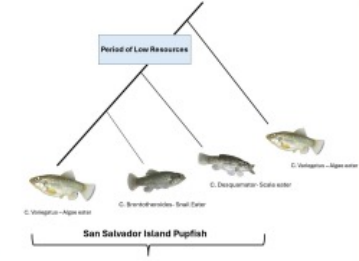
Conditions	χ^2	Df	P-value
Treatment	18.872612	2	7.98E-05
Species	15.289101	2	4.79E-04
Treatment:Species	9.949153	4	4.13E-02



- Above graph displays the mean number of grid transitions for all three species for each treatment type.

Conclusions/Predictions

- Generalists showed higher levels of behavioral aggression that then trended downwards as food was given.
- Specialist behavioral aggression remained relatively constant.
- While data appears different than predicted, the hypothesis is still supported, though aggression during feeding is different than aggression during interactions.
- It is possible that the generalists years ago went through a period of starvation, which led to an increase in their aggression and then specialization.
- If 11kt appears opposite of our behavioral aggression, it is possible that hormonal mechanisms of aggression are independent from behavior in specialist species.



San Salvador Island Pupfish

Acknowledgments

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 Dr. Michelle St. John, Dr. Laura Stein, Rionach McCarthy, Honors College FYRE Program, and the University of Oklahoma Biology Department

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Dominance of Nok4 Gene: Body Size Expression in F1 Prodigy of NKZ35xWOU12 Cross

Author: Kaylee McWhorter

Coauthors: Gavin Woodruff, Kimberly Moser

Fig Worm Lab, Department of Biology, University of Oklahoma



Dominance of Nok4 Gene: Body Size Expression in F1 Prodigy of NKZ35xWOU12 Cross

Author: Kaylee McWhorter

Coauthors: Gavin Woodruff

Kimberly Moser Fig Worm Lab,
Department of Biology, University of
Oklahoma

Background:

Figure 1

(Woodruff, 2018)



Recently discovered Sister Species, *Caenorhabditis inopinata*

Characterized by its significantly larger body size

Our lab is interested in what genes regulate its size -- applications in cancer research.

Objective:

For our experiment, we sought to determine whether the *Nok4* gene mutation, responsible for the WOU12 mutant, is dominant or recessive. Furthermore, we hoped to identify if the gene was x-linked based on its compliance with Mendelian inheritance. This poster focuses on the first cross direction for the F1 progeny.

Hypothesis:

The gene associated with body size regulation (*Nok4*), being a loss of function mutation in WOU12, is recessive and x-linked because there are only male mutants in the F1 progeny.

Methods

- Cross: Picked 100 NKZ35 males and 50 WOU12 females and separated them onto 10 plates to reproduce.

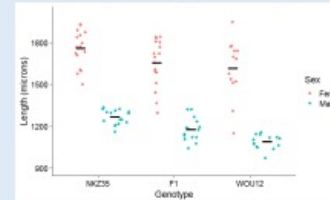
- Synchronized Egglay: Took the gravid females off and isolated them on fresh plates to lay their eggs. After a few hours, I removed the females. Then waited 3 days for the egg population to mature into adults.

- Phenotyping: Mounted nematodes onto slides by paralyzing them with levamisole and took pictures at 10x with the microscope. used Fiji to measure arbitrary length and After converting this to microns (micrometers), I graphed and analyzed the results using R-Studio.



Results:

Figure 2 Length (microns) vs Genotype



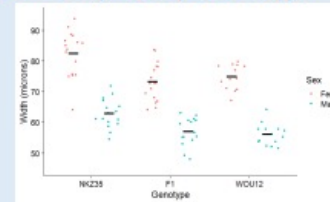
Wilcox Rank Sum Exact Test:

NKZ35 vs WOU12 P-Value = 0.004664

Female NKZ35 vs Female WOU12 P-Value = 0.05554

Male NKZ35 vs Male WOU12 P-Value = 1.375e-08

Figure 3 Width (microns) vs Genotype



Wilcox Rank Sum Exact Test:

NKZ35 vs WOU12 P-Value = 0.01105

Female NKZ35 vs Female WOU12 P-Value = 0.003796

Male NKZ35 vs Male WOU12 P-Value = 0.0002966

Figure 4 Length (microns) vs Width (microns)

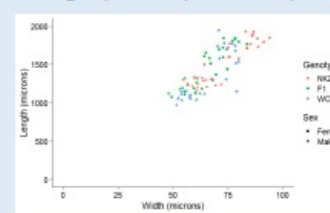
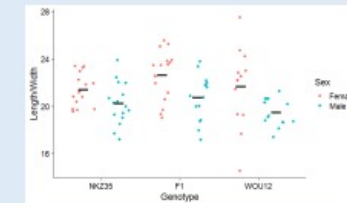


Figure 5 Length Over Width vs Genotype



NKZ 35 vs WOU12 P-Value = 0.3762

Discussion/Conclusion:

- Hypothesis and observations were incorrect
- WOU12 strand is smaller than NKZ35 (wild-type).
- Body size ratio is lower
- Gene seems to be dominant for width but does not follow Mendelian Inheritance for length
- Differences in Male and Female

What could be causing this?

The gene could be Non-Mendelian or width alone could follow Mendelian inheritance.

What are our next steps?

Further research is needed to determine the gene expression. Our next step is to do the cross direction in the reverse direction. If the gene follows Mendelian inheritance and the allele is dominant, 100% of the F1 progeny will have the wild-type phenotype.

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Examining Bee Visitation Patterns in Oklahoma through Flower and Bee Pollen Samples

Isabella Encapera, Sam O'Dell, Isabelle Gonzales, and Keng-Lou James Hung
University of Oklahoma



Examining Bee Visitation Patterns in Oklahoma through Flower and Bee Pollen Samples

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University of Oklahoma

Introduction

There is substantial evidence demonstrating that many bumble bee species (*Bombus spp.*) across the globe are declining in both their range and relative abundance (Cameron et al. 2011, Rasmont et al. 2015, Cameron et al. 2020). While the causes of these declines are less clear, understanding and protecting these pollinators is critical. We lack basic data on the distribution, plant use, or habitat preferences. This is particularly true when considering Oklahoma (OK), as there are few occurrence records available for OK. To address these critical information gaps, we are conducting a multi-year study of bumble bees in OK to determine their contemporary distribution, document habitat characteristics and floral visitation, and pollen choice of female bumble bees. We ask whether pollen loads largely match the plant species bees were observed upon and whether there were additional species detected in pollen loads?



Figure 1.1 *Bombus pensylvanicus* (Sam O'Dell)



Figure 1.2 Map of pollen collection sites. (Dr. Keng-Lou James Hung)

Methods

Pollen load samples were suspended in a fuchsin gel mixed with alcohol-based mouthwash. When the proper amount of fuchsin gel was used, the pollen was dyed to be clearly visible against the lighter background (see Figure 2.1). Under a microscope at x40 magnification, we examined these samples and compared collected bee pollen to a reference library of pollen collected from plant species we observed bumble bees visiting in the field. We determined if the

Methods Continued

had collected pollen from the plant they were observed visiting, the number of pollen types collected, and the relative composition of each pollen load. The relative composition of each pollen load was described in increments of 20 (e.g. 0:100, 20:80, 40:60, 60:40, 80:20, and 0:100 were the possibilities).

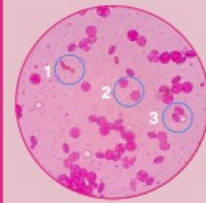
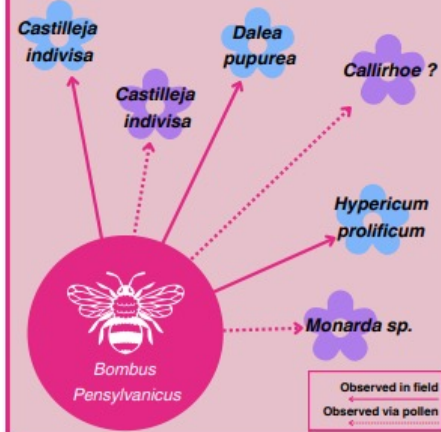


Figure 2.1 Ideal pollen slide. The background is distinct from pollen, visible texture, pollen is spread out. This slide also demonstrates multiple pollen types being found on a single bumble bee. (Isabella Encapera)

Results

Figure 3.1 Diagram representing visiting patterns of *B. pensylvanicus*.



Results Continued

We examined 18 female *Bombus pensylvanicus*, who were observed foraging on 12 different plants from 10 families. 1 pollen load was collected from a bee observed resting on pink flagging tape in the field, and therefore did not originate from a typical observation documenting floral visitation. In more than 90% of cases, pollen loads were found to contain some pollen from the plant bees were observed visiting. In approximately 25% of these cases, bees were found to have collected a majority of their pollen load from plants other than those they were observed on. On average, approximately 3 pollen types were found in a pollen load.

Discussion

This data suggests we cannot simply indicate plant preference using only visitation data, and that examining pollen use gives critical insight into the foraging habits and resource use by bumble bees. It also suggests that bumble bees use a smaller subset of plants for pollen than for all resources

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Acknowledgements


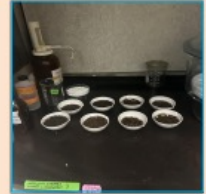

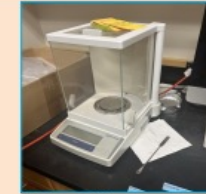



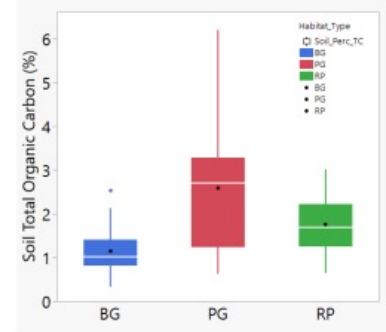
We would like to extend gratitude to The University of Oklahoma, the Honors College, the First Year Research Experience, and our friends and family for their support.

Methods in soil organic carbon: findings in 3 grassland habitat types

Methods in soil organic carbon: findings in 3 grassland habitat types

Zaid Alkalan, Lauren Rosenfelt, Lara Souza

University Of Oklahoma

Problem / Question	Procedure			
Land-use change can have large impacts on ecosystems including reducing soil carbon storage(2). In our research the main question asked is whether there are clear differences in the amount of soil organic carbon between three grassland habitat types, 1. remanent prairies (RP), 2. bermudagrass turfs (BG), 3. pollinator gardens (PG).(Land use impacts on SOC)	 Step 4 -Grinding Process	 Step 5 -HCl Fumigation	 Step 6 -Filtration process	 Step 7 -Final Weighing
Project Overview	Central Oklahoma Habitat Types			Results (2022)
Soil organic carbon is an indicator of carbon sequestration (A soil's retention of carbon"CO2"). "Soil organic carbon is a measurable component of soil organic matter. "Organic matter makes up just 2–10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils. Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, and carbon sequestration."(2) We looked at soil organic carbon between three habitat types in central Oklahoma to see if there were any differences between plant communities in Urban and Rural areas.	 Habitat 1 (RP) Flower and grass mix	 Habitat 2 (BG) Grass Dominant	 Habitat 3 (PG) Flower Dominant	
Methods (In lab)				
<p>In field methods:</p> <p>Step 1</p> <ul style="list-style-type: none"> Soil core collection (10 cm depth) from 10 randomly generated 1m² quadrats from 9 sites from 2022(3 sites per habitat) and 18 sites in 2023 (6 sites per habitat). <p>Step 2</p> <ul style="list-style-type: none"> Place collected cores in Ziplock bags and then into coolers filled with ice. <p>Step 3</p> <ul style="list-style-type: none"> Place collected samples into lab fridge for storage. 	<p>In lab methods:</p> <p>Step 1</p> <ul style="list-style-type: none"> Sieve collected soils to remove rocks, roots, and plant litter. <p>Step 2</p> <ul style="list-style-type: none"> Weigh out approximately 10 grams of soil per sample. <p>Step 3</p> <ul style="list-style-type: none"> Air dry weighed soils for 24 hours. <p>Step 4</p> <ul style="list-style-type: none"> Grind to pass through a 0.25-mm mesh sieve <p>Step 5</p> <ul style="list-style-type: none"> Take approximate 10g soil samples Add in HCL to fully dissolve the soils (until 	<ul style="list-style-type: none"> soil is soaked) Keep at room temperature for 24h to remove carbonates <p>Step 6</p> <ul style="list-style-type: none"> Wash out HCL withing samples by filtering with distilled water (place soil in folded filter paper in a funnel sitting on a beaker). Add DI water until the filter paper is almost full. Repeat 5 times. <p>Step 7</p> <ul style="list-style-type: none"> Weight minimum of 1 g <p>Step 8</p> <ul style="list-style-type: none"> air dry for OSU testing. 	<p>General Linear Mixed Model, (Binomial, Logit Test). Indicates that there are no significant differences per soil organic carbon across habitat types (P Value = 0.5015).</p>	<p>Acknowledgments</p> <p><small>Lauren Carlson-Rosenfelt - Photo, Data Research Dr. Lara Souza - Principal Investigator Tyson Gentry, Israel Lopez, Jayden Thomas, and Marissa Holsby - 2023 Soil Collections Dr. Liz Wang - Lab User 2022 Bobby Nguyen, Alex Flowers, and Alex VanCuren - 2022 Soil Collections Mikaela T. (2022) Jank SO: What is Soil Organic Carbon? Agriculture and Food https://www.agricultureandfood.org/soil-organic-carbon/ - Soil Organic Carbon Source (2) Duo, L.H. and Gifford, R.M. (2002) Soil carbon stocks and soil use change: a meta-analysis. <i>Global Change Biology</i>, 8, 369-380. (1)</small></p>

Genetic Diversity of *Bartonella* in Vampire Bats from Belize

Allison Holter 1, Lauren R. Lock 1, Kristin E. Dyer 1, M. Brock Fenton 3, Nancy B. Simmons 4, Daniel J. Beck 1

School of Biological Sciences, University of Oklahoma, Norman, USA 1; Center for Biologics Evaluation & Research, U.S. Food & Drug Administration, Silver Spring, MD, USA 2; Department of Biology, Western University, London, Canada 3; Department of Mammalogy, American Museum of Natural History, New York, USA 4

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School of Biological Sciences, University of Oklahoma, Norman, USA¹; Center for Biologics Evaluation & Research, U.S. Food & Drug Administration, Silver Spring, MD, USA²; Department of Biology, Western University, London, Canada³; Department of Mammalogy, American Museum of Natural History, New York, USA⁴



Introduction

- The spread of pathogens has the potential to increase spillover risk worldwide.
- Bats have been identified as pathogen carriers with high transmission potential to humans and domestic animals.
- Specifically, the bacterial pathogen *Bartonella* has shown high prevalence in vampire bats (1).
- *Candidatus* *Bartonella mayotimonensis* can cause endocarditis in humans (2).
- We compared genetic similarity of *Bartonella* in vampire bats (*Desmodus rotundus*) from northern Belize.

Methods

- Blood samples were collected from vampire bats at the Lamanai Archaeological Reserve (LAR) and Ka'Kabish (KK) in the Orange Walk District of Belize in 2017-2019, 2021, and 2022.
- DNA was screened for *Bartonella* using nested PCR to target the citrate synthase gene (*gltA*).
- Positive amplicons were Sanger sequenced, then quality checked using Geneious (Biomatters).
- We developed a maximum likelihood phylogeny to identify lineages of *Bartonella* found in vampire bats (3).

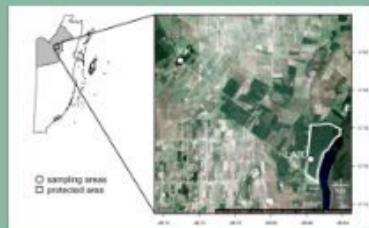
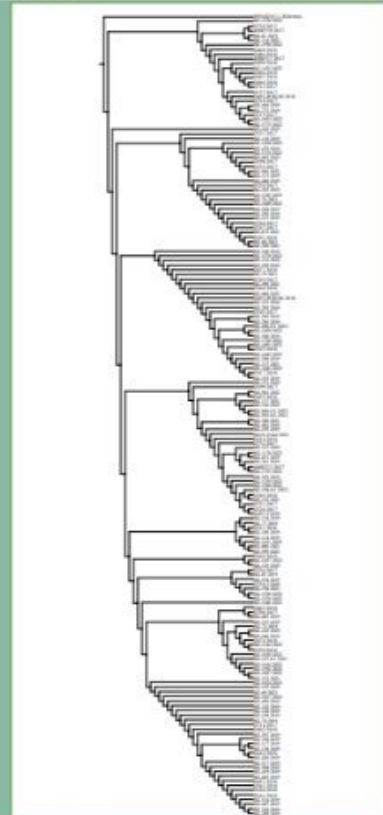


Figure 1. Map of the sites, the Lamanai Archaeological Reserve (LAR) and Ka'Kabish (KK), where vampire bats were captured in Belize.

Results



- 14.12% of samples were new *Bartonella* genotypes and 85.88% of samples were existing *Bartonella* genotypes.
- Shows transmission of pathogens from bats to bat flies.

Discussion

- Transference between bats and bat flies confirms the indication of pathogen spread.
- Relatively substantial percentage of new genotypes of *Bartonella* because the pathogen is rapidly evolving.
- In the future we could expand our study by including various species of bats and samples from different location.

Acknowledgements

- Becker Lab
- Mark Howells and staff of the Lamanai Field Research Center
- Belize Forest Department
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Contact

Allison Holter
The University of Oklahoma
Email: Allison.M.Holter-1@ou.edu

Investigating the Role of Heparin for Sustained Drug Release via Hydrogel

Ava Cassidy 1, Christopher Pierce 1, John R. Clegg 1,2,3,4



Investigating the Role of Heparin for Sustained Drug Release via Hydrogel

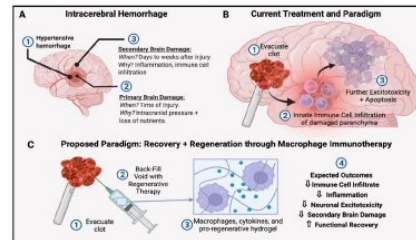
Ava Cassidy¹, Christopher Pierce¹, John R. Clegg^{1,2,3,4}

[1] Stephenson School of Biomedical Engineering, University of Oklahoma, Norman, OK, USA, [2] Stephenson Cancer Center, University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA, [3] Harold Hamm Diabetes Center, University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA, [4] Institute for Biomedical Engineering, Science, and Technology, University of Oklahoma, Norman, OK, USA

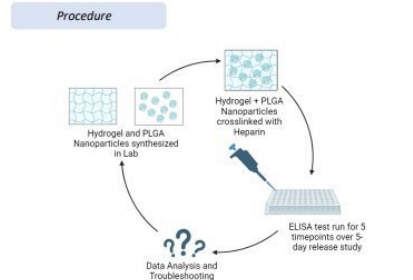
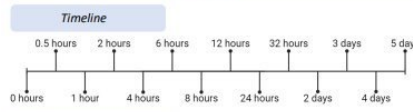


Introduction

The aim of this project was to determine how heparin affects drug release to continue working towards developing an injectable hydrogel to combat secondary brain damage after intracerebral hemorrhage.



Methods



Results

DLS Characterization of PLGA Nanoparticles

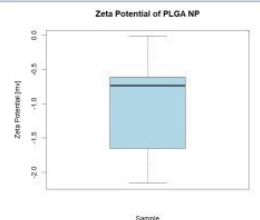


Figure 1: The zeta potential of the PLGA nanoparticles.

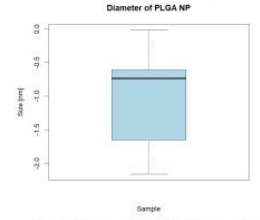


Figure 2: The Z-average size of the PLGA nanoparticles.

NMR Characterization of HAMA

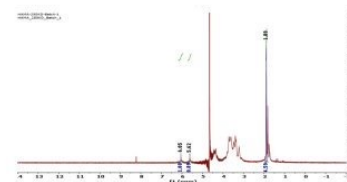


Figure 3: NMR data used to calculate percent degree of methacrylation (62.09%). [1] [2]

ELISA Test Troubleshooting

Several issues arose when performing ELISA tests, so several replicates were performed

- ELISA tests are highly sensitive to variations in concentration and even slight contamination
- Sources of contamination:
 - Plate washer
 - Pipette tips (using the same tip for multiple samples)
- Other potential sources of error:
 - Expired or otherwise compromised standards
 - Extremely sensitive kit
 - Hydrogel breaks up when supernatant is collected for release study

	1	2	3	4	5	6	7	8	9	10	11	12
A	0.049	0.050	0.051	0.056	0.045	0.060	0.041	0.070	0.056	0.039	0.044	0.041
B	0.027	0.061	0.060	0.167	0.055	0.057	0.040	0.106	0.046	0.116	0.045	0.047
C	0.037	0.056	0.057	0.052	0.052	0.134	0.050	0.035	0.046	0.101	0.049	0.050
D	0.133	0.158	0.179	0.071	0.081	0.054	0.090	0.141	0.064	0.106	0.061	0.069
E	0.120	0.121	0.062	0.138	0.130	0.151	0.140	0.273	0.143	0.220	0.118	0.115
F	0.101	0.111	0.102	0.130	0.130	0.134	0.150	0.150	0.140	0.140	0.130	0.130
G	0.146	0.146	0.174	0.150	0.177	0.150	0.150	0.174	0.150	0.150	0.170	0.140
H	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060

Figure 4: ELISA data from 2/29/24.

Conclusions & Future Work

Goal: Zero Order Release Profile

- Drug release is characterized as zero order if the concentration of drug decreases linearly as time passes
- Burst release occurs when a large amount of drug is released at any point in time
 - Very common for drug delivery systems to have an initial burst release
 - Can have toxic or unhealthy effects on patients

Future Work:

- I will continue researching the effect of hydrogel composition on release profile in Fall 2024

Acknowledgments

I would like to thank the University of Oklahoma Honors College and Dr. Heather Ketchum for leading the FYRE program and facilitating my research experience.

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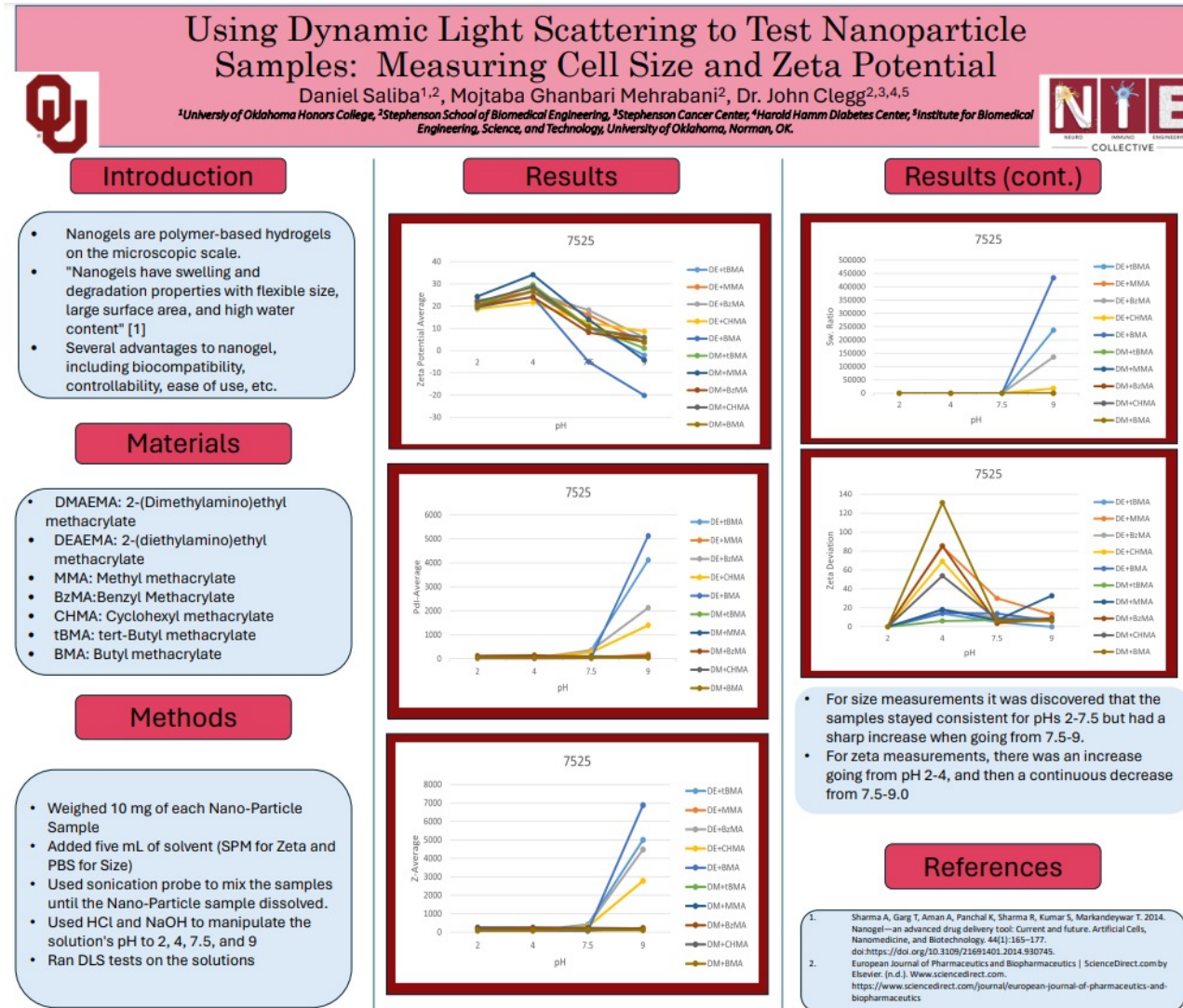
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Using Dynamic Light Scattering to Test Nanoparticle Samples: Measuring Cell Size and Zeta Potential

Daniel Saliba 1,2, Mojtaba Ghanbari Mehrabani 2, Dr. John Clegg 2,3,4,5

1 University of Oklahoma Honors College, 2 Stephenson School of Biomedical Engineering, 3 Stephenson Cancer Center, 4 Harold Hamm Diabetes Center, 5 Institute for Biomedical Engineering, Science, and Technology, University of Oklahoma, Norman, OK.



Evaluation of Repurposing Anti-Parasite Drugs for Ovarian Cancer from Cell to Animal Level Using Optical Coherence Tomography

Takaki Mishima, Feng Yan¹, Rajani Rai², Chen Wang¹, Qinghao Zhang¹, Ebenezer Raj Selvaraj Mercyshalinie¹, Lauren E. Dockery², and Qinggong Tang¹

¹Stephenson School of Biomedical Engineering, University of Oklahoma, Norman, OK 73019, USA.

²Stephenson Cancer Center, University of Oklahoma Health Sciences Center, Oklahoma City, OK 73104, USA



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Background

Repurposing drugs is an increasingly popular strategy in oncology due to the financial and logistical constraints of new drug development. Recently, anti-parasitic drugs such as mebendazole have surfaced as repurposed oncology drugs and showed promise in treating multiple types of tumors. The anti-parasitic drug mebendazole, is in the benzimidazole class and have been FDA-approved to treat pinworm and other helminthic. Although these seem to be the mechanisms of action in parasites, the exact mechanism of their anti-cancer effect in human cells is unknown.

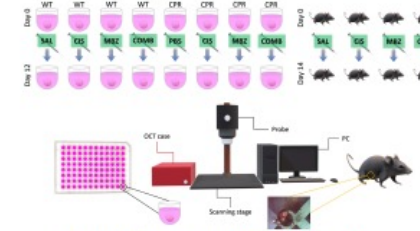


Fig. 1. Schematic of the scanning system and protocol of drug treatments.

Material and Method

5×10^3 cells/well parent OVCAR8 (wild type, WT) and CPR OVCAR8 (cisplatin-resistant cells) MCTs were treated by saline (control group), cisplatin (1 μ M), mebendazole (0.25 μ M), and the corresponding combination. 80 MCTs in total were imaged by a polarization-sensitive optical coherence tomography (PS-OCT) system every two days within 12 days. The mice model implanting OVCAR8 tumors were scanned by PS-OCT before, one week after, and two weeks after treatments of saline (control group), cisplatin (2.5 mg/kg every other day), mebendazole (50 mg/kg per day oral gavage), and the corresponding combination. Two-dimensional (2D) and three-dimensional (3D) imaging modes were used to provide cross-sectional, *en face*, and spatial information of MCTs and tumors within mice *in vivo*. A GAN-based ResNet model was used to segment tumor spheroids.

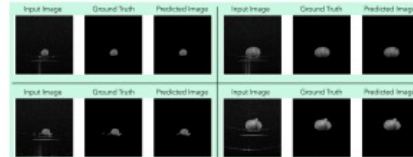


Fig. 2. Representative predicted images by the GAN-based ResNet model.

Results

1. We found that cross-sectional OCT images provided the visualization of internal microstructures and tissue distribution of tumor spheroids. The 3D OCT images showed the spatial size and morphological structure of tumor spheroids, which provided the precise monitoring of growth change in volume size with drug treatments. We observed that CPR tumor spheroids have relatively larger volume sizes compared to WT tumor spheroids in all groups. With the drug treatments, the volume size of tumor spheroids became smaller.

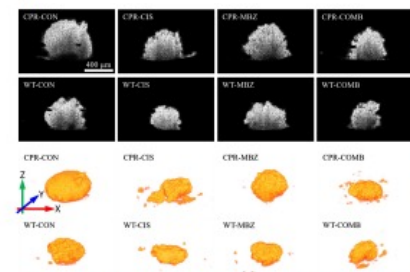


Fig. 3. Representative 2D and 3D OCT images of tumor spheroids with drug treatments.

2. We observed that 2D and 3D OCT images also provided the information of internal microstructures and tissue distribution of animal tumors. Our results showed that CIS, MBZ, and the COMB substantially inhibit the growth of the tumor within the mouse body.

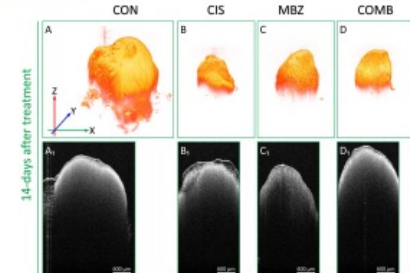
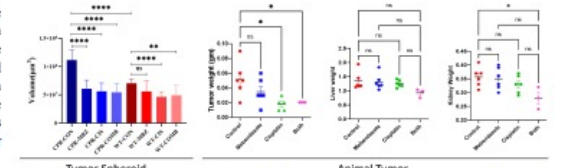


Fig. 4. Representative 2D and 3D OCT images of animal tumors with drug treatments.



3. We further provided the statistics of the change of volume size in tumor spheroids and the change of tumor and relative organ weights in the mouse body. We found that CIS, MBZ, and the COMB significantly inhibited the volume size of tumor spheroids except for the MBZ in WT tumor spheroids. CPR tumor spheroids exhibited a larger volume size compared to WT tumor spheroids, which indicated that CPR tumor spheroids were less inhibited by the treatment of CIS, MBZ, and the COMB.

4. We observed that CIS and the COMB of CIS and MBZ significantly inhibited the weight of tumors within the mouse body, but the MBZ showed the inhibition was not significant, which kept consistent with the treatment in WT tumor spheroids. We also observed the weight of livers and kidneys was not affected by CIS and MBZ, but the COMB treatments. This convinced there was no toxicity to livers and kidneys from singly CIS or MBZ, except for the COMB to the kidney.

Conclusion

We demonstrated that OCT images provided effective information of the spatial size and morphological structure of tumor spheroids and animal tumors to monitor the growth and change of tumor spheroids and animal tumors with the treatment of drugs. OCT imaging was able to observe the correlation between *in vitro* cell and *in vivo* animal levels for the repurposing of FDA-approved drugs on anti-cancer studies.

Acknowledgement

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Quantitative Analysis of PLGA Nanoparticles Produced by Microfluidic Synthesis

Aidan Sison, Stefan Wilhelm

Stephenson School of Biomedical Engineering, University of Oklahoma, Norman, Oklahoma, 73019, USA

Quantitative Analysis of PLGA Nanoparticles Produced by Microfluidic Synthesis

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Motivation

Nanoparticles exhibit dimensions in the 1-100 nanometer size range [1]. They are involved in a wide variety of fields, such as diagnostics, imaging, and drug delivery. The focus of this study is on poly-lactic-co-glycolic acid (PLGA) nanoparticles for drug delivery. For drug delivery, a nanoparticle acts as a middleman, helping the drug get absorbed by its target cell, and decreasing the likelihood that the drug is absorbed by a non-target cell [1]. PLGA is a useful nanoparticle material because it is biocompatible, meaning it is not harmful to the body, and biodegradable, meaning it is not harmful when broken down [2]. Another important aspect of PLGA is the control over the release of the drug [2]. The challenge associated with PLGA nanoparticles we attempt to mitigate is an inconsistent PLGA nanoparticle size, likely due to the synthesis method used for nanoparticle creation [3].

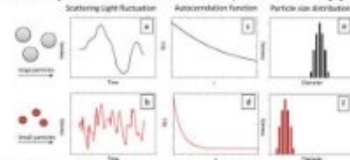


Figure 1: This figure shows the different steps involved in characterizing nanoparticles with Dynamic Light Scattering (DLS) to determine the hydrodynamic diameter [4].

Another query that we researched was the comparison of nanoparticle characterization instruments that use Dynamic Light Scattering (DLS). In DLS, a laser is directed at a sample, and the light is scattered. In a sample, the smaller a particle is, the bigger the change in scattered light intensity [4]. The bigger a particle is, the smaller the change in the frequency of the scattered light intensity. We use the magnitude of the change in intensity to determine a particle's hydrodynamic diameter (HDD) [4]. We can also determine the uniformity of a sample's particles, known as polydispersity index (PDI). The lower the PDI, the more uniform the particles are [4].

Methods



Figure 3: This is the old tubing design. The company who created this design is called RESTEK.

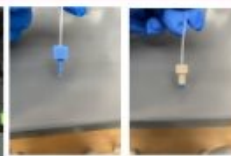


Figure 4: This is the new tubing design. The company who created this design is called IDEX.

Methods

Figure 2 depicts the setup for the method we utilized for creating PLGA nanoparticles: the Ender3. The Ender3 was a 3D printer that was modified for microfluidics. Microfluidic methods are shown to have more uniform nanoparticles and higher reproducibility rate [3]. We utilized the Ender3 because it has more precise fluid flow rates, which can decrease error.

Results

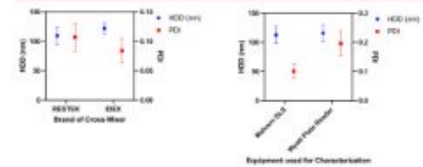


Figure 5: This depicts results from the comparison of the two cross mixer designs. The two left bars are results from the old RESTEK cross mixer. The two right bars are results from the new IDEX cross mixer.

Figure 6: This depicts results from the comparison of the two DLS instruments that the lab owns. The Malvern and the Wyatt are two different DLS instruments. We used the same trial of nanoparticles for both instruments.

We also researched PLGA shelf life by placing nanoparticles in different temperature environments and plotted how this affected their size and uniformity over a two-week period.

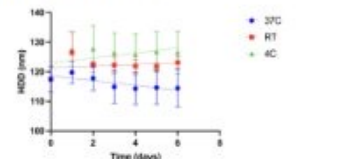


Figure 7: This depicts the nanoparticle size results from the PLGA Shelf Life Test. The results are in nanometers. We characterized the nanoparticles every other day.

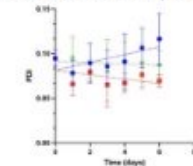


Figure 8: This depicts the nanoparticle PDI results from the PLGA Shelf Life Test. We characterized the nanoparticles every other day.

Results

In Figure 5, we can see that the IDEX produced a lower PDI than the RESTEK overall. This means that the IDEX's PLGA nanoparticles tend to be more uniform on average. One explanation for this difference is that in the RESTEK design, the tube would be pinched to secure it to the cross mixer. This pinching could affect the fluid flow rate, which could affect how the nanoparticles come out. The new design employs ferrules which decreases the amount of pinching the tube experiences. In Figure 5, we can also see that the IDEX produced bigger PLGA nanoparticles. On average, the nanoparticles produced by the IDEX were 12 nanometers bigger in diameter. In Figure 6, we see that the PLGA nanoparticles were characterized similarly with regards to size. However, we also see that the Malvern characterized the trials to have lower PDIs than the Wyatt. This could be due to different manufacturing techniques for following the steps of nanoparticle characterization via DLS. In Figure 7 and 8, we can see that nanoparticles in cold storage (4C) slightly increased in size and became more uniform over time. Nanoparticles stored at room temperature maintained a similar size and they became more uniform over time. Nanoparticles stored in a body-temperature environment (37C) decreased in size and became less uniform over time.

Conclusions

The new IDEX cross mixer may be better because it produces PLGA nanoparticles that are, on average, more uniform. If this is further supported by more testing, we would change to the IDEX cross mixer permanently. Nanoparticle uniformity is important because we want drug effects to be uniform. It appears that Malvern DLS is more reliable because the PDI that it measures has a smaller standard deviation. Many people in the lab do not use the Wyatt Plate Reader for DLS due to the widely varying PDIs that it characterizes, which further supports our findings since the standard deviation for the PDI of the Wyatt is much bigger. It appears, when storing PLGA nanoparticles, they should be stored in room temperature due to its maintenance of size over time while improving in uniformity over time.

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Thank you to Sam Ferguson, Madison Shelton, the rest of Wilhelm lab, the FYRE program, and the University of Oklahoma College of Engineering.

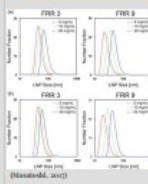
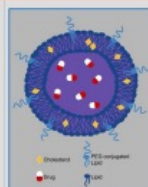


Background and Motivation

Liposomes have applications in Drug Delivery, Immunology, and Cancer Treatments. **Microfluidic Synthesis** is a method of Liposome synthesis that relies on the controlled flow rates of an ethanol lipid solution and a polar liquid (PBS). The ratio of polarizing/ethanol flow rates is commonly known as the **FRR**. Studies show that **concentration and FRR play a role in particle size and precision** (Masatoshi, 2017).

One of the components of the Lipid Solution **DSPE-PEG** is a lipid-conjugated Polyethylene-glycol. This component prolongs the half-life of the Liposome in the bloodstream and enhances colloidal stability.

Due to the molecular properties of DSPE-PEG, the lipid solution may not dissolve as fast as Cholesterol or DSPE. **The goal is to test whether the Sonication of the DSPE-PEG lipid solution before synthesis improves particle quality?**



Methods

Particle Synthesis

1. Solutions

a. Prepare 5 mg/ml Ethanol solution of DSPE, Cholesterol, and DSPE-PEG.

b. 1x synthesis 0.6/0.6/1.6mg Chol/PEG/DSPE

2. Mixing (a - unsonicated, a+b - sonicated)

a. Vortex Lipid solutions for 4 min or until solute is no longer visible.

b. Sonificate DSPE-PEG solution for 10 min on High.

3. Lipid Solution/PBS

a. 300/100/100 μ l, DSPE/Chol/PEG (5mg/ml)

4. Synthesis

a. Assemble T-Mixer (Fig 1)

b. Load the 0.5 ml of lipid solution into X pump.

c. Load the 3.5ml of PBS into the Y pump.

d. Start synthesis

i. G-CODE is calibrated for FRR 7 and output of 15 ml/min

5. If aggregate above 220 nm (particles should be around 80-100 nm) Filter with a .22 Micron Syringe Filter (Fig 2)

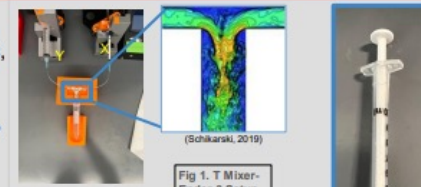


Fig 1. T Mixer-Ender 3 Setup.

Analysis of Particles

1. Dynamic Light Scattering, (Malvern Zetasizer Nano) To get PDI and Hydrodynamic Diameter.

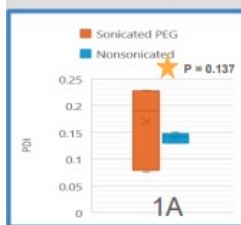
2. Wyatt Platt Reader to get concentrations (Dynapro III)

Fig 2. .22 Micron Syringe Filter

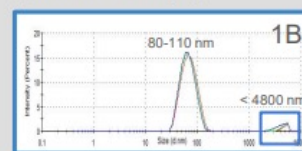
Manipulating Fluidic Mixing Techniques to Optimize Liposome Synthesis

Jay Agarwal, Hamilton Young, Dr. Stefan Wilhelm

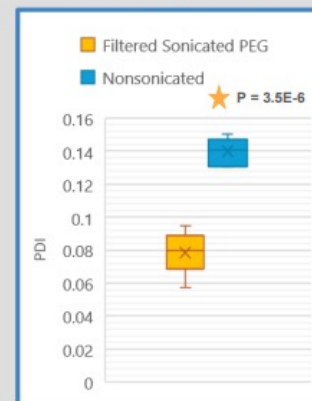
Results



(Fig 1A) Comparison of sonicated vs. nonsonicated DSPE-PEG liposomes. (Fig 1B) Presence of aggregate around 5 μ m (88% of sonicated samples)

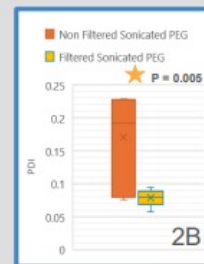
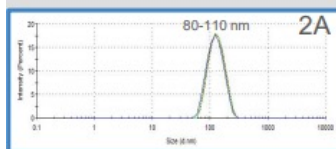


Final Comparison



Nonsonicated PEG particles are less precise than the sonicated PEG Particles.

(Fig 2A) shows the DLS readings after the filtration with the .22 micron syringe filter (Fig 2B) Comparison of the Sonicated DSPE-PEG Particles before and after filtration.



Discussion

It is reasonable to assume that sonicating the DSPE-PEG lipid solution produces better particles, **we will from now on incorporate in our protocols the sonication of polymer solutions before Lipid particle synthesis.**

The aggregate present in my Sonicated Solutions, this could be due to multiple factors.

1. During Sonication Bath I used could've been contaminated with the presence of water.
2. Or the DSPE-PEG solution could've been oversaturated.

Using the Wyatt Plate Reader I have measured the concentrations of my lipid solutions. For the futre scale up, to compare the FRR and diffrences that come with the scale up.

Acknowledgments

Stephenson School of Biomedical Engineering (SBME), University of Oklahoma. This work was supported in part by an NSF CAREER award (2048130) and the NIH MIRA R35 (1R35GM150758).

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Three-Dimensional Super-Resolution Microscopy-Based Imaging of Cancer Spheroids

Natalie Waters, Connor Baroody, Stefan Wilhelm PhD
Stephenson School of Biomedical Engineering,
University of Oklahoma, Norman, OK

Three-Dimensional Super-Resolution Microscopy-Based Imaging of Cancer Spheroids



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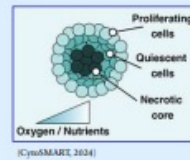
Background

Two-Dimensional vs Three-Dimensional

- 2D cultures are grown as a monolayer, while cells in a 3D culture can self-organize and form complex three-dimensional structures, mimicking the in vivo tissue architecture more accurately.
- 3D spheroid cell culture allows for cell-cell interactions and facilitates the formation of an ECM, making them more representative of in vivo tissue (Kapalczyńska et al, 2018).
- 3D cell culture exposes the entire surface area of cells for treatment, whereas 2D monolayer culture has parts of the cells surfaces that are potentially not exposed.

What is a Spheroid?

- Spheroids are 3D aggregates of cells, typically epithelial cells.
- Spheroids, like some tumors, have necrotic cores, making them useful in the study of cancer (Ryu et al, 2019).

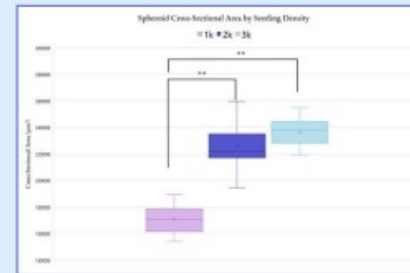
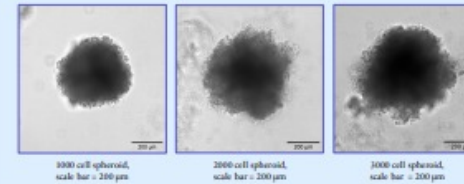


What is Expansion Microscopy?

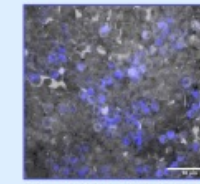
- To enhance the resolution of the spheroids, we expand them in a polyacrylamide hydrogel before imaging them.
- When submerged in water, the gel's polymer chains absorb water molecules, causing them to swell, allowing for up to a 11x increase in the spatial resolution when using the Magnify Protocol for expansion (Klimas et al, 2023).
- Our objective is to find how the seeding density of spheroids affects their size, stability, and potential for expansion.

Results

Comparing Seeding Densities

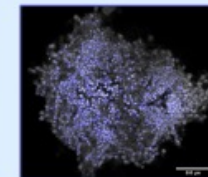
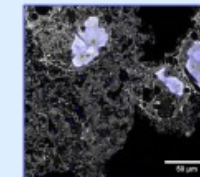


Expansion Microscopy

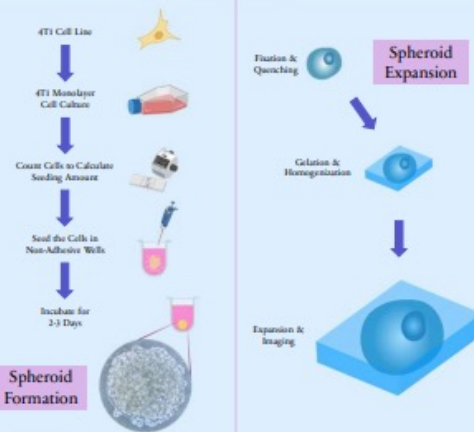


Expansion produced a much more magnified microscopy image of the spheroid cell cultures.

The unexpanded spheroid at 40x looks more similar to the expanded spheroid at 5x magnification.



Methods



Conclusion

- The seeding density of 4T1 spheroids has a significant positive effect on their final cross-sectional areas.
- 4T1 epithelial cells can be used to form spheroids that will withstand the aggravation from the Magnify expansion protocol when modified for spheroids.
- 4T1 spheroids with seeding densities of 1000, 2000, or 3000 cells/well can all be successfully expanded.

Future Directions for Research

- The consistency in spheroid size of different seeding densities can be evaluated.
- The expansion factors of spheroids and their seeding densities can be related.
- The expansion process can be used to characterize spheroids, such as the number of vesicles throughout the spheroid.
- The enhanced resolution can be used to assess the cell uptake and spatiotemporal distribution of administered treatments such as nanoparticles.

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Multimodal Imaging with Transcranial Magnetic Stimulation in the Human Brain

Jeff Engelman 1, Quinn Smith 2, Summer Edwards 2, Jesse Farrand 2, Han Yuan 2, 3

1Department of Chemistry & Biochemistry, Dodge Family College of Arts and Sciences, 2 Stephenson School of Biomedical Engineering, Gallogly College of Engineering, 3 Institute for Biomedical Engineering, Science, and Technology, University of Oklahoma, Norman, OK, USA.



Multimodal Imaging with Transcranial Magnetic Stimulation in the Human Brain

Jeff Engelman¹, Quinn Smith², Summer Edwards², Jesse Farrand², Han Yuan^{2,3}

¹Department of Chemistry & Biochemistry, Dodge Family College of Arts and Sciences,

²Stephenson School of Biomedical Engineering, Gallogly College of Engineering,

³Institute for Biomedical Engineering, Science, and Technology, University of Oklahoma, Norman, OK, USA.

Lab of Integrated Neuroimaging and Neuromodulation

Background

Transcranial magnetic stimulation (TMS) is a noninvasive way of promoting activation in specific portions of the brain using magnetic pulses. It is considered safe and has been approved by the FDA to treat medication-resistant depression.

A previous study has shown that **TMS stimulation of the left dorsolateral prefrontal cortex (L-DLPFC)** portion of the brain was able to **improve the working memory function** in human subjects. **This current study aims to test the improvement via TMS and brain imaging.**

A **combined functional near-infrared spectroscopy (fNIRS)** and **electroencephalography (EEG)** modality is used. fNIRS and EEGs are noninvasive tools that are used to measure neurological activity in humans. fNIRS measures the blood oxygenation in the brain and EEG measure the electrical activity of the brain. Together they work well to measure neurovascular coupling (NVC). **The long-term goal of combining TMS and fNIRS-EEG imaging is to elucidate the mechanism of improving working memory and further improve its effectiveness.**

Methods

The protocol that I mainly focused on is the imaging the brain at the **motor task**. The motor task was chosen because it helps gauge the quality of the fNIRS measurements and subject's NVC response.



Figure 1. Imaging setup

Experimental Procedure:

1. Place a combined fNIRS-EEG cap compatible with TMS on the subject, as shown in Fig. 1.
2. Determine the resting motor threshold for TMS for each subject
3. Subject begins seven experimental tasks: Resting 1, Working Memory 1 (WM), WM2, WM3, Single Pulse, **Motor**, and Resting 2.

Data Analysis and Results

The fNIRS topography in Figures 3 and 4 shows the activation of different fNIRS channels due to the subject's fist clenching. This activation is the rise in oxygenated hemoglobin (OxyHb). **A rise in the OxyHb and a decrease in the DeoxyHb** is expected to be found in the

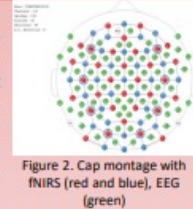


Figure 2. Cap montage with fNIRS (red and blue), EEG (green)

motor cortex within ten seconds after the initiation of the task and this is shown in Figures 4 and 6.

In Figure 7, the 005-1 EEG and 005-2 EEG results show activations at 168 and 176 milliseconds, respectively. Together these modalities confirm that **motor task leads to a rise in oxygenated hemoglobin accompanying a rise in electrical activation after fist clenching.**

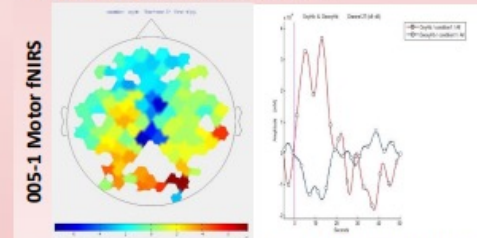


Figure 3. fNIRS map in a subject

Figure 4. fNIRS signals in a subject

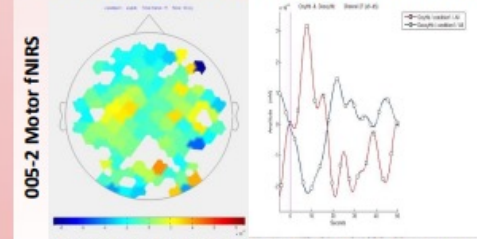


Figure 5. fNIRS map in a subject (repeated visit).

Figure 6. fNIRS signals in a subject (repeated visit).

Results Cont.

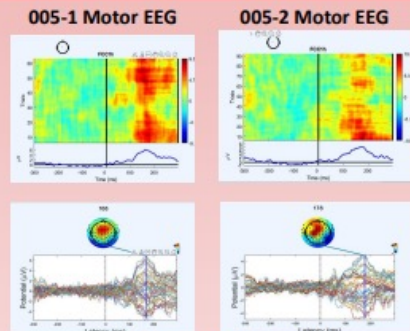


Figure 7. Results of EEG analysis.

Discussion & Future Directions

Summary: The fNIRS and EEG imaging modalities are reliable imaging tools to measure the brain activations. It is important to have the motor task and to analyze the data in order to cross check that the quality of the data from other tasks, such as the TMS stimulation, are reliable.

Future Directions: The ultimate goal of this study is to see if it would help with increasing the working memory of patients that would be affected by their condition. The next step is to recruit glioma patients with cognitive impairment and compare them to the healthy subjects provided in this study.

Acknowledgements

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Biophotonic Imaging Utilizing Deep Learning Techniques

Caitlin Varghese, Kaustubh Pandit, Warid Islam

Department of Biomedical Engineering, University of Oklahoma



Biophotonic Imaging Utilizing Deep Learning Techniques

Caitlin Varghese, Kaustubh Pandit, Warid Islam
Department of Biomedical Engineering, University of Oklahoma

Background

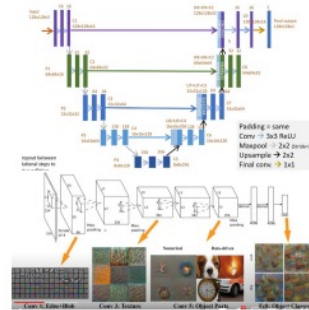
- Exportation Analysis:**
 - It takes about an hour to meet the 7 parameters of imaging successfully per one image. The 7 parameters include:
 - Total Intensity - structure of light penetrating tissue
 - Retardation - propagation speed in birefringent tissue changes
 - Optic Axis - angle of polarization light changes
 - DOPU - volume quantification measuring polarization change
 - Linear 0-90 - $Q > 1$ = horizontal vs $Q < 1$ = vertical direction
 - Linear 45-135 - rotates linear 0-90 by 45 degrees
 - Circular left-right - rotates polarization light in a circle
- Our Objective:** is to analyze the data being exported the regular way while researching deep learning techniques to increase the time efficiency in exportation and analysis

Methods

With our imaging being analyzed from each organ experiment, the application of deep learning (specifically U-Net segmentation) techniques to data imaging and exportation will enhance the efficiency while shortening the time.

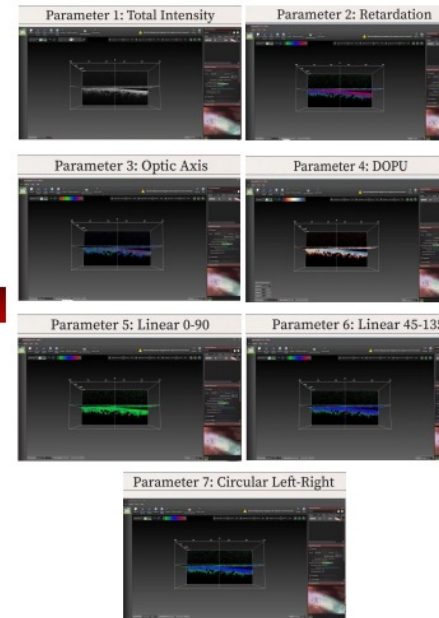
To apply U-Net segmentation:

- Python coding will need to be integrated
- Designed for semantic segmentation, where every pixel either represents the object of the background
- Composed of encoder, bottleneck module, and decoder



Results

- Although the python portion for U-Net segmentation is still being developed, the comparison to the data analyzed the original software of ThorImaging:



```
# Contrastive Path
c1 = H(nn.Layers.Conv2D(1024, (3, 3), activation='relu', kernel_initializer='he_normal', padding='same')(6)
c1 = H(nn.Layers.Dropout)(0.1)(c1)
c1 = H(nn.Layers.Conv2D(1024, (3, 3), activation='relu', kernel_initializer='he_normal', padding='same')(6)
p1 = H(nn.Layers.MaxPool2D)(2)(c1)

# Residual path
r1 = H(nn.Layers.Conv2D(1024, (3, 3), activation='relu', kernel_initializer='he_normal', padding='same')(6)
r1 = H(nn.Layers.Conv2D(1024, (3, 3), activation='relu', kernel_initializer='he_normal', padding='same')(6)
r1 = H(nn.Layers.Conv2D(1024, (3, 3), activation='relu', kernel_initializer='he_normal', padding='same')(6)
r1 = H(nn.Layers.Conv2D(1024, (3, 3), activation='relu', kernel_initializer='he_normal', padding='same')(6)

output = H(nn.Layers.Conv2D)(1, (1, 1), activation='sigmoid')(c1)
model = H(nn.Model)([input, output], output=[output])
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
model.summary()
```

Discussion/Conclusion

- To go more into the process of U-Net and how that can be applied to the current imaging process, U-Net, a branch of deep learning, is designed to optimize results by improving accuracy and computing the efficiency of medical image segmentation through changing network structure. Four different segmentation tasks within U-Net include:
 - Encoder Path:** The input image is passed through a series of convolutional layers with downsampling operations such as max-pooling. This path is responsible for capturing the context and extracting features from the input image.
 - Decoder Path:** The features extracted by the encoder are then passed through a series of upsampling layers, which gradually increase the spatial resolution of the feature maps. This path is responsible for generating the segmentation mask.
 - Skip Connections:** U-Net also incorporates skip connections between the encoder and decoder paths. These connections allow the decoder to access high-resolution features from the encoder, which helps in preserving spatial information and improving segmentation accuracy.
 - Final Layer:** The final layer of the decoder typically consists of a convolutional layer followed by a softmax activation function, which produces the segmentation mask with pixel-wise class probabilities.
- Although the error analysis with this project includes time and skills being a constraint given that this is intermediate-developed coding required, it is a project that will be continued
- Increasing imaging efficiency to spot fibrosis and get rid of birefringent tissue to evaluate whether the organ can be transplanted

Acknowledgments

Thank you to Dr. Tang for allowing me to be a new addition to this lab. A special thank you to Kaustubh for mentoring me throughout this process and teaching me how to export data. Thank you to Warid for researching deep learning branches and aiming to apply them to the Tang lab. Lastly, thank you to Gallogly College of Engineering and the FYRE program.

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Experimental Designs to Grow Larger Crystals of RNA

Daniel Shamsee and Dr. Blaine Mooers
Department of Biochemistry & Physiology, OUHSC

Experimental Designs to Grow Larger Crystals of RNA

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Introduction

RNA crystallography is study of RNA structure with X-ray diffraction data collected from crystals. RNA structures provide insight into function and are being used to design new drugs by using the structure as a docking template and then by co-crystallization of the RNA with the drug. The X-ray scattering power of a crystal is proportional to its size, provided that the crystal lacks packing defects and the crystal was properly. Larger crystals will usually give greater scattering power and higher resolution diffraction data. Higher resolution datasets have more data available for fitting molecular structures. The final model will be determined with greater precision than a model fit to low resolution data. As a result, larger crystals are highly valued in X-ray diffraction work. There are a multitude of factors that can affect RNA crystal growth, including pH, protein concentration, precipitant concentration, and temperature^[1]. The levels of these factors can be optimized to give larger crystals. RNA crystal growth often responds in a curvilinear fashion to rising factor levels, so three level experiments are required to detect the nonlinear response. Designed experiments are a systematic approach to locating the optimal levels^[2]. The results are analyzed by fitting linear models to the data using response surface methods.

Experimental Designs

One-Factor-at-a-Time (OFAT)

Designs

OFAT experiments are the traditional approach. In an OFAT experiment, all factor levels are held constant except for one, which is varied over several levels. The disadvantage of OFAT designs is that interactions between factors are hard to characterize, and more sample volume is required to achieve similar levels of precision^[3].

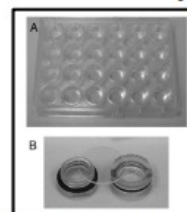
Definitive Screen Designs (DSD)

A DSDs are new three-level response surface method^[4]. It involves testing multiple variables at a time in an efficient manner determined by a computer algorithm. In short, all the important variables are changed during each trial to prevent unforeseen effects.

Objective

Identify the "active" factors in crystal growth using designed experiments. Then focus on these active factors to find the combination of their levels that yields larger RNA crystals.

How to make RNA Crystals



24-well crystal Tray (A) and Wellcaps (B)

RNA crystals were grown by vapor diffusion with the hanging drop method in 24-well trays with the concentration of crystallization solutions being randomized between each individual well. Diluted 2-Methyl-2,4-pentanediol (MPD) is used as the reservoir solution, and its concentration was held constant across the entire tray. One RNA variant was used per tray.

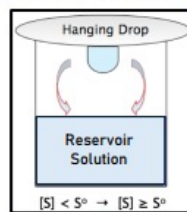


Diagram of vapor diffusion within wells

For each well, the RNA stock solution was mixed with an equal volume of crystallization solution on the undersurface of the wellcap (XtalTool). The factor levels in the crystallization solution varied from well to well based on experimental design. The wellcaps were flipped over and screwed shut over the reservoir solution. Crystals appeared in several weeks as water vapor diffused out of the crystallization drop and into the reservoir.

Results

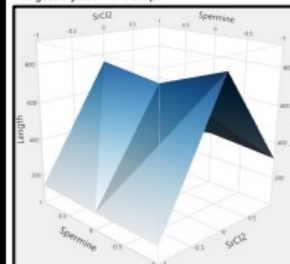


A 201-micron crystal grown with a DSD

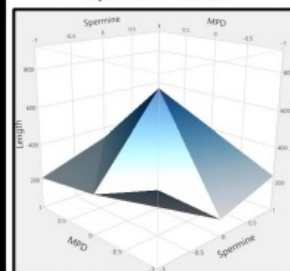


A 170-micron crystal grown with an OFAT design

Using a DSD and OFAT with 4 factors being tested (SrCl₂ concentration, Spermine concentration, MgCl₂ concentration, and MPD concentration) at 3 levels, several RNA crystals were grown. Not enough time had passed for all of the drops to give crystals. We provide below simulated results if all drops had given crystals. The analysis and plots were done with JMP^[5]. The factor levels were scaled between -1 and 1. The response was the longest length of the largest crystal in the drop.



Simulated response surface for RNA crystal length (microns) against concentrations of SrCl₂ and Spermine within a DSD



Simulated response surface for RNA crystal length grown against concentrations of Spermine and MPD within a DSD

Expected OFAT Results

The following are the different patterns a factor can potentially follow in an OFAT experiment^[6].

I. Factor has no effect



II. Negatively correlated linear response



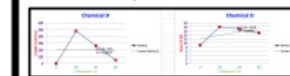
III. U-shaped response



IV. Positively correlated linear response



V. Quadratic Response



VI. No lengths to measure



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Interfacial Behavior of Aqueous PFAS Solutions During Droplet Pinch-Off

Ethan Klein, Daniel Park, Babak Valipourgoodarzi, Reza Foudazi

School of Sustainable Chemical, Biological and Materials Engineering, The University of Oklahoma

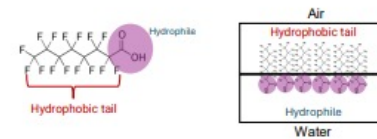
Interfacial Behavior of Aqueous PFAS Solutions During Droplet Pinch-Off

Ethan Klein, Daniel Park, Babak Valipourgoodarzi, Reza Foudazi
School of Sustainable Chemical, Biological and Materials Engineering, The University of Oklahoma



Introduction

- Poly and perfluoroalkyl substances (PFAS), also known as forever chemicals, are a class of chemicals that comes from plastics and synthetics that is harmful to the environment and humans. It is linked to cancer, diabetes, poorer immune systems, etc. (2)
- Promising filtration is remediation through foaming away PFAS
- We are researching the viscoelastic properties of samples to help better understand how "foaming" can help filter and get rid of PFAS from various water sources.

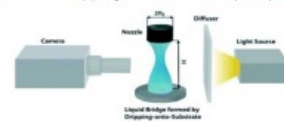


Objectives

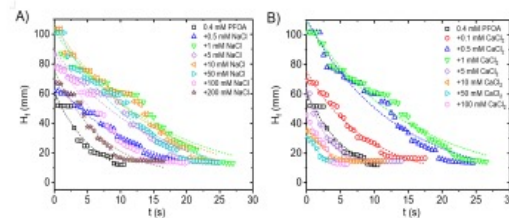
- Check for correlation of foaming stability through analyzing various samples of PFAS
- Find other ways to observe and extract more information on the properties of PFAS

Methods

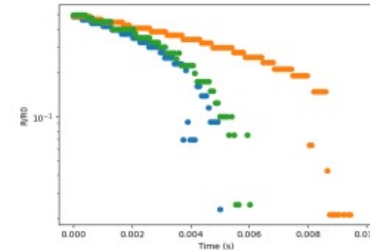
Dripping onto Substrate (DoS)



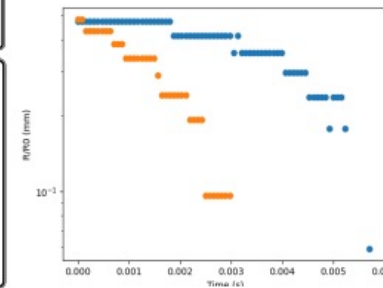
(1)



Results



- 4000 PPM PFOA (L/D= 1.64)
- 4000 PPM PFOA + 0.1M NaCl (L/D= 1.088)
- 4000 PPM PFOA + 0.01M NaCl (L/D= 1.531)



- 150ppm PFOA_DoS1 (L/D= 1.442)
- 150ppm PFOA_DoF2 (L/D= 1.789)

Conclusion

- Experiments show a relationship between the concentration of sodium chloride salt and the neck stability of a droplet containing 4000 ppm of PFOA. We see that a concentration of 0.1M increases the neck-stability of the droplet by increasing its necking time by almost 2-times.
- Experiments also show that adding lower concentrations of NaCl is irrelevant, matching closely with the 4000 ppm PFOA sample.
- DoF method is promising; however, is not ready for broad testing yet (consistent testing and recording methods are still being evaluated).
- When tested with DoF, the 150 ppm PFOA necking time appears similar to the 4000 ppm PFOA necking time, tested with DoS. This may show that DoF is a more accurate method of measuring necking properties compared to DoS.

Moving Forward

- One of our biggest goals is to refine the DoF method to gather more accurate and replicable data. DoF could replicate the conditions of PFOA removal methods, providing a tangible link between the two studies.
- Continue to test DoS method while refining the DoF method. DoS is the more published and established method, making it more reliable.
- Obtain results about removal of PFOA from samples and cross reference it with our own to find a possible correlation.

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Acknowledgments

- Dr. Reza Foudazi, Babak Valipourgoodarzi, Muchu Zhao, and the SMart Group
- Honors College First Year Research Program (FYRE)
- Mewbourne College of Earth and Energy

Developing an Escape Room Technique in the Chemical Engineering Curriculum

Frank Abbeduto, Professor Jie Gao

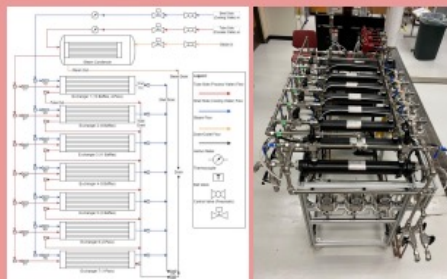
Developing an Escape Room Technique in the Chemical Engineering Curriculum

Frank Abbeduto, Prof. Jie Gao

Background

In the classroom, rote memorization and lectures often exhaust students. This includes topics like lab safety precautions, which are essential, if not abstract and tedious to study. A way of teaching the students this material while keeping them engaged would be beneficial to the classroom.

In the CH E-3432 class, students will learn how to operate several different pieces of equipment in their laboratory classes. Students only learn how to operate the equipment from textbooks and lectures before they record data from them, so an intermediary step between these two could better the learning experience.



The Heat Exchanger is a series of black metal pipes, containing inner tubes surrounded by an outer shell. The tubes run water through, while being heated by the water in the shell around them. The drop of the water pressure between the beginning of the pipe and the release is measured. The shells contain varying amounts of baffles, increasing the amount of time the two fluids are in contact with each other.

Introduction

Escape Room Teaching Method

The intention of an escape room activity is to captivate the student's imagination, causing them to think independently about a subject. By making the students solve puzzles about the material, they will be forced to analyze it in a new way, strengthening their knowledge and their self-efficacy (3).

The Classroom

This research will be focusing on the instructions for machinery necessary for the CH E-3432. The Laboratory setting is specifically the Huntington Laboratory in the Sarkeys Energy Center.

The Machinery

The two machines that were analyzed in this study were the Heat Exchanger and the Tray Hydraulics. While both machines were studied, the focus will be mostly placed on the Heat Exchanger, as it was the only machine to have a puzzle designed from it (2).

Methods

The puzzle will need to be cheap, as it should be replicable in other classrooms.

A rough draft of the puzzles were produced for testing. These drafts were solely paper questions, designed to replicate the function of combination lock that use numbers or letters. This means that every puzzle should result in a final answer of a string of letters or numbers, replicating turning the dials of a combination lock.

Puzzle Design

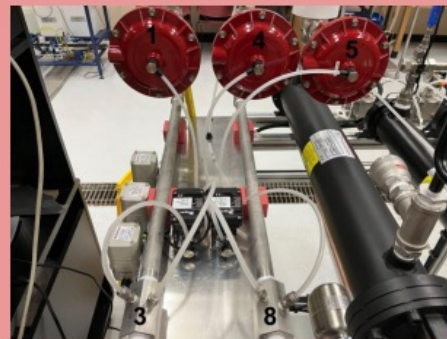
Three puzzles were made in the model tested on the day of testing. The first was a matching puzzle, connecting descriptions and images of various locations in the room and on the machine. The descriptions were in rhyming clues in the form of the question—

"Build up too much steam and your end is nigh, How can you check if the pressure is too high?"

The answer to this question was a picture of the pressure gauge.

The second of these puzzles involved marking the machine with tape, labelling the numbers. The paper guide to the puzzles also contained a picture of the heat exchanger, labelled with the numbers in the same positions of the machine.

The third of these puzzles involved selecting true-or-false statements about the machine's function. Every statement had a letter next to it, and the students were instructed to cross of the letters next to the incorrect sentences. The leftover letters from the correct facts would spell out the correct password, BAFFLE.



An image used in the second puzzle, students were to identify parts of the machine from their function. On the actual machine, labeled tape was also placed on these parts.

Results

Three groups of three to four students took the test and later reported the experience to a student volunteer of the experiment. They agreed that the puzzles were fun, and made them think about the heat exchanger in a new way. The challenge of the material was, if anything, too easy, each completing the tests in under 25 minutes total.

Discussion

The students that ended up taking the mock puzzles

The puzzles were, at times, ambiguous. The second puzzle had some numbers that were hard to read. This was a flaw noticed in development, and in any possible future versions of the design.

Only a three trial runs of a model of these puzzles was performed. This was due to the student researchers having to learn the material before making the puzzles based around it. By the time of the final lab of this class, there was only any time to make puzzles of one of the two machines. The tray hydraulics machine was studied, but no puzzles would end up being produced from it. If this research was extended into the next fall semester, both pieces of equipment could be tested, as well as more finalized products of the puzzles.

In the future, the following steps could be made to improve the puzzles already produced:

- Include physical combination locks in the next version
- Label the numbers in the second puzzle more clearly
- Scramble the letters in the third puzzle

Conclusion

The trial runs showed that the escape room method can work in this laboratory setting. It can turn safety and lab procedures into a fun experience for the student, and in turn, the student is more active and aware of their learning.

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Effect of Temperature on Contact Angle of Liquids on Particulates

Jonah Buyten, Brian. P. Grady Ph.D.

School of Sustainable Chemical Biological and Materials Engineering Panel

Effect of Temperature on Contact Angle of Liquids on Particulates

Jonah Buyten, Brian. P. Grady Ph.D.

School of Sustainable Chemical Biological and Materials Engineering
Panel Presentation for the 2024 FYRE Research Symposium



FYRE 2024

Goal and Hypothesis

The goal of my project is to standardize the secant slopes of different types of powdered silicas at varying temperatures. This is for a point of comparison against the heat of immersion experiments that will be conducted with a Setaram calorimeter later in the project process. This is to verify the values from a previous publication from the Grady group comparing the wettability of different particles.



DCAT Tensiometer (Left) and Washburn Method Measurement Tool (Right)

Background Information

- Heat of Immersion was proven to be an appropriate method of measurement for wettability in a previous publication [1].
- The Washburn Method is most often used to measure the contact angle of liquids on particles.
- Cross comparison of the contact angle slopes to the wettability values measured using the heat of immersion at high temperatures (75° C) is the goal of this project [2].

Methods

- First, 20mm of one of three dehydrated silica powders (R300, R380, and R974) is packed into a test tube for measurement in the DCAT Tensiometer.
- Water supply to the DCAT Tensiometer is set to 40°C, 75°C, 115 °C, or 145 °C for standardization of slopes at each temperature.
- The Tensiometer is set to measure with the Washburn method for a period of 900 seconds.
- Afterwards the data is stored for figure creation, as depicted below:



Measurement and Results



- DCAT Tensiometer liquid well
- A test tube is slightly submerged in liquid for contact angle measurement via the Washburn method
- Standardized slopes for R380 at 40° C: 0.008496
- R974 at 40° C: 0.006995

Applications

This data is being collected for comparison with heat of immersion data that has yet to be collected. This project is still underway but aims to affirm that heat of immersion is the best method for measuring the wettability of particles. This proving this method is the most appropriate for wettability measurement has many implications for surfactant research and would allow for new cleaning supplies to be developed that would be more effective overall.

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I would like to acknowledge the Grady Research Group from the School of Chemical Engineering here at OU, and in particular Dr. Brian P. Grady for all of his guidance and help. It has been an honor to work under him this semester.

Studying the Stress Experienced by a VWF Protein in Hydrodynamic Flow Using Coarse Grained Simulations

Emma Kelly Creasey, Dr. Dimitrios Papavassiliou

Galoggly College of Engineering,
School of Sustainable Chemical,
Biological, and Material Engineering;
University of Oklahoma

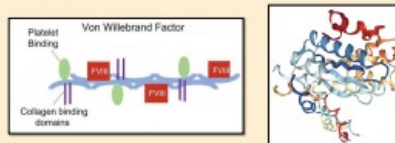
Studying the Stress Experienced by a VWF Protein in Hydrodynamic Flow Using Coarse Grained Simulations

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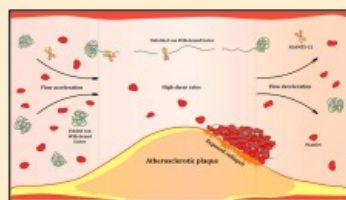
Galoggly College of Engineering, School of Sustainable Chemical, Biological, and Material Engineering; University of Oklahoma

Background

Von Willebrand factor, or VWF is a protein found in the blood. it aids in blood clotting by adhering to blood cells when it is broken. VWF should only break under certain conditions and forces, which typically happen when the body experiences a cut or blunt force. When someone gets a blood pump or a prosthetic heart put in, the protein is significantly more likely to break than in regular human blood vessels due to the harsher conditions the protein is placed under.



The solution to this problem would be to have prosthetics and pumps mimic the conditions found inside natural human organs and veins as well as possible, and to do this we must study the protein and find what specific conditions it breaks under. We are using computer simulations to simplify this process. Doing this research could help prevent a significant amount of death and injuries related to Prosthetic hearts and pumps.

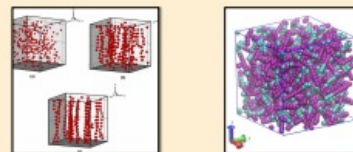


Methods

VWF is extremely small, so we are using coarse grained simulations to study it. The specific method we are using is Dissipative Particle Dynamics, or DPD. DPD specializes in the motion and forces applied to small particles.

We use Linux code to set the parameters we want and how we want the simulation to run, and then submit it to the OU Supercomputer to be ran.

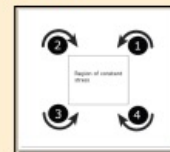
One of the major parameters we must set is the how the bonds of the VWF molecule will function so that it will move correctly in the simulation and not over bend or go through itself.



Four-Roll Mill

To test the stress applied to VWF in hydrodynamic flow, we created a four-roll mill using DPD and placed the protein in the center.

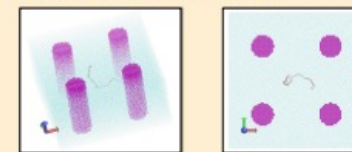
A four-roll mill is a box filled with water and four cylinders in each corner of the box, the cylinders will rotate in different directions and apply stress to the protein in the center.



Results/conclusions

So far, All current tests have been done with a pre-made PVP protein. This is because we are still working out small bugs and perfecting the process before we do any real testing on the VWF protein.

We have recently worked on upscaling the four-roll mill to see if we can not only get that to work but also how it will affect the PVP protein when we do it.



Within the last four years, there has been updates in the research of VWF, Namely a new product called Modulheart.

In 2024, Puzzle Medical Devices Inc launched a product called Modulheart, a transcatheter heart pump with the intention of reducing unnecessary VWF activation when the device is in use. Modulheart is a novel aortic flow entrainment device using 3 endovascular pumps assembled in parallel. This device has been tested several times on pigs and has recently been tested on the first human patients, all of whom have survived post operation.



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Purifying Pfu DNA polymerase for Polymerase Chain Reactions

Ellie I. Mescher, Hashim Ali, Grace Ha, Christina R. Bourne

Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK 73019

Purifying *Pfu* DNA polymerase for Polymerase Chain Reactions

Ellie I. Mescher, Hashim Ali, Grace Ha, Christina R. Bourne
Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK 73019

Introduction

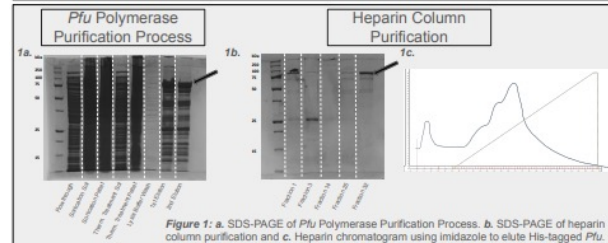
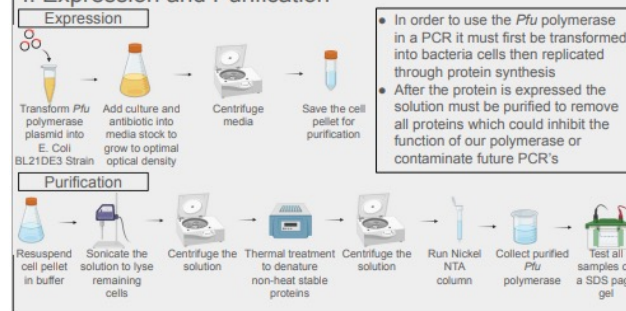
- DNA Polymerase are responsible for DNA replication
- DNA polymerases are highly accurate enzymes with proofreading capabilities, ensuring precision by detecting and correcting errors during DNA replication
- Polymerase structure is compared to a right hand and is broken down into the catalytic (palm), nucleotide binding/selection (fingers), and DNA-binding sections (thumb)
- DNA Polymerase can be used for Polymerase Chain Reactions (PCR), a process that rapidly produces copies of DNA through multiple cycles of denaturing, annealing and extending



Pfu DNA Polymerase

- Derived from *Pyrococcus furiosus* (*Pfu*) genomic DNA
- Error rate of 1.3×10^{-6} mutations/bp/duplication is 8-fold lower compared to Taq Polymerase
- High heat stability in comparison to common proteins
- The protein contains a histidine tag which allows it be purified through nickel column purification
- The size is of the protein is 90 kDa

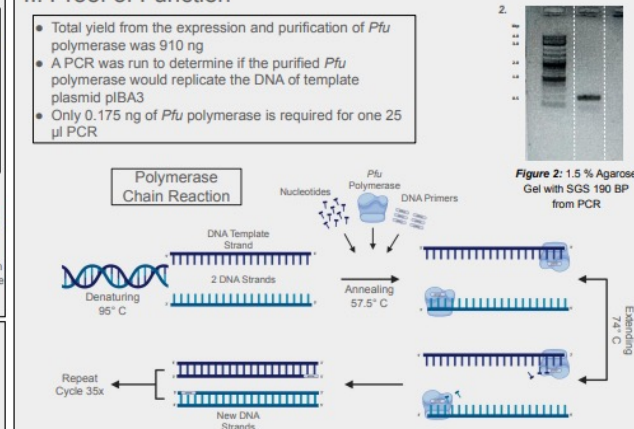
I. Expression and Purification



Conclusion

- The *Pfu* polymerase was accurately expressed and purified as shown through **Figure 1a** and **Figure 1b**
- Its ability to replicate template DNA is proven through the successful PCR of DNA plasmid pIBA3, shown in **Figure 2**
- This research provides a renewable resource from which the graduate students can use to make reagents for future studies

II. Proof of Function



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Synthesis of manganese-doped cesium lead chloride nanocrystals through the hot-injection method

Arjumand Shafiq, Lamia Hidayatova, Yitong Dong*

Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK, USA



Synthesis of manganese-doped cesium lead chloride nanocrystals through the hot-injection method

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Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK, USA



What Are Perovskite Nanocrystals?

- Nanocrystals, or quantum dots, sit in the perovskite structure that allows for visible light emission.

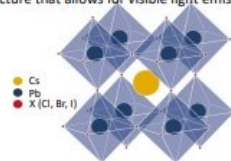
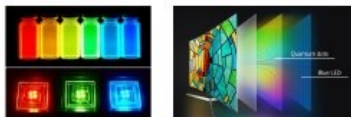


Figure 1: Perovskite Structure

- Can be found as a source material in LED lights, solar cells, lasers, and quantum dot TVs



- Valence Band | band gap | conduction band
- Selective impurities change the optical, electronic, and magnetic properties of nanocrystals
- Manganese-doped quantum dots have substituted lead atoms with manganese atoms in the crystals
 - About 8-10% of the lead is replaced with the manganese
- Goal:** optimize the methodology for manganese-doped nanocrystals to increase the light-emitting efficiency of the doped nanocrystals.

Methodology: Schlenk Line

The use of a Schlenk line in nanocrystal synthesis:

- Inert Atmosphere:** Facilitates synthesis under nitrogen, protecting sensitive materials from oxygen and moisture.
- Control of Reactivity:** Maintains inert conditions to manage precursor reactivity and promote uniform, high-quality nanocrystal growth.



Figure 2: Schlenk Line

Methodology: Undoped Particles

- Preparation of Cs Precursor:** Mix cesium carbonate (Cs_2CO_3) with oleic acid in octadecene and heat to form cesium oleate.
- Preparation of Pb Precursor:** Dissolve lead (II) bromide (PbBr_2) in oleic acid, oleylamine, and octadecene and heat until fully dissolved.
- Injection at Different Temperatures:** Inject the Cs precursor into the hot Pb mixture. Temperature controls nanocrystal size and emission color due to quantum size effects.
- Washing:** Wash the nanocrystals to remove excess ligands and byproducts, enhancing their optical properties.

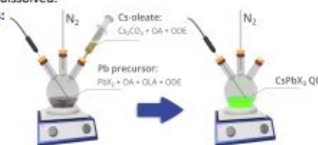


Figure 3: Hot injection process for undoped particles

Methodology: Doped Particles

- Remains the same, except the lead solution contains a manganese source
- Injection temperature: 180 C

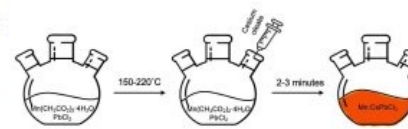


Figure 4: Hot injection process for doped particles

Results and Discussion

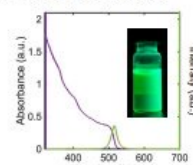


Figure 5: Absorbance and PL of Large CsPbBr_2 Nanocrystals

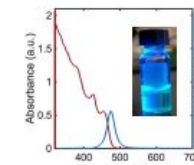


Figure 6: Absorbance and PL of Small Undoped Nanocrystals

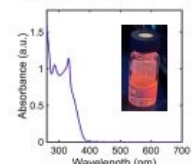


Figure 7: Absorbance of Mn-doped CsPbCl_3 Nanocrystals

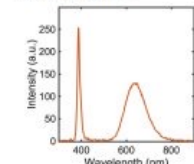


Figure 8: Intensity of Mn-doped CsPbCl_3 Nanocrystals

Although such a small amount of manganese atoms substituted the lead atoms, there was a significant difference in the optical properties.

- Compared to the CsPbBr_3 nanocrystals, the Mn - CsPbCl_3 had a lower luminescence intensity
- The substitution ratio was not 1:1 for Mn:Pb, but rather about 1:20 or less.
- Over time, the crystals begin to crash down and degrade (Figure 9).
- Instability between the crystals and the ligands
- Ligands detached from the surface

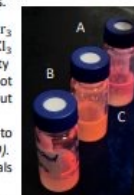


Figure 9: Degrading Nanoparticles

Further Research Plans

- Optimize doping strategies and performances
- Determine and extend the longevity of quantum dots
- Test other sources of impurities
- Determine synthesis strategies that could be used in commercial manufacturing

Conclusion

Throughout my research journey in this lab, I have learned there are numerous possibilities for technology to advance. Although it may take time and effort to fully understand the pathways to navigate advancement, the final product is never quite the end. Nanocrystals will be the foundation for modern technology and research.

Acknowledgements

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Synthesis of Formamidinium Lead Halide Perovskite Nanocrystals on a Liquid-Liquid Interface

Jack Wilton, Sohom Chandra, Yitong Dong*
*Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK



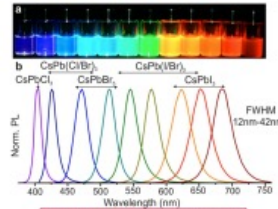
Synthesis of Formamidinium Lead Halide Perovskite Nanocrystals on a Liquid-Liquid Interface

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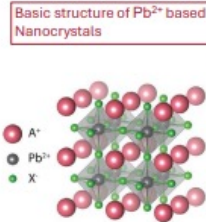
Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK

What are Perovskite Nanocrystals

Metal halide-based perovskite nanocrystals, also referred to as quantum dots, are nanometer scale crystals which have a wide variety of potential applications, highlighted by LEDs and solar cells. They can be created with a wide range of inputs and their properties can be adjusted through the environment they are created in. When stimulated, nanocrystals can emit light across the visible wavelengths in intensities generally determined by their size.



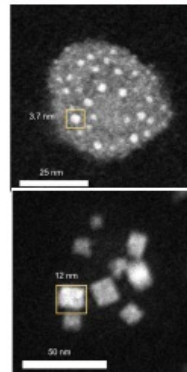
Demonstration of nanocrystal emissions across the visible wavelengths achieved using different precursors



Why Liquid-Liquid Interface Generation

- Current nanocrystal growth is largely done in flasks generating large crystals which can be homogeneous, but have formation kinetics that are too rapid for proper testing
- Through this method we can slow crystal growth, reduce crystal sizes, and control growth location

Nanocrystal growth using Liquid-Liquid interface method. $CsPbBr_3$ sample exhibited



This method has been proven to work with $CsPbX_3$ based dots, and we have applied it organic-inorganic hybrid nanocrystals

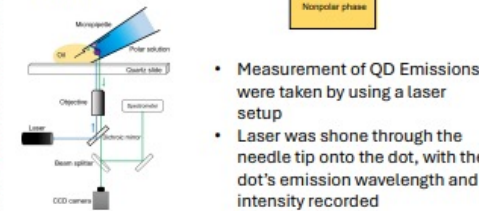
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L-L synthesis method

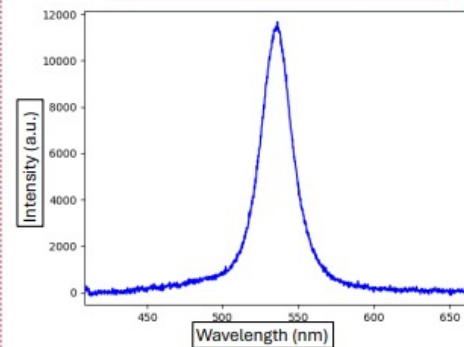
- Polar and Nonpolar Prerequisite solutions
- Nonpolar: Lead (II) acetate, Trioctylphosphine oxide, and 1-Octadecene
- Polar: Formamidinium acetate, Dimethylformamide, and Zinc Bromide

- To achieve QD generation in a desired location and size, an interface created at the tip of a glass microneedle
- Needle is filled with polar solution and dipped into a small sample of nonpolar solution



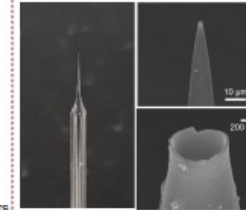
- Measurement of QD Emissions were taken by using a laser setup
- Laser was shone through the needle tip onto the dot, with the dot's emission wavelength and intensity recorded

FAPbBr3 Nanocrystal Emission Data

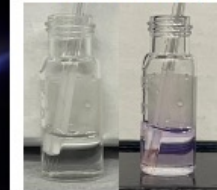


Sample intensity peaks at wavelength of 540 nm

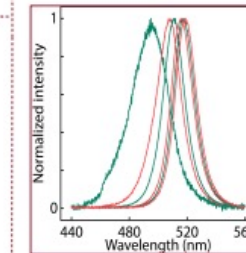
Results



- Laser pulling method was used to generate our microneedles
- Generation of organic-inorganic hybrid nanocrystals was successful
- Resulting NCs were in the green wavelengths



Future aims



- Fine changes to needle tip diameter to measure more closely differences in formation caused by interface size
- Observations of Nanocrystal emission wavelength shifts over time

Acknowledgements



DODGE FAMILY COLLEGE OF ARTS AND SCIENCES
DEPARTMENT OF CHEMISTRY
AND BIOCHEMISTRY
UNIVERSITY OF OKLAHOMA



VICE PRESIDENT FOR RESEARCH AND PARTNERSHIPS
UNIVERSITY OF OKLAHOMA



DODGE FAMILY COLLEGE OF ARTS AND SCIENCES
CENTER FOR QUANTUM
RESEARCH AND TECHNOLOGY
UNIVERSITY OF OKLAHOMA



SAMUEL ROBERTS NOBLE MICROSCOPY LABORATORY
UNIVERSITY OF OKLAHOMA

Professors: L. Yakunin, S. Bodarchuk, M. L. Klieg, F. Caputo, R. Hendon, C. H. Yang, R. X. Wang, A. Kovalenko, M. V. Nanocrystals of Cesium Lead Halide Perovskites ($CsPbX_3$, $X = Cl, Br$, and I): Novel Optoelectronic Materials Showing Bright Emission with Wide Color Gamut. *Nano Letters* 2015, 15 (6), 3692-3698. <https://doi.org/10.1021/nl504877g>.

Using Spectroscopy to Understand CsPbBr₃ Quantum Dots as Single Photon Emitters



Michael LaSala, Gavin Gee, Yitong Dong
Department of Chemistry and Biochemistry

Using Spectroscopy to Understand CsPbBr₃ Quantum Dots as Single Photon Emitters

Michael LaSala, Gavin Gee, Yitong Dong

Department of Chemistry and Biochemistry

Introduction

What is Spectroscopy?

Spectroscopy is the study of the **absorption and emission of light by matter**.¹

By measuring the absorption and emission properties of a new material, it becomes easier to apply a new material into a technology.

What are Quantum Dots?

Quantum dots are a type of nanocrystal measuring 2-10 nm in diameter. These nanocrystals typically contain many atoms, and also, they have different electrical properties, in comparison to large molecules or single atoms, due to their size.

Larger quantum dots **emit longer wavelengths** of light. Also, larger quantum dots are generally **more photostable**, they degrade less, than smaller dots.

Applications

CsPbBr₃ quantum dots have:

- High luminescence efficiencies
- Narrow emission band widths
- Single-photon emitting capabilities
- Room temperature operations

These promising properties of CsPbBr₃ would allow for quantum computers to operate at room temperature instead of at near absolute zero.

Applications Cont.

In addition, the absorption and emission profile of cesium lead bromide is also of importance in increasing the efficiency of solar cells.

Methods

A spectroscopy setup was created to measure the properties of prepared samples of quantum dots. Pulsed lasers, constant lasers, and controlling the energy of the laser were techniques commonly used to observe these quantum dots.

Results

Narrow Bandwidth Emissions

More ideally

There should be a **peak wavelength** and a **defined bell curve** of emitted wavelengths. Ongoing research is trying to understand this bell curve to narrow it, smooth it out, and get a more defined bandwidth emission profile.

Photostability

More ideally

The intensity of the quantum dot should **remain constant and not diminish**. Also, the quantum dot should **not change wavelengths**. Normally, drops in photostability are clues that the observed quantum dot contains deformities.

Results Cont.

Discrete Single Emissions

More ideally

The center peak represents when **two emitted photons** are recorded at the same time. Eliminating this center peak makes discrete single photon emissions possible.

Consistency and Nonblinking

More ideally

Blinking, **inconsistent brightness**, may occur, especially in small quantum dots. More stable quantum dots do not blink.

Blinking is caused due to the lattice structure being deformed, as is the case for much of the other nonideal deviations in recorded data.

Conclusion

CsPbBr₃ is a promising single photon emitter due to its narrow bandwidth emissions, photostability, high luminescence efficiencies, and room temperature operations. Recent research in our lab has been focused on fully understanding and controlling these processes. With a full understanding of these quantum dots, it becomes increasingly likely quantum dots will be applied into new technologies in the near future.

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Acknowledgements

Special thanks to my mentor Yitong Dong, Gavin Gee, and the whole lab for guiding me through this research.

Synthesis of a 5-membered Cyclophane

Michelle Nhã Anh Cao, Ira Joseph Studebaker, Kiran N. Naidu, Chenxin Ou, Yuanning Feng*

Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, Oklahoma 73019, United States

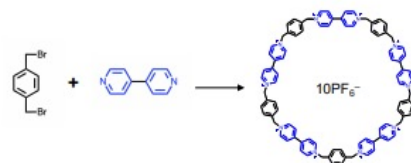


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Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, Oklahoma 73019, United States
michelle.cao@ou.edu; yf@ou.edu

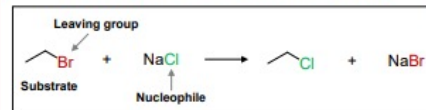


Overview



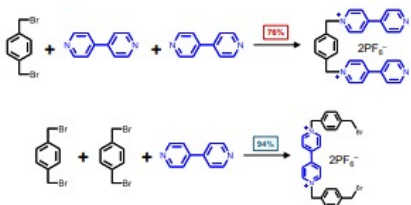
Cyclophanes are box-like macrocyclic molecules that contain rigid structures within specific cavities which allows for isolation. Our goal was to synthesize a truncated **5-membered cationic cyclophane** to investigate host-guest complexes and redox behavior.

Nucleophilic Substitution (S_N2)



Nucleophilic Substitution is the reaction between an electron pair donor and acceptor, in which an S_N2 substitution involves two molecules in the transition state. The **nucleophile** attacks the **substrate** that hosts the **leaving group**.² The leaving group's departure occurs simultaneously with the nucleophile attack, producing a substitution. In our reactions, the bromine (Br) was the leaving group, while the nitrogen (N) in the bipyridine acted as a nucleophile and attached itself to the dibromo-*p*-xylene; thus, forming **Product 1** and **2**. In our methods, we dissolved both reactants in acetonitrile (MeCN) and combined them by using a syringe pump. The MeCN solvent acted as a stable environment for the solid reactants to undergo substitution.

Syntheses of Product 1 and 2



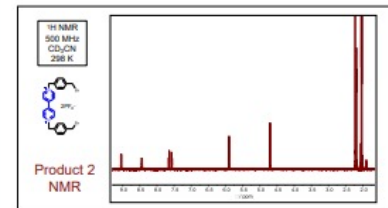
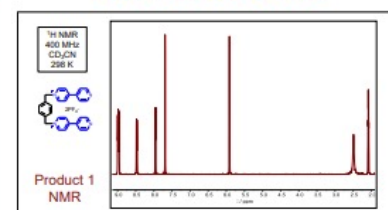
The first two reactions shown include the visualized products from dibromo-*p*-xylene and bipyridine underwent the S_N2 .

Methods

1. Added equivalent(s) of **dibromo-*p*-xylene** in acetonitrile (MeCN) into a solution of equivalent(s) of **bipyridine** in MeCN by using a syringe pump.
2. Heated under reflux for 18 h.
3. Cooled to room temperature and filtered precipitate.
4. Washed with CH_2Cl_2
5. Dissolved in H_2O and methanol (MeOH).
6. Recrystallized from H_2O .
7. Added NH_4PF_6 to solution.
8. Separation techniques: vacuum filtration.

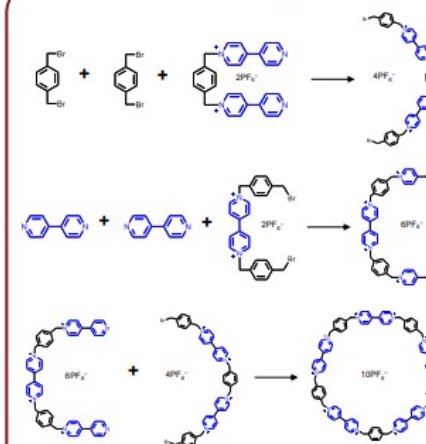


Results: NMR Spectra



We used **Nuclear Magnetic Resonance (NMR)** spectroscopy to confirm our products' structures. We used a proton (1H) NMR to test the proton resonances and yield sharp signals. Having prominent peaks for each structure correlates to less "interruptions," or unknown protons present.³ We have assigned the peak representing the protons in the product to confirm their structures and purities. In the case of our NMR spectra, we had good results for both reactions 1 and 2, respectively.

Planned Steps



To complete the final product, we need to build its two halves and connect them together. We would need additional equivalents of dibromo-*p*-xylene or bipyridine to react with **Product 1** or **2** to create each half. The reaction would require additional methods of S_N2 , in which there would be equal amounts of bipyridine to the amount of Br ions that leave the initial product(s). Once we complete each half, we will confirm the structure via NMR and conduct another round of S_N2 to combine them.

Acknowledgments

I would like to thank everyone in the **Feng Research Group!** I would especially like to thank Drs. Yuanning Feng and Chenxin Ou for their guidance throughout my research. I would also like to acknowledge Kiran Naidu and Ira Joseph Studebaker for working with me as lab partners. Finally, I would like to show my gratitude to OU, the Honors College, and the FYRE program for introducing me to the group and providing me the opportunity to carry out my research!



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Supramolecular Antenna Effect in Fluorescent Dyes

Niharika Ashutosh Sule, Natalie P. Chapel, Daniel A. Appleton, Chenxin Ou, Yuanning Feng*

Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, Oklahoma 73019, United States




Supramolecular Antenna Effect in Fluorescent Dyes

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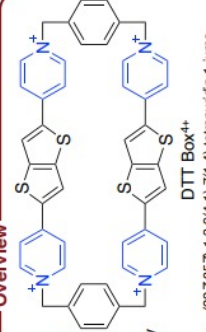
Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, Oklahoma 73019, United States

niharika.sule@ou.edu, yf@ou.edu




Overview

By using the supramolecular antenna effect, we can attempt to achieve greater fluorescent brightness in dyes. The purpose of these dyes is so that they can be used alongside with other complex molecules, polymers, and in biological applications.



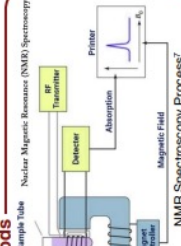
DTT Box⁴⁺

(2,2',8,8'-1,3,9(4',1',7(1',4')-tetrapyrroldin-1-iuma-2,8(2',5'-dithienyl)3,2'-bithiophene-5,11(1',4')-dibenzazacyclododecapentane-11,31,71,91-tetraam)

Methods

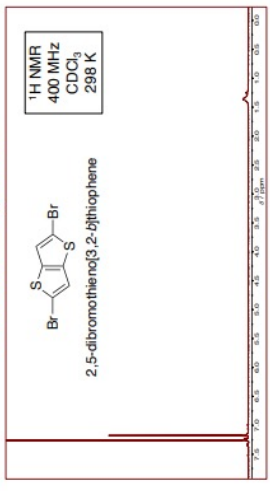
Instruments and techniques used:

- NMR Spectrometer
- Schlenk Line
- Hot Plate/Heating Block
- Rotary Evaporator



NMR Spectroscopy Process⁶

Results: NMR Spectrum



2,5-dibromo-3,2'-bithiophene

¹H NMR
400 MHz
CDCl₃
298 K

We employed **NMR spectroscopy** to validate the structures of our products. Specifically, we utilized proton (¹H) NMR to examine proton resonances and observe clear peaks. The presence of distinct peaks for each structure indicates fewer unidentified protons (impurities), reducing "interruptions" in the spectrum.⁹ We identified the peaks corresponding to the product's protons to verify both their structures and purities. Our NMR spectra yielded satisfactory results.

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Special thanks to The University of Oklahoma, the Honors College, the FYRE program, Dr. Yuanning Feng for his guidance, Dr. Chenxin Ou for his assistance, Natalie Chapel for being a great lab partner, Daniel Appleton for his assistance, and all of the Yuanning Feng Research Group for their support!






Dr. Yuanning Feng Dr. Chenxin Ou
Natalie Chapel Daniel Appleton

Department Banquet 2024

Project Objective

The goal of this project is to achieve higher fluorescent intensity limitation posed by quantum yield using the DTT Box⁴⁺.

Useful Terms

Cyclophane: a box-like macrocyclic molecule that contains a rigid geometric structure and a specific cavity.²





Nuclear Magnetic Resonance (NMR) Spectroscopy: a powerful tool to investigate structures and dynamics of molecules under a strong magnetic field.³

Rotary Evaporator (rotavap): an instrument used in laboratories for the efficient removal of solvents from solutions by evaporation under reduced pressure.⁴

Suzuki Coupling: organic reactions that use a palladium catalyst to cross-couple a boronic acid to an organohalide.⁵

TLC Plate: a chromatographic technique used to separate the components of a mixture using a thin stationary phase supported by an inert backing.⁸

Experimental Set-Up

Heating the mixture to execute the reaction (Suzuki coupling)

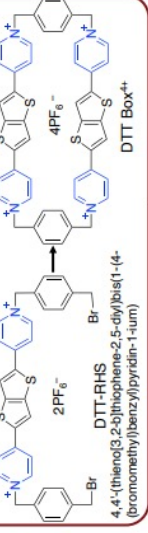
Removing the solvent using a rotavap

Washing the extracts by 10% K₂CO₃ solution (30 mL x 3) and brine (30 mL x 2)

Drying the organic fraction by MgSO₄

Future Plans

The next steps for our synthesis are to extract the residue with CHCl₃ left over from heating our reactants, reagents, catalysts, and solvents. Then, we will wash and dry the extracts to ensure that the CHCl₃ is washed out. We will wash the products again and then collect them via centrifuge. Finally, we will characterize the product by using **NMR spectroscopy** and **TLC Plate** to test the purity and calculate our percent yield and check the purity of the product. Depending on the yield we achieve, we will proceed by repeating the reaction to synthesize the **cyclophane**.



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Synthesis of the Pentagonal Cyclophane

Sheridan K. Munoz, Jennifer T. Ou,
Yuanning Feng* FYRE Program 2024,
Honors College

Department of Chemistry and
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Oklahoma, Norman, Oklahoma 73019,
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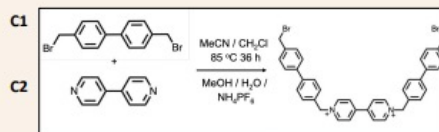
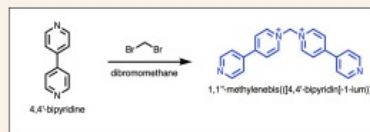
FYRE Program 2024, Honors College

Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, Oklahoma 73019, United States



Goal and Hypothesis

We wanted to synthesize create a full cyclophane in the shape of a pentagon. While we have the "top half", the hat, consisting of two edges, we need to synthesize the "bottom half" - the reverse horseshoe. We are forming this reverse horseshoe using 4,4'-bipyridine, and 4,4'-bis(bromomethyl)-1,1'-biphenyl.

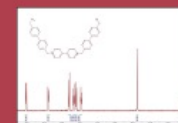
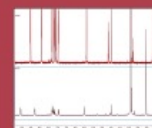


Background

- Typically, cyclophanes are considered as organic molecules exhibiting a loop of cyclic structures (Garcia).
- They are used as drug carriers because they bind more selectively to a guest.
- The typical shapes are triangles and hexagons with some variants.

Process

- Firstly, we ensured we could form the hat. We then mixed C1 and C2, collecting the newly formed precipitate.
- We attempted to dissolve our solution in water and ethanol.
- It did not dissolve, so we moved to using MeCN. This formed a usable precipitate.
- Using paper chromatography and NMR, we found that a large portion of our product was formed, but still undissolved.
- In order to form our product, we had to break down the polymer into individual units. The yield was 35%.
- We are currently starting our reaction to join the two pieces. This is an $\text{S}_{\text{N}}2$ reaction.



Application

- Synthesizing a new shape of macrocycle opens up new opportunities for drug and chemical carriers because of different geometries.
- Different cavities are suitable for different guests, so having a pentagon could allow for larger guests.

Useful Terms

- **NMR Spectroscopy:** A technique used to characterize a sample. This determines its purity and molecular shape.
- **$\text{S}_{\text{N}}2$ Reaction:** A nucleophilic substitution reaction mechanism.
- **MeCN:** Acetonitrile

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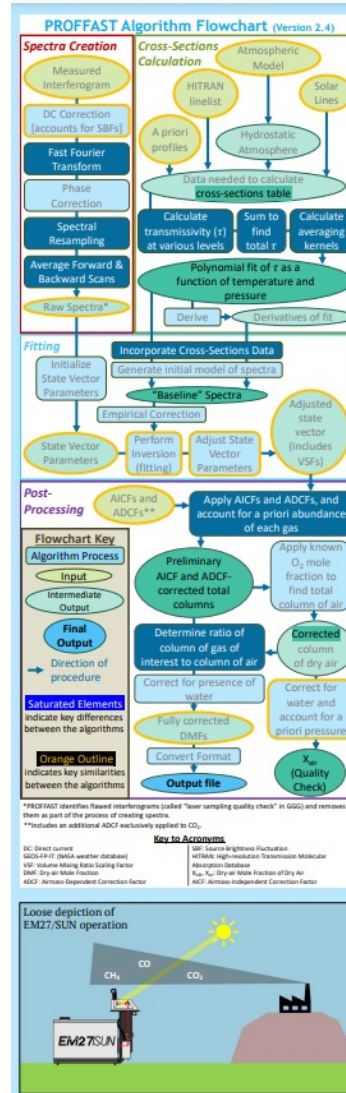
Acknowledgments

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Comparison of Retrieval Algorithms for EM27/SUN Spectrometer Data

Noah A. Schneiderman 1*, Elizabeth Spicer 1, Wesley T. Honeycutt 2

1 University of Oklahoma, School of Meteorology, 2 University of Oklahoma, Gallogly College of Engineering, *Presenting author



Comparison of Retrieval Algorithms for EM27/SUN Spectrometer Data

Noah A. Schneiderman^{1*}, Elizabeth Spicer¹, Wesley T. Honeycutt²

¹University of Oklahoma, School of Meteorology; ²University of Oklahoma, Gallogly College of Engineering

*Presenting author; contact: noahschneiderman@ou.edu

Abstract

There exist two networks that use ground-based infrared spectrometers to determine the abundance of trace gases in the atmosphere at various locations worldwide, each of which developed a separate retrieval algorithm for converting raw spectra data into processed dry-air mole fractions. Although these two algorithms should produce identical results, discrepancies have been observed between them. In this project, I conducted a deep analysis of the structure of each retrieval algorithm by performing an extensive literature review and confirming my findings with the code itself. I created a detailed flowchart depicting the operation of each algorithm, noting both major differences and key similarities between them. I also used each algorithm to analyze sample data collected with the University of Oklahoma's EM27/SUN instrument. In doing so, I observed a slight disparity between retrievals from the two algorithms, which worsened under nonideal conditions.

Introduction and Methods

Broad scientific consensus holds that anthropogenic greenhouse gas (GHG) emissions are causing global climate change at an unprecedented rate (Intergovernmental Panel on Climate Change 2023). As such, it has become more important than ever for the scientific community to have accurate measures of atmospheric GHG concentrations and distribution. Two networks, known as the Total Carbon Column Observing Network (TCCON) and the Collaborative Carbon Column Observing Network (COCCON), composed of Bruker 125HR FTS spectrometers and Bruker EM27/SUN spectrometers, respectively, monitor trace gases—principally carbon dioxide (CO_2), methane (CH_4), and carbon monoxide (CO)—measured as dry-air mole fractions (Wunch et al. 2011) (Frey et al. 2015). The retrieval algorithms used by each network to produce this information from raw data, GGG2020 and PROFFAST, respectively, differ slightly, causing inconsistencies in obtained results. Although relatively minor (Sha et al. 2020), these discrepancies are nonetheless problematic, as even a small error can hinder analysis of the minute spatial and temporal variations of GHG concentrations. The literature review entailed mainly searching databases, and the flowcharts were created based on detailed notes on each section of the algorithm. When collecting sample data, we used a Bruker EM27/SUN spectrometer and Vaisala PTB330 with Campbell-Scientific CR6 data logger software.

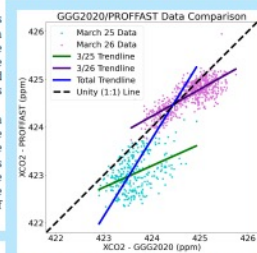
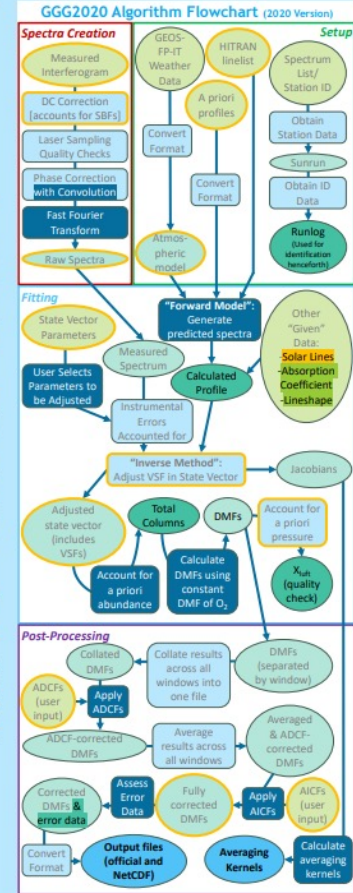
Results and Discussion

My analysis of the algorithms yielded the flowcharts shown on either side. Some of the most notable differences between the algorithms include the order of steps in the interferogram-to-spectra conversion process, the differing methods of incorporating a priori data (GGG2020's forward model vs. PROFFAST's cross-sections table), and the order in which the post-processing steps are carried out.

In the sample data, I observed that retrievals taken with GGG2020 tended to be mildly higher than those taken with PROFFAST. We deployed the EM27/SUN on two days, March 25th and 26th, and the mean difference ($GGG - PROFFAST$) in the retrieved dry-air mole fraction of carbon dioxide (X_{CO_2}) was 0.613 ppm on the 25th and 0.102 ppm on the 26th. All in all, especially for the 26th, this is a remarkably small discrepancy considering the number of differences between the algorithms. The difference was likely worse on the 25th due to clouds hindering measurements more on that day, and the variations in solar intensity could exacerbate the differences between the algorithms' methods of converting interferograms to spectra.

Conclusions

Although their structural differences can cause minor inconsistencies between them, GGG2020 and PROFFAST are both effective tools for the processing of EM27/SUN data. Further analysis of the code and more rigorous empirical testing is needed to definitively relate algorithm differences to observed discrepancies.



References

All references can be viewed using this QR code.

Acknowledgments

I would like to thank the University of Oklahoma's Honors College for organizing and funding the First-Year Research Experience (FYRE) program. I would also like to thank Anamaria Eldering for her role in guiding this project, and Nicole Jacobs for processing the data with GGG2020 on my behalf.

Topology-Dependent Proton-Coupled Electron Transfer (PCET) Thermochemistry of Ce-based Metal Organic Frameworks

Andrew Lynch and Hyunho Noh

Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, OK



Topology-Dependent Proton-Coupled Electron Transfer (PCET) Thermochemistry of Ce-based Metal-Organic Frameworks

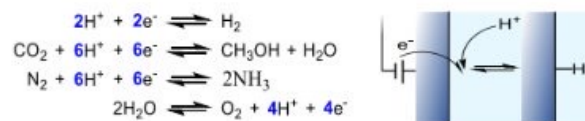
Andrew Lynch, Hyunho Noh*

Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, OK



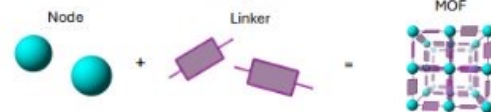
Introduction

Heterogeneous electrocatalysts that can generate fuels in a carbon-neutral manner are vital for a sustainable future. Many chemical reactions that involve the generation of fuels involve proton-coupled electron transfer (PCET) reactions. These reactions are essentially hydrogen atom (H) transfer because 1 proton (H⁺) and 1 electron (e⁻) are equivalent to one hydrogen atom.³

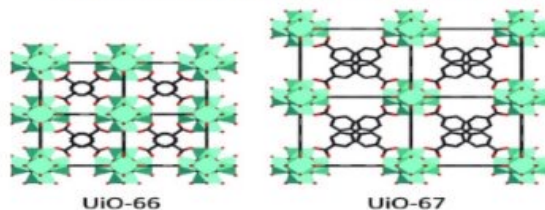


Metal-Organic Frameworks (MOFs)

Metal Organic Frameworks (MOFs) are highly porous, crystalline structures composed of an electrochemically active metal node, and a large organic (carbon based) linker.



Crystal Structure of Ce-UiO-66 and Ce-UiO-67



References and Acknowledgement

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2. Yuan, Shuai, et al. Nature Communications, 2019, 37, 12.
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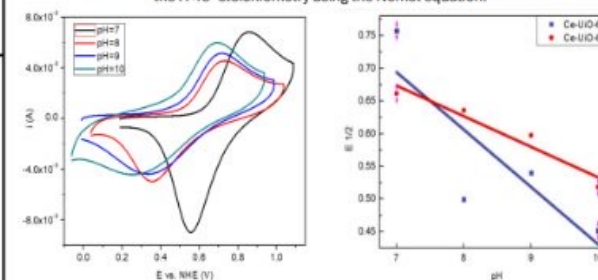
We thank the University of Oklahoma and the Joe C. and Carol Kerr McLendon Honors College for supporting the FYRE program.

Objective

To determine the stoichiometry (ratio) of proton to electron being transferred during a proton-coupled electron transfer reaction occurring at the Ce node to reduce Ce(4+)-O to Ce(3+)-OH in Ce-UiO-66 and Ce-UiO-67.

Methods

To determine H⁺/e⁻ stoichiometry, we measured cyclic voltammograms (CVs) at various pH. These CVs measure oxidation (loss of electron) at the higher peak, and reduction (gain of electron), at the lower peak. The average of the waves is known as half-wave potential (E_{1/2}) and is plotted against pH, which can be used to calculate the H⁺/e⁻ stoichiometry using the Nernst equation.⁴



Results

To find H⁺/e⁻ stoichiometry, we can derive an equation from the Nernst equation.

$$E = E^{\circ} - \frac{0.0592V}{n} \log \left[\frac{red}{ox} \right] \longrightarrow E = \left(\frac{m}{n} \right) 0.0592V$$

By plugging in the slope of the diagram above for E (48 in UiO-67 and 88 in UiO-66), we find the values for m/n to be 2/3 for Ce-UiO-66 and 1/1 for Ce-UiO-67, correlating to 3H⁺/2e⁻ and 1H⁺/1e⁻ stoichiometry respectively, giving us the following reaction in Ce-UiO-67, while exact chemistry of the PCET reaction of 3H⁺/2e⁻ is unknown.



Conclusions

The H⁺/e⁻ stoichiometry of Ce-UiO-67 is promising as the even H⁺/e⁻ stoichiometry means that Ce-UiO-67 could be a potential catalyst for the aforementioned reactions, and it is possible to study the proton topology. The uneven H⁺/e⁻ stoichiometry of Ce-UiO-66, however, is not as promising as the chemistry of the PCET reaction is not yet understood.

Effect of DNA Binding Agents On Cell Division and Chromosome Segregation

Madeline Stout, Dr. Valentin Rybenkov, Sidra Ajmal
Department of Chemistry and Biochemistry, University of Oklahoma



Effect of DNA Binding Agents On Cell Division and Chromosome Segregation

Madeline Stout, Dr. Valentin Rybenkov, Sidra Ajmal

Department of Chemistry and Biochemistry, University of Oklahoma

Introduction

Pseudomonas aeruginosa

- *P. aeruginosa* is an opportunistic, gram-negative human pathogen, which typically infects those in hospital settings, as these cells have become increasingly antibiotic resistant [1].
- This bacterial strain has multiple virulence factors, such as its outer membrane and biofilm formation capabilities.

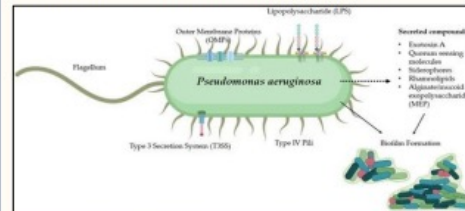


Figure 1: Virulence factors of *P. aeruginosa* [2]

Cell Division

- The processes of DNA replication, segregation, and cell division are intertwined through the timing of different proteins like oriC, MksB, and FtsZ.
- The cell division FtsZ allows for the formation of the Z-ring [3].
- If the localization of FtsZ is not perfect, then the process of cell division will possibly be ineffective and irregular.

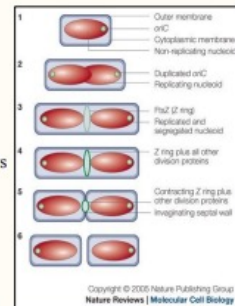


Figure 2: Cell division process in bacterial cells

DNA Binding Compounds

- Proflavine: effective drug against gram-positive bacteria, has been proven to work as an antibacterial drug [4].
- Hoechst 33342 (HT): a blue fluorescent compound that binds to the DNA of a cell. It has proven to inhibit DNA synthesis, which could impact cell division later in the cell cycle [5].

Question: Will DNA binding agents like Hoechst 33342 and Proflavine affect the process of cell division and the localization of FtsZ?

Methodology

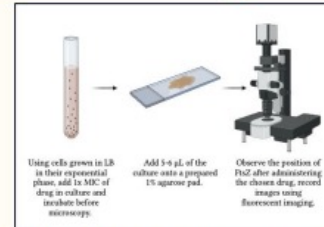


Figure 3: Method for fluorescent microscopy using sub-cultured bacterial strains that have fluorescent tagged proteins

MIC Values (Minimum Inhibitory Concentration): Hoechst 33342 (2µM) and Proflavine (3.12 µg/mL)

Results

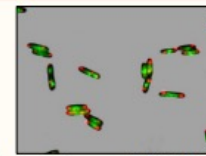


Figure 4: Fluorescent imagery of MksB-GFP and oriC-mCherry tagged strain of *P. aeruginosa*.

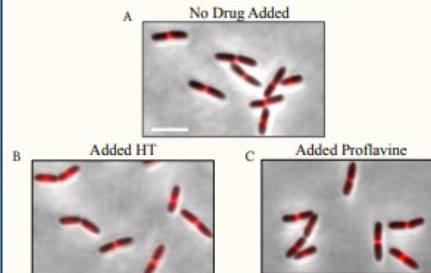


Figure 5: The effect of DNA binding compounds on FtsZ. (A) Fluorescent image of FtsZ naturally located in the mid-cell after no addition of a DNA binding compound. (B) Fluorescent image of FtsZ located in the mid-cell after the addition of Hoechst 33342. (C) Fluorescent image of FtsZ located in the mid-cell after the addition of Proflavine.

Conclusion

- FtsZ, a protein vital for cell division, was not immediately impacted by DNA binding compounds like Hoechst 33342 or Proflavine. The localization of this protein remains at the midcell.
- In the future, further experimentation could include testing the multi-generational mutagenic effects of these compounds on cells and exploring other DNA binding compounds and their effects on cell division and chromosomal segregation.

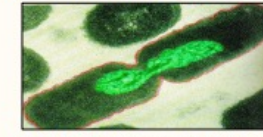


Figure 6: The process of cell division in bacteria, septum formation in the mid-cell [6].

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Acknowledgements

Special thanks to Dr. Valentin Rybenkov, Sidra Ajmal, and the rest of the members of the Rybenkov lab. Also, to the Honors College for sponsoring the First Year Research Experience program and for providing this event. Finally, thanks to Dr. Heather Ketchum for guiding the FYRE students through this semester.

Impact of DNA-binding compounds on chromosome segregation in *Pseudomonas aeruginosa*

Promise Okpah, Valentin V. Rybenkov

Department of Chemistry and Biochemistry, University of Oklahoma

Impact of DNA-binding compounds on chromosome segregation in

Pseudomonas aeruginosa

Promise Okpah, Valentin V. Rybenkov
Department of Chemistry and Biochemistry, University of Oklahoma



Introduction/Background

Antibiotic Resistance

- Antibiotic resistance is an increasing problem as the overuse of certain antibiotics has selected for new generations of resistant bacteria.

Chromosome Segregation

- Chromosome segregation is the process of separating newly replicated DNA to be shared equally by two daughter cells. Condensins, a type of protein, play an important role in segregation as they aid in chromosome maintenance and organization.

Pseudomonas aeruginosa

- Pseudomonas aeruginosa* is a gram negative, opportunistic pathogen responsible for a variety of infectious diseases. Its ability to cause disease is aided by its virulence factors, cell envelope, and numerous metabolic enzymes suitable for varying niches.

Project Objective

- Our objective is to see whether DNA mutagens such as proflavine and Hoechst 33342 affect chromosome segregation.

Methods

1. Grow bacteria to be observed
50 microliters of bacteria are inoculated in 5 milliliters of LB, rich, media along with the necessary compounds. The inoculated tube is placed in a 37-degree shaker for approximately 1 hour and checked to see if it is in the appropriate growth phase.

2. Prepare Slide

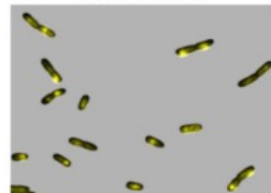
50 to 70 microliters of 1% agarose is placed on a slide to produce a pad for the bacteria. 5 to 6 microliters of bacteria is placed on this pad and allowed to dry before being covered and placed under oil.

3. View under microscope

A microscope, Olympus BX50, is used to observe the cells through fluorescent protein tagging. DAPI is used to view the DNA, while TRITC is used to view the oriC and GFP is used to view the SMC condensin. After images are taken, the images are overlaid to compare positioning.

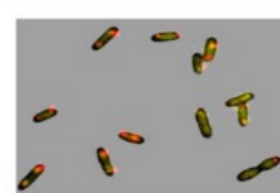
Results

SMC-mVenus



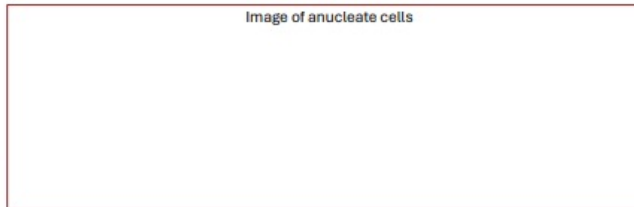
Localization of SMC condensin

SMC-mVenus and oriC-mCherry



Localization of SMC in comparison to the origin of replication

Image of anucleate cells



Composite 1

	Normal	Anucleate	% Anucleate
No Drug			
HT	110	0	0
Proflavine	101	0	0

Composite 2

	Normal	Anucleate	% Anucleate
No Drug			#DIV/0!
HT	85	0	0
Proflavine	160	0	0

During this project, we observed the localization of the origin of replication, oriC, and the condensin, SMC. In this observation, we noted that SMC tends to be located near the origin of replication. Additionally, we looked to see if the addition of the drugs resulted in the formation of anucleate cells, cells without DNA. There were not any anucleate cells observed as we were able to see DNA contained in the membrane of the cell.

Discussion/Conclusion

Ultimately, microscopy was utilized to observe the localization of the SMC condensin and determine whether the mutagens produced any anucleate cells. SMC was found at the cell quarters near the oriC, which was confirmed by previous research. Additionally, there were no major defects in chromosome segregation, which meant that the mutagens did not successfully target chromosome segregation. Further research could be aimed at looking at other classes of compounds to see if they cause defects in chromosome segregation as a pathway for causing cell death.

References



Acknowledgements

I would like to thank the Honors College and the FYRE program, directed by Dr. Ketchum, for their continuous support. I would also like to thank Dr. Rybenkov, Sidra Ajmal, and the rest of the lab in the department of Chemistry and Biochemistry.

Investigating the Role of m6A Methylation in Regulating Secondary Structure and Stress Response of the *SIPP2C3* mRNA Transcript in Tomato Anthers

Kara Meloni and Anayat Yousuf
Lab of Dr. Susan Schroeder PhD.

Department of Chemistry and
Biochemistry, University of
Oklahoma, OK



Investigating the Role of m6A Methylation in Regulating Secondary Structure and Stress Response of the *SIPP2C3* mRNA Transcript in Tomato Anthers



Kara Meloni and Anayat Yousuf

Lab of Dr. Susan Schroeder PhD, Department of Chemistry and Biochemistry, University of Oklahoma, OK

Background

- Methylation is the addition of a methyl group (CH_3) to a nucleic acid usually due to environmental factor such as stress, hormone levels, etc.

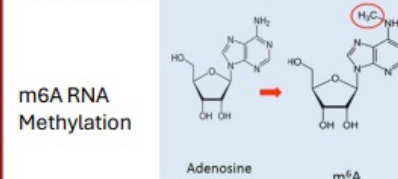
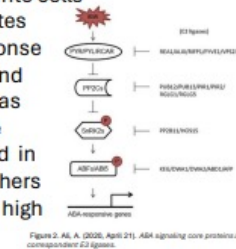


Figure 1. Romano, G. (2014, July 15). A schematic representation of the Principal methylation modification in eukaryotic DNA.

- m6A methylation may also alter the 3D structures of 3' untranslated regions of RNA, and while these sites do not code for proteins, they play a role in regulation of gene expression
- Changing 3D structure changes interaction with other molecules
- SIPP2C3* is an mRNA strand that signals the transduction of abscisic acid (ABA) into cells
- ABA regulates stress response in plants, and *SIPP2C3* was found to be upregulated in tomato anthers in times of high stress.



- Increased ABA in anthers leads to reproductive dormancy and increased focus on sustaining homeostasis within the plant
- 3D structures are not necessarily changed due to methylation

Hypothesis

The m6A methylation of the *SIPP2C2* transcript in tomato anthers changes under moderate low-temperature (MLT) stress, and these changes affect the secondary structure of the RNA, potentially influencing its interaction with proteins and its translation by the ribosome.

2D structure of *SIPP2C3*



- Color corresponds to probability that the region is folded correctly.
- Warmer colors- More probable.
- Cooler colors- Less probable.

Results

- Analysis of the 2D diagrams of *SIPP2C3* before and after methylation shows very little difference in secondary structure in high probability regions.
- The difference in structure in lower probability regions of the diagram is not reliable data.

Results (cont.)

- Let it be known, the graphic representation of the mRNA structure is not exact.
 - The secondary structure prediction does not account for variables such as protein interactions or multiple functional structures.
 - RNA can change shape on its own, without the introduction of methylation.
- Therefore, with the data presented, we are unable to confirm or reject our initial hypothesis at this time.

Effect on Future

- Although our results were inconclusive for this specific mRNA strand, this is not the case for all stress responsive mRNA strands.
- Understanding how different stressors and resulting methylation effect plant development and gene regulation is the key to understanding, more accurately, what environment plants, tomatoes in this case, grow best in.
- This leads to higher crop yields and higher quality crop overall, which is so important in a time of food insecurity for billions of people across the globe.
- Additionally, further study into temperature and drought methylation effects can be used to our advantage when dealing with issues like climate change.
- If we can understand what causes the tomatoes to fail in certain environments, we can understand what we need to do to combat it.

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Analyzing Spatial Organization of Metabolites Involved with Polymicrobial Wound Infections

Hannah Smith, Nathan Colwell,
Carolyn Ibberson, Zhibo Yang

Department of Chemistry and
Biochemistry, Department of Biology

Analyzing Spatial Organization of Metabolites Involved with Polymicrobial Wound Infections

Hannah Smith, Nathan Colwell, Carolyn Ibberson, Zhibo Yang
Department of Chemistry and Biochemistry, Department of Biology



Introduction

- Annually, \$25 billion are spent on wound care in the United States and a large amount of chronic wound infection are caused by *S. aureus* and these infections are worsened by coinfections with *P. Aeruginosa*. However, the mechanisms of these bacteria are not well known. (2)
- To better understand how *S. Aureus* and *P. Aeruginosa* interact within an infection, differential spatial organization of their metabolites will help determine where these bacteria localize.
- Using metabolomic analysis on these wounds will enable insight in the mechanisms of polymicrobial bacteria during infection. (2)
- Data acquisition through desorption electrospray ionization mass spectrometry imaging (DESI-MSI) is a novel technique is significant due to the minimal sample preparation it requires, its rapid data acquisition, and its direct measurements of metabolites. (1)

Methods



Mice Wound Model:

A wound was created on the back of the mouse then infected with *S. aureus* and *P. aeruginosa*. Wound is excised and stored until sectioning.

Sample Collections:

Wound samples are prepared into slide by slicing the wound horizontally with a microtome.

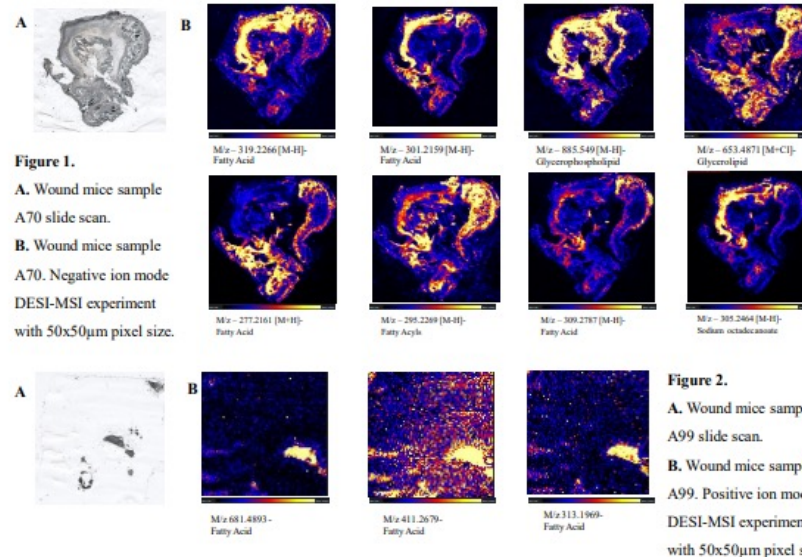
DESI-MSI:

Data acquisition is done on the wound sample through DESI XS/Water Synapt G2SI. Trails of both positive and negative ion mode were completed.

Data Analysis:

The M/z data is corrected to the luccine enkephalin lock mass and background ions are removed. Significant ions and their heat maps were further reviewed.

Results



Conclusion

- Through DESI-MSI, high spatial resolution images of non-bandage wound mice samples were produced.
- Analysis of the DESI-MSI results reveals a variety of fatty acids and significant metabolites to the metabolism of polymicrobial bacteria during in vivo wound infection.
- The spatial distribution of the metabolites found through DESI-MSI provide insight to where polymicrobial bacteria are localized.
- This wound analysis approach will provide significant advancements in understanding pathogen biology. By analyzing wound dressings on mice, these finding will eventually lead to the analysis of human wound infection to better wound dressing and infection treatment clinically.

Acknowledgements

Thank you to Dr. Zhibo Yang for providing me with this opportunity to research in your lab and for providing the equipment to complete the DESI-MSI trials. Thank you to Dr. Carolyn Ibberson for providing the mice samples!

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Quantification of Benznidazole in Single Cells Using Single-Probe Mass Spectrometry Technique

Shayla N. Van, Christina Chau, Tra D. Nguyen, and Zhibo Yang*²

1. Department of Chemistry & Biochemistry, The University of Oklahoma, Norman, OK 73019

*Corresponding author email: Zhibo.Yang@ou.edu

Quantification of Benznidazole in Single Cells Using Single-Probe Mass Spectrometry Technique

Shayla N. Van, Christina Chau, Tra D. Nguyen, and Zhibo Yang*² 1.

Department of Chemistry & Biochemistry, The University of Oklahoma, Norman, OK 73019

Introduction

- Single cell mass spectrometry (SCMS) can analyze molecular features of individual cells and quantify small molecules after the treatment condition.
- Chagas disease is a neglected infectious disease that started in South America, which is caused by the parasite *Trypanosoma cruzi*.
- Benznidazole is an anti-parasitic medication used to treat Chagas disease by damaging the DNA of *Trypanosoma cruzi*.
- Due to cell heterogeneity, the Benznidazole-treated cells will have different amounts of Benznidazole from cell-to-cell, therefore a study needs to be conducted at single cell levels.
- SCMS is a very powerful tool to sensitively detect and identify molecules at low abundance. Therefore, SCMS is employed to study the quantification of small molecules, Benznidazole, at the single cell level.

Methods

Single-probe SCMS technique

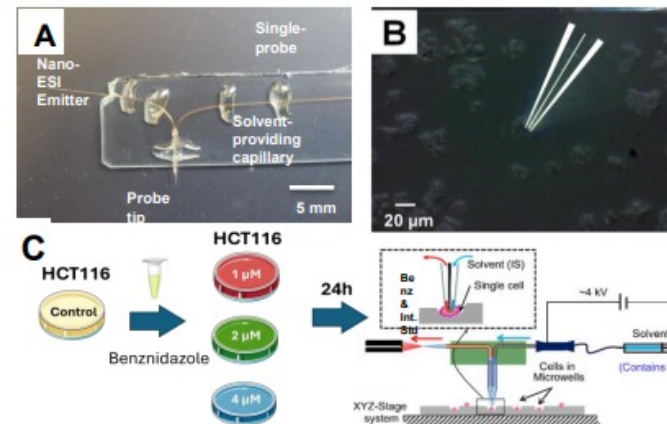
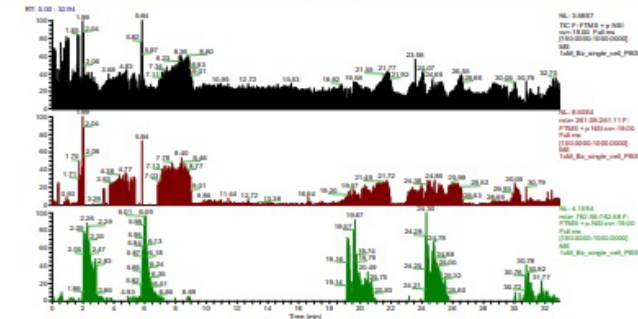


Figure 1. The experiment design for quantification of Benznidazole (Bz) in single cell. (a) Real-life image of the Single-probe device and their components; (b) Microscopic image of HCT116 during SCMS analysis; (c) Experimental workflow of quantification of Benznidazole.

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- Advisor: Professor Dr. Zhibo Yang
- Yang lab members: Tra D. Nguyen, Zongkai Peng, Yunpeng Lan, Dan Chen, Amit Singh, Shakya Munige, Deepthi Bhusal, Nathan Colwell, Christina Chau, Annalise Huynh
- Funding: National Institute of Health (NIH) and National Science Foundation (NSF)

Results



The Effects of Tobacco Mosaic Virus on Environmental Stressors and RNA Structure in Tomato Plants (*Solanum lycopersicum*)

Sarah Joseph, Kara Meloni, Anayat Yousef, Matt Lettow, Kristen Duong, Andrea Jones, and Dr. Susan J. Schroder

Department of Chemistry and Biochemistry and School of Biological Sciences



The Effects of Tobacco Mosaic Virus on Environmental Stressors and RNA Structure in Tomato Plants (*Solanum lycopersicum*)

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Department of Chemistry and Biochemistry and School of Biological Sciences



Introduction and Background

Throughout this semester, there were a series of projects done in order to understand the effects of Tobacco Mosaic Virus (TMV) in tomato plants (*Solanum lycopersicum*).

- TMV is a single-stranded RNA virus easily transmitted between plants.
- Signs of infection: wilted leaves and other physical characteristics.
- Changes in RNA support that the plant may gain resilience to environmental stressors.
- **Objective: 1. Determine if TMV benefits the plant response to stress 2. Determine structure of methylated RNA and response to environmental stressors**



Infected Dry (TD) Uninfected Dry (UD)

Methods

Collecting tomato plant samples:

- 48 total plants were divided into four groups: uninfected wet (UW), uninfected dry (UD), infected wet (TW) and infected dry (TD). These were grown in a controlled growth chamber to minimize discrepancies.
- Infections was done by rubbing abrasive with TMV or water and leaves were monitored through stomatal conductance for four weeks using a leaf porometer.

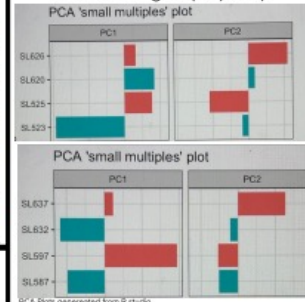


Top: Infected Bottom: Uninfected

Results

Results were based on data collected in similar experiments performed in the spring and fall of 2021. Data analysis has been ongoing since 2021 for several rounds of biological replicates:

- From results of previous experiments, as well as data collected from these, there were lower stomatal conductance recorded for dry plants infected with TMV against uninfected plants
- From plots generated by R studio on multiple biological replicates, the effects of TMV can be shown clearly. According to these plots, infected groups (pink) hold greater resilience factors than uninfected groups (blue).



- These PCA plots are generated from the RNAseq data mentioned above.
- They show the variance of each group and are divided based on infection status.

Analysis

Analysis of the data collected was done through a number of ways:

- RNA sequencing was done through the OMRF clinical genomics center
- Programs such as Kallisto and R studio were used to process the data collected and make the above graphs
- Through analysis we were able to gain immediate results of how each plant reacted to the infection
- All these tools are still being used to investigate further questions about how TMV and other viruses can benefit a plants stress response.

m6a Methylation

- m6a is a modification made in both DNA and RNA that regulates gene expression
- SIPP2C1 is a transcript that can be used to inhibit enzyme activity.
- Through measuring the amount of methylation in transcripts of RNA, we were able to plot an approximate structure of RNA with and without methylation, and see the effects of methylation on the RNA structure.

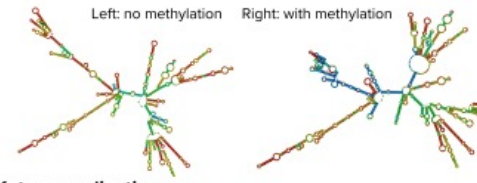
Discussion

Uninfected and infected TMV plants:

- The effects of infection are not always negative
- Infected dry plants fared better than the uninfected dry plants, and gained resilience to biotic and abiotic stressors.
- The stomata of dry plants had a lower conductance rate.
- There may be some genetic difference that is altered in the RNA of infected plants

m6a Methylation:

- In Yang et al. it was reported that changes in m6a were due to response to cold stress
- mRNA folding is different in structure when comparing structures with and without methylations
- As shown in the following pictures, m6a methylation provided a different structure when the same mRNA (*SIPP2C1*) strand was examined.



future application:

- test other plants in this family and see the effects of infection
- determine genes and transcription factors that changed as a result of infection
- understand how methylation and structures effect plant development in certain environment
- Long term goal: predict RNA structure and function from sequence

Institute for Theoretical Chemistry, University of Vienna, INFOLD WebServer, Vienna RNA, <http://rna.ict.ac.at/infold/>

Acknowledgements

I would like to thank Dr. Schroeder for accepting me in to her lab alongside the following lab members: Kara Meloni, Anayat Yousef, Matt Lettow, Kristen Duong, Andrea Jones, Averi Bates, Meena Ramadugu, Cole Kiger, Dongyu Wang and Dr. Graham Wiley at OMRF. I would also like to thank Dr. Ketchum and the University of Oklahoma Honors College for this opportunity.

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Bond Behavior of Nano-Enhanced Polymer Concrete for Bridge Deck Overlays

Ali Akbarpour, Trent Rogers, Dr. Shreya Vemuganti

2021 REPORT CARD FOR AMERICA'S INFRASTRUCTURE

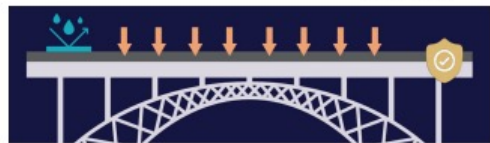
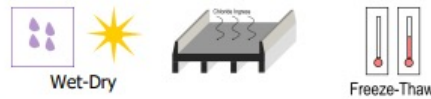
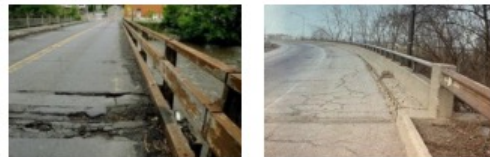
ASCE **Mediocre - At Risk**

- Deterioration
- Aging components
- Deficiencies in condition
- Increased vulnerability to risk
- Concern to functionality



Introduction

- 46,154 (7.5%) of the nation's bridges, are considered structurally deficient and 260,000 (42%) bridges are at least 50 years old
- Bridges deteriorate due to long-term fatigue from load, freeze-thaw cycles, and corrosion.
- One solution involves overlaying a thin layer of polymer concrete on top of the existing substrate to protect from further damage.
- Carbon Nanotube improves the adhesive abilities by interfering in the polymerization process, this improves bond strength, wear resistance, and ductility of the overlay.
- There is a gap in understanding how adding carbon nanotube impacts the bonding strength of neat polymer concrete overlays.
- We hypothesize that incorporating carbon nanotube will improve neat polymer concrete's bond performance with a substrate.



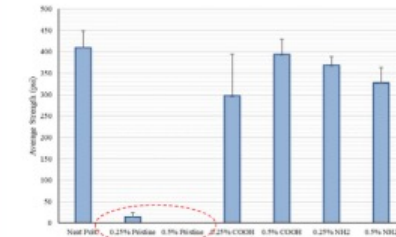
Methods

- This study aims to assess bond performance of neat polymer concrete mixed with different quantities of carbon nanotube.
- We first mixed Portland cement concrete blocks to represent typical composition of a bridge deck.
- Then we submerged the blocks in sulfuric acid for 28 days to recreate long-term environmental exposure.
- We created a control sample by overlaying one block with neat polymer concrete.
- Next we mixed polymer concrete with varying concentrations (0.25%, 0.5%) and types (Pristine, COOH, NH₂) of carbon nanotube.



Results

- 0.5% COOH Carbon nanotube displayed similar bond strength to neat polymer concrete overlays.
- While maintaining bond strength, the addition of carbon nanotube increased pore character and wear resistance of the overlay.



No.	Result (N)	Area (mm ²)	Pull-Off Strength (MPa)
1	5000	2026.8	2.5
2	9100	2026.8	4.5
3	6500	2026.8	3.2
4	10000	2026.8	4.9
5	12500	2026.8	6.2

Discussion

- Further investigations with varying thickness and larger sample sizes could explain the differences between bond strength in nano-enhanced polymer concrete and neat polymer concrete.
- We plan to investigate how different nano-enhanced polymer concrete overlays perform in adverse environmental conditions.
- Future direction could include studying these samples under

Conclusion

- This study identified a carbon nanotube that has potential for application in bridge overlays.
- This project's impact could be a reduction in carbon emissions, traffic interruptions, and overall material use while improving the bridges structural integrity.

Bond Behavior of Nano-Enhanced Polymer Concrete for Bridge Deck Overlays

Ali Akbarpour, Trent Rogers, Dr. Shreya Vemuganti



ADS-B Tracking with GNU Radio: Tracking Planes for Radar Surveillance

Peter Voegeli and Wyatt Saunders
Faculty Advisor: Dr. Justin Metcalf

School of Electrical and Computer Engineering and Advanced Radar Research



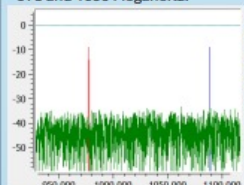
ADS-B Tracking with GNU Radio: Tracking Planes for Radar Surveillance

Peter Voegeli and Wyatt Saunders
Faculty Advisor: Dr. Justin Metcalf
School of Electrical and Computer Engineering and Advanced Radar Research

Background

What is ADS-B?
ADS-B or automatic dependent surveillance-broadcast is an automatic broadcast of an airplane's GPS location, altitude, and other relevant information. This information is broadcast by the plane and is intended to allow for air traffic control to have reliable information about all planes in the sky. However, ADS-B's use is not just limited to ATC because it is broadcast for anyone with an antenna to pick up.

How do we find it?
ADS-B is broadcast at specified wavelengths. Specifically, 978 and 1090 Megahertz.



When we know the wavelength, we can focus on just those wavelengths. As the signals are unencrypted we can receive the ADS-B data by just receiving the signal. Seen left is an example of an antenna receiving a

noticeable amount of ADS-B frequencies (978 MHz and 1090 MHz) when compared to the frequencies around it. This indicates an ADS-B signal is being transmitted (non-ADS-B signals at this frequency would be illegal) because the frequency is stronger than it would be if it was just background noise.

Why do we need to find an ADS-B signal?

Radars emit signals, but the signals may not be distributed equally. Most radars are directional and can only scan a small portion of the sky at a

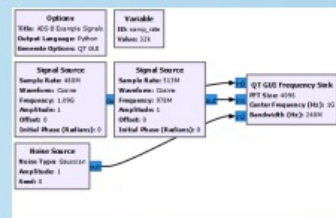


time. Therefore, finding potential targets through other means will greatly improve the radar's efficacy. Moreover, radars produce an enormous amount of data, and even if the storage is not an issue all the data would need to be sifted through. Without any way to know when the relevant data was collected, it could take hours to look through the recorded data. However, when the ADS-B information is collected it can be stored. Then that data can be used to find and differentiate between planes that were within range when data was collected.

Methods

Although ADS-B is not encrypted it is still not human readable until the signals are processed by a program. The specific program that will be used is from a development toolkit for software-defined radios called GNU Radio.

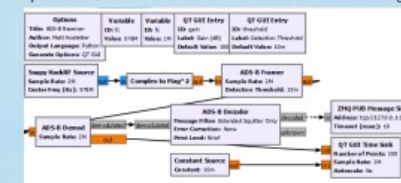
What is GNU Radio?
GNU Radio is an open-source software development toolkit that provides signal processing blocks for software-defined radios. In other words, it is a collection of premade programs that make it easier to express what occurs in radar devices. Moreover, if there is not a block to express the idea the user can create their own block.



The GNU Radio blocks used to create the example frequency display of ADS-B signals.

The flowchart is of 3 signal sources (background noise, 978 MHz, and 1090 MHz) and is then converted into a visual representation.

ADS-B Decoder GR-ADSB
A potential GNU radio flowchart that would detect ADS-B signals.



The flowchart is of a GNU Radio program that would collect the data from some ADS-B signal. It collects the signal from an antenna device and decodes the signal into a human-readable ADS-B message. Then the data can be output (live feed or just plain text) and can be recorded for future use if needed.¹

Results

Example Data
An assortment of example signals an antenna could receive from an ADS-B message.

Time	ICAO	Callsign	Alt	CLimb	Speed	Hdg	Latitude	Longitude	Flgs
			ft	ft/m	kt	deg	deg	deg	deg
00:00:00	a12345	EXAMP11	10000	2312	270	31	35.222658	-97.431973	10
00:00:00	abcdef	TEST	2000	-128	150	180	35.222569	-97.431919	15
00:00:00	ghijkl	ENTRY	0000	2312	205	-167	35.222523	-97.431924	20

The ADS-B transmits its callsign, altitude, speed, and location. This is not the only information transmitted, but this is the most relevant information for the purposes of a radar. As a radar will track the movement of a plane, if the radar is to be validated through any external data only the position and its derivatives would be necessary. Therefore, the ADS-B signal message can be limited to just its identifying characteristics (ICAO and Callsign), location (Latitude and Longitude), and speed. The output message can also increase or decrease the amount of information output, depending on future needs.

Conclusion

ADS-B can be picked up by relatively weak antennas, which can allow for stronger radars to find live targets in the sky. The ADS-B message is decoded by GNU Radio and if the location is within a certain range of the radar the program will tell the radar where to look in the sky. The true path of the plane is also stored by the program, which allows for any data the radar creates to be checked against reality. Moreover, the program saves however many manhours that would have been wasted checking to see if a plane is nearby for the radar to use and the time used to manually get the radar to collect that data. As well as create additional radar data when there is no one to manually check for planes.

Acknowledgments

We'd like to thank Dr. Metcalf, Assistant Professor from the School of Electrical and Computer Engineering; the undergraduate student Sarah Zeko. Additionally, this was only possible due to the open-source nature of GNU Radio and GR-ADSB. Finally, we'd like to thank the First Year Research Experience program and Dr. Heather Ketchum.

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Foundations of Discovery: Delving into Lab Techniques on the Path of Super-Resolution Ultrasound

Austin Shepherd and Billy Sweiger

University of Oklahoma, Molecular Ultrasound Imaging and Delivery Laboratory

Foundations of Discovery: Delving into Lab Techniques on the Path of Super-Resolution Ultrasound

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University of Oklahoma, Molecular Ultrasound Imaging and Delivery Laboratory

Background

Dr. Yoon's lab aims to develop better imaging systems to help diagnose and track cancer growth. His current focus is super-resolution ultrasound and using gas vesicles as a contrast agent³.



Goals

Our goals for this semester included:

- Developing a deeper understanding of processes behind Dr. Yoon's research
- Learn about ultrasound technology
- Observe/aid in cell transfection
- Gain proficiency in basic laboratory skills

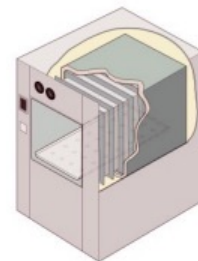
Future Work

We plan to continue working with Dr. Yoon through Summer/Fall 2024. Our next steps include:

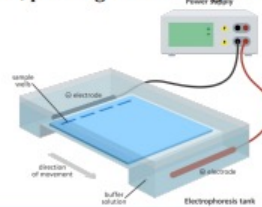
- Designing and building an ultrasound pressure-measurement system
- Understanding the code behind signal processing and continuing to improve it

Procedures

- Autoclaving
 - "Autoclaves use water, pressure, and heat to create superheated steam that kills microorganisms and spores¹."
 - Necessary to sterilize our equipment
 - Otherwise, experiments could become contaminated and distort our results



- Polymerase Chain Reaction (PCR)
 - "Technique for rapidly amplifying millions to billions of copies of a specific segment of DNA²"
 - Our lab utilized PCR to aid in the manipulation of cells to produce gas vesicles.
- Gel Electrophoresis
 - A square gel is to be made and placed in the buffer solution
 - The wells in the gel are filled with solutions of DNA to be tested
 - Electrical current runs through from the cathode to the anode, pushing shorter fragments farther⁴



Procedures Cont.

- Cell Culture⁵
 - Cells are very delicate, so they must be kept in a specific environment to survive
 - HeLa cells are a specific kind of cancer cell that divide infinitely
 - If they divide too much, the plate becomes confluent, and they die
 - Before that happens, some cells get removed and replated



- Reading Relevant Literature
 - Start with important, succinct points
 - Scan title to see if it will have relevant info
 - Read abstract to understand scope of the data
 - Use conclusion to see if the results are helpful
 - Go to the rest of the paper if it is deemed useful to understand procedures and how to apply it

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Special thanks to Dr. Sanggil Yoon and Musarrat (Hina) Amin for guidance and support.

Impact of SMART Machine Learning Algorithms in Classifying Social Media Misinformation and Disinformation


Josiah Abraham 1, Dr. Gopichandh Danala 2, Dr. David Ebert 2

1 School of Electrical and Computer Engineering, 2 Data Institute for Societal Challenges



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BACKGROUND

Misinformation in Social Media:

- False or inaccurate information
- Severe threat to public interests
- Sensitive domains: disaster, health, and politics

Real World Examples:


- Public health: COVID-19 pandemic
- Politics: 2016 USA Presidential election
- Disaster: Hurricanes, Floods, Tornadoes, Wildfires
- Riots: Public protests, fights in sporting arenas



OBJECTIVE


SMART:

- Graphical, web-based, and user-friendly interface
- Allows to map, interactively explore, filter, and navigate large volumes of data by hiding the complexity of advanced algorithms
- SMART uses intelligent machine learning (ML) algorithms to identify misinformation in social media data.
- This process involves combination of multiple natural language processing (NLP) techniques with ML models




WORDCLOUD

Misinformation



Not Misinformation



METHODOLOGY

Approaches ("Total Not Misinformation / Total Misinformation"):

- Air Travel Tweets (826/ 793)
- Random Tweets (1474/1526)
- Covid Tweets (940/ 856)
- Security Tweets (1000/700)
- Combined Dataset (4944/4545)

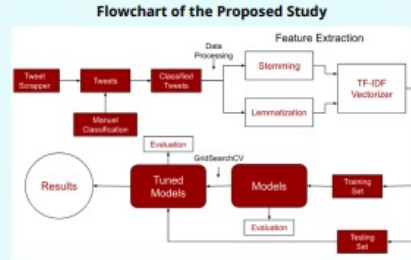
ML Models:

- Linear Regression (LR): Predicts unknown value with known value
- Multinomial Naive Bayes (MNB): Calculates probability distribution
- Probably Approximately Correct (PAC): Approximates hypothesis

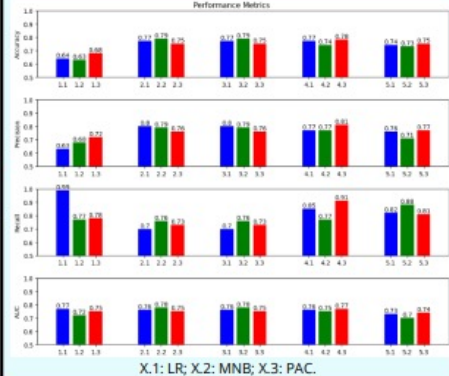
Evaluation Metrics:

- Accuracy: Percentage of data that is accurately classified
- Precision: How often ML model correctly predicts the positive class
- Recall: Ratio of the number of true positives to the number of false negatives (tp/tp+fn)
- AUC: Overall performance of the binary classification model

Flowchart of the Proposed Study



RESULTS



X.1: LR; X.2: MNB; X.3: PAC.

DISCUSSION

Modeling Air Travel Tweets:

- Lower Accuracy and Precision values compared to others
- Linear regression had an outlier Recall value of 0.99
- Difficult to discern reliability of overall dataset

Modeling Random Tweets:

- Average values for all metrics
- Similar results for three models (0.75 < Accuracy2 < 0.79 and 0.76 < Precision2 < 0.8)

Modeling Covid Tweets:

- Average values for all metrics
- Similar results for three models (0.75 < AUC3 < 0.78)

Modeling Security Tweets:

- High results for all metric evaluated points to strong dataset
- Highest average values for Recall (0.77 < Recall4 < 0.91)

Modeling Combined Dataset:

- No significant improvement in values when all datasets are combined
- High average values for Recall (0.82 < Recall5 < 0.88)

CONCLUSION

- ML algorithms are shown to have the ability to predict and classify misinformation in social media posts.
- With improvements in the algorithm, there is the potential for SMART to be used by the social media industry in order to curb the spread of misinformation and disinformation.
- Interactive human-in-loop ML system can help further process and understand misinformation in social media data.

ACKNOWLEDGEMENT

Special thanks to the
Data Institute for Societal Challenges (DISC),
the First-Year Research Experience (FYRE), and
the University of Oklahoma Honors College

Modeling Carbon Dioxide Fluxes and Evapotranspiration in Grain-Only Wheat Pastures Using Weather and Satellite Data

Travis Lloyd, Dr. Gopichandh Danala, Dr. David Ebert



Modeling Carbon Dioxide Fluxes and Evapotranspiration in Grain-Only Wheat Pastures Using Weather and Satellite Data

Travis Lloyd,¹ Dr. Gopichandh Danala,² Dr. David Ebert²



Background	Methodology
<p>Accurate estimation of flux changes is essential to understand ecosystem dynamics, land productivity, and monitoring carbon & water cycles.</p> <p>Benefits:</p> <ul style="list-style-type: none"> • Guide agricultural practices • Irrigation scheduling • Crop management • Carbon sequestration strategies <p>Challenge: Expensive to deploy and maintain -- Eddy covariance systems for measuring ET and CO₂ fluxes.</p>	<p>Approaches: We have employed three approaches to model ET and flux variables.</p> <ol style="list-style-type: none"> 1. All Weather + EVI 2. A subset of relevant Weather + EVI 3. A subset of relevant Weather + EVI + flux attributes <p>ML Models:</p> <ol style="list-style-type: none"> 1. Random Forest (RF): Ensemble learning algorithm that builds multiple decision trees and combines their predictions to improve accuracy. 2. Ridge Regression (RR): linear regression method that addresses multicollinearity and prevents overfitting <p>Evaluation Metrics:</p> <ol style="list-style-type: none"> 1. R²: Quantifies the goodness of fit of the model to the observed data 2. Mean Square Error (MSE): Average squared difference between the actual and predicted values 3. Mean Absolute Error (MAE): Average absolute difference between the actual and predicted values <div style="text-align: right;"> <p>Flowchart of the Study Methodology</p> </div>
Definitions of Key Variables	Results
<p>Measured by Eddy Covariance Systems:</p> <ul style="list-style-type: none"> • ER - Ecosystem respiration; the total release of CO₂ from an ecosystem to the atmosphere. • NEE - Net Ecosystem Exchange; the net balance of CO₂ exchange between an ecosystem and the atmosphere • GPP - Gross Primary Production; the total amount of carbon uptake by plants through photosynthesis. • ET - Evapotranspiration; the process of water evaporation from the soil surface and transpiration from plant leaves. <p>Measured by Satellite:</p> <ul style="list-style-type: none"> • EVI - Enhanced Vegetation Index, quantifies vegetation greenness. 	<p style="text-align: center;">X.1 represents RF; X.2 represents RR.</p>
Study Objective	Discussion
<p>Develop predictive machine learning (ML) models to assess CO₂ and ET dynamics by leveraging weather data and vegetation index from remote sensing sources.</p>	<p>RF performed better than RR in all scenarios.</p> <p>Modeling ET:</p> <ul style="list-style-type: none"> • The optimal fit of the model (RF) with $0.81 < R^2 < 0.83$. • Similar performance <u>can be attained</u> on small attribute sets. • Lowest MSE and MAE reported. <p>Modeling NEE:</p> <ul style="list-style-type: none"> • Not the best overall fit, but yielded (RF) with $0.74 < R^2 < 0.76$. • Similar performance <u>can be attained</u> on small attribute sets. • Higher MSE and MAE reported. <p>Modeling ER:</p> <ul style="list-style-type: none"> • Difficult to model in our dataset, with RF yielding $0.69 < R^2 < 0.77$. • Performance significantly improved on small attribute set 3.1 • Lower MSE and MAE reported. <p>Modeling GPP:</p> <ul style="list-style-type: none"> • Best fit overall in our analysis, RF with $R^2 = 0.84$. • Similar performance <u>can be attained</u> on small attribute sets. • Lower MSE and MAE reported. <p>Findings Summary:</p> <ul style="list-style-type: none"> • Random Forest performs better than Ridge Regression. • Smaller attribute sets can attain comparable or significantly better results eliminating the need to collect the rest of the attributes. • ET and GPP are easier to model as compared to NEE and ER.
Dataset	Conclusion
<p>The dataset consists of several wheat pastures under the same management collecting a variety of measurements ranging from weather satellite, and flux measurements.</p> <p>Data was collected by United States Department of Agriculture - Agriculture Research Services (USDA-ARS) at El-Reno, Oklahoma, USA.</p> <ul style="list-style-type: none"> • Crop management: Wheat Pastures with Grain-only Management • # of Observations: 644. • Time period: Multi-year, seasonal (Mid Oct to Mid-June) • Weather: Collected from infield measurements. • EVI: Remote sensing data (Landsat and Sentinel) estimated using satellite observations • Fluxes: Eddy covariance measurements. (in-field) 	<ul style="list-style-type: none"> • Predictive ML algorithms have good potential to model ET and carbon fluxes using remote sensing data. • This preliminary study can further be extended to apply more sophisticated ML and data analytic approaches to improve the modeling capabilities.
Acknowledgements	<p style="text-align: center;">Special Thanks to USDA-ARS, El-Reno, the Data Institute for Societal Challenges, the OU Honors College and the First Year Research Program</p>

The Effect of EDHF on the Resistance of Sympathetic Vasoconstriction In Healthy Young Adults



Ria M. Sachdev, Alexander A. Buelow, Matt Stanford, Jacob E. Matney, Sarah Skillett, John D. Ashley, Jiwon Song, Chris Mixon, Debra A. Bembem, Daniel J. Larson, J. Mikhail Kellawan
Human Circulation Research Laboratory-Department of Health & Exercise Science, University of Oklahoma—Norman, OK, USA

The Effect of EDHF on the Resistance of Sympathetic Vasoconstriction In Healthy Young Adults

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Human Circulation Research Laboratory-Department of Health & Exercise Science, University of Oklahoma—Norman, OK, USA

Introduction and Background

- The sympathetic nervous system helps control blood flow by narrowing some blood vessels to direct more blood to active muscles. This is called sympathetic vasoconstriction.
- However, in healthy individuals, the ability to resist sympathetic vasoconstriction is necessary to meet the increased need for blood flow in exercising skeletal muscles. This mechanism is termed functional sympatholysis.
- There is evidence to suggest that functional sympatholysis is nitric oxide and prostaglandin independent. However, it remains unknown if endothelium-dependent hyperpolarization factor (EDHF) contributes to Functional Sympatholysis.
- EDHF is a diffusible factor that causes smooth muscle hyperpolarization, thus, relaxation or vasodilation
- Fluocanazole can be used to inhibit EDHF production

Research Question and Hypotheses

- Does blocking EDHF significantly impair functional sympatholysis in healthy, young adults?
- H₀**: there is no difference in the efficacy of functional sympatholysis between Fluocanazole and placebo conditions.
- H_a**: Blockade of EDHF (via Fluocanazole) significantly impairs functional sympatholysis (thus Forearm Vascular Conductance (FVC) compared to a placebo in healthy, young adults.

Methods

- This experiment involved 21 participants
- There were three total study visits (at least 72 hours apart), the first for familiarization, the second and third for experiment.
- On one experimental day, they were subject to a placebo, and on the other Fluocanazole. This was selected at random and single-blind.
- Each subject was observed at rest, at rest with Lower Body Negative Pressure (LBNP), during exercise, and during exercise with LBNP.
- Following an additional rest/baseline period, subjects performed 7 min of steady state, submaximal handgrip exercise @ 20% 1RM, with exposure to the same LBNP stimulus during the last 2 minutes of exercise.
- Data collected included: Brachial Artery blood Velocity (cm/s) and Brachial Artery Diameter (mm), via ultrasound, as well as Mean Arterial Pressure (MAP) via Finger Photoplethysmography.

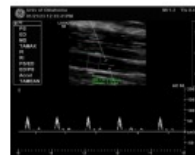


Figure 1: Ultrasound Image
The above image is an example of what was obtained from an ultrasound of a subject's brachial artery. The mean blood velocity and diameter was determined.



Figure 2: Experiment Protocol
The above diagram shows the step by step protocol procedure used for each subject during this experiment with times listed for each step. This protocol the placebo and fluocanazole was the same in every regard other than what was ingested 120 minutes before beginning.

Data and Statistical Analysis

- Steady-state values were determined from the average of the last 30 seconds of each event. These include Rest, Rest&LBNP, Exercise, and Exercise&LBNP.

$$FBF \Delta\% \text{ at Rest} = \left(\frac{Rest_{FLZ} - Rest_{PLZ}}{Rest_{FLZ}} \right) \times 100$$

$$FVC \Delta\% \text{ at Rest} = \left(\frac{Rest_{FLZ} - Rest_{PLZ}}{Rest_{FLZ}} \right) \times 100$$

$$MAP \Delta\% \text{ at Rest} = \left(\frac{Rest_{FLZ} - Rest_{PLZ}}{Rest_{FLZ}} \right) \times 100$$

$$FBF \Delta\% \text{ with Exercise} = \left(\frac{Exercise_{FLZ} - Exercise_{PLZ}}{Exercise_{FLZ}} \right) \times 100$$

$$FVC \Delta\% \text{ with Exercise} = \left(\frac{Exercise_{FLZ} - Exercise_{PLZ}}{Exercise_{FLZ}} \right) \times 100$$

$$MAP \Delta\% \text{ with Exercise} = \left(\frac{Exercise_{FLZ} - Exercise_{PLZ}}{Exercise_{FLZ}} \right) \times 100$$

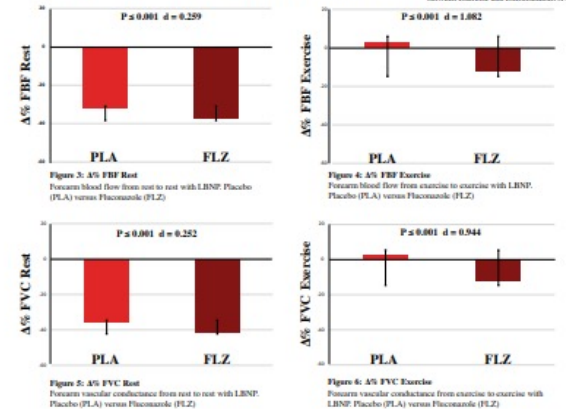
- FBF = Forearm Blood Flow
- FVC = Forearm Vascular Conductance
- MAP = Mean Arterial Pressure
- Equation relating FBF, FVC, and MAP
$$FVC = \frac{FBF}{MAP}$$
- Normality and Homogeneity of Variance (HoV) will be determined via the Shapiro-Wilk Test and Levene's Test, respectively.
- Mean differences between Magnitudes of FS will be evaluated via Paired Sample t-tests, or Wilcoxon Tests if data fails Normality
- A prior value set at $p \leq 0.05$

Results

	Male (n=9)	Female (n=11)	Entire Sample (n=21)
Age (years)	23.4 ± 3.9	20.7 ± 2.6	22.1 ± 3.3
Height (cm)	178.9 ± 8.8*	165.9 ± 6.9	172.2 ± 7.7
Bodyweight (kg)	80.0 ± 9.9*	64.3 ± 7.8	72.2 ± 8.9
BMI (kg/m ²)	25.3 ± 2.4	23.5 ± 2.9	24.4 ± 2.7
SBP (mmHg)	122.0 ± 6.7*	108.3 ± 7.6	115.1 ± 7.2
DBP (mmHg)	65.2 ± 3.4	69.9 ± 4.5	67.6 ± 9.0
MAP (mmHg)	60.0 ± 8.1*	26.0 ± 4.9	38.5 ± 6.3

Table 1: Descriptive Characteristics
BMI (body mass index) SBP (systolic blood pressure) DBP (diastolic blood pressure) MVC (maximum voluntary contraction). Values are means ± standard deviations. * indicates that $p < 0.05$ between sexes.

Table 2: Absolute Peripheral Hemodynamics
LBNP (lower body negative pressure) FBF (forearm blood flow); MAP (mean arterial pressure); FVC (forearm vascular conductance); PLA (placebo); FLZ (fluocanazole). * indicates that $p < 0.05$ between Rest and Rest&LBNP. # indicates that $p < 0.05$ between Exercise and Exercise&LBNP.



Conclusion

- Our findings indicate that in healthy young adults, resistance of sympathetic vasoconstriction was impaired in response to inhibiting EDHF production.
- In the trials where subjects ingested the fluocanazole treatment, there was found to be a significant effect impairment of the functional sympatholysis mechanism.
- This difference was shown when the significance values were less than or equal to 0.05 in the data comparing the placebo results to those of the fluocanazole.
- As such, we can conclude that EDHF is involved in impairing the ability to blunt sympathetic vasoconstriction in young and healthy adults.

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Training for Math TAs: Perceptions, Challenges, and Lingering Needs

Alexis Brown and Dr. Deborah Moore-Russo – Department of Mathematics, University of Oklahoma

Training for Math TAs: Perceptions, Challenges, and Lingering Needs

Alexis Brown and Dr. Deborah Moore-Russo
Department of Mathematics, University of Oklahoma



Context

- OU math department has 57 graduate teaching assistants (TAs).
- TA work can include acting as grader, tutor, discussion leader, and instructor.
- TAs receive training from the department in August prior to their first and second years.

Research Questions

- RQ1 How is Math TA Training perceived by TAs?
RQ2 What do TAs report as being helpful for them; what do they still find challenging?

Literature Review/ Coding Categories

Code	Description	Reference
Exp	Prior Experience (teaching or tutoring) is helpful	1, 7
CultPol	Culture and Policies, expectations specific to OU and to certain courses	4
Com	Communication, general comment about more/better communication in department	8
PeerMent	Peer Mentor advice given informally from other TAs	16
FacMent	Faculty Mentor advice given informally	2, 9, 16
SMK	Subject Matter Knowledge (already knew/had strong math concepts)	1, 3, 11
InstrRes	Instructional Resources (important of providing instructional resources, instructional techniques)	8, 9
TchgTech	Teaching Techniques (e.g., helpful to cover, allow time to practice)	1
BalRoles	Balancing Roles of instructor and student (dual roles of a TA)	6, 12
Wkld	Workload is too heavy; time allotted doesn't match assignment; too much work	8
TimeMngmt	Time Management; learning to manage one's time	8
No Details	Response given offered no information, "fine as is"	

- Experience
- Personal Interactions and Expectations
- Content and Pedagogical Aspects
- Workload/Time Balance

Methods

Data Collection

An anonymous, optional digital survey was sent out to math TAs. Ratings were done on a five-point Likert-scale ranging from "Not at all" to "fill in".

- Q1 Rate preparedness for TA role prior to training (five-point Likert scale) and explain rating
- Q2 Rate preparedness post training and explain
- Q3 Suggestions for TA training
- Q4 Other (non training) supports for TA work
- Q5 Most difficult aspects of being a TA
- Q6 Suggestions for improved support

Data Coding and Analysis

Quantitative: Used non-parametric statistics since the data collected was ordinal (Likert-scale)

Qualitative: Used inductive coding; looked at the data to see what categories were represented, coded data (by categories), then did coding counts

RQ1 Findings

21 of 57 TAs responded for a 37% response rate. The pie chart and box-and-whisker plots below display preparedness differences, prior to and post training.



Preparedness for TA Role

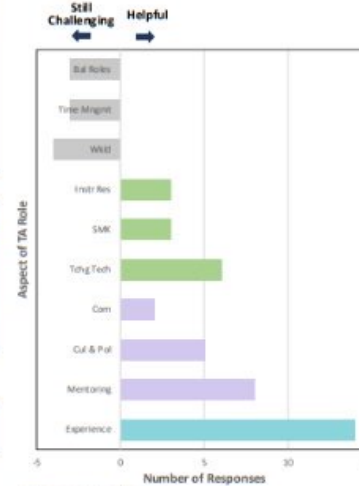


Wilcoxon Signed Rank Test Results

p-value: 0.004694
Effect size: 0.73

RQ2 Findings

Of 21 responses, only 15 made contributions, past the numeric scores given, that provided information on what was helpful and what was still challenging in their TA roles.



Conclusion

- Current training has a positive impact on TAs' feelings of preparedness
- TAs may benefit from adding sessions on areas of concern, such as TimeMngmt, to August training
- Managing student interactions may be a significant part of TA challenges although it did not come up because it is not always classified as part of the work [9, 13-15]
- While 8/15 TAs valued informal mentoring from both faculty and peers, there was no mention of formal mentoring. On-going feedback or more formal mentoring could be helpful [2, 13, 17]
- International TAs may face unique challenges that not addressed in this study [4, 5, 10]

Acknowledgements

Thank you first to Dr. Deborah Moore-Russo for her patient and encouraging mentorship and secondly to the FYRE program for the opportunity to learn about the research process firsthand.

Scan QR code for References



Deep Learning Linear Regression Experiment to Predict Housing Price

Caleb Smith, Iman Ghamarian

Gallogly College of Engineering | Accelerated Materials Development Lab

Deep Learning Linear Regression Experiment to Predict Housing Price

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Introduction

Machine learning and its application are becoming increasingly important in today's world as it continues to integrate itself in various fields. Specifically, a field of machine learning known as deep learning which involves the use of neural networks has seen a rise in use cases across various industries as it has an unparalleled ability to learn off pre-existing data and perform various tasks. This research aims to explore deep learning at a fundamental level and to create a linear regression model that can be used to predict housing sale price based on a variety of variables.

Materials

- Kaggle housing data set – This is the data set we will be using for the experiment. It contains 80 feature variables with 1 output variable (Sale price)
- Python and PyTorch – This is the language and library that will be used to build the model. PyTorch specifically is a library designed for deep learning applications through the use of tensors.

Methodology

Preprocessing Data
Includes One-hot encoding, normalization, and training/testing split.

Design Model
Three linear layers with two ReLU layers, 200 hidden units.

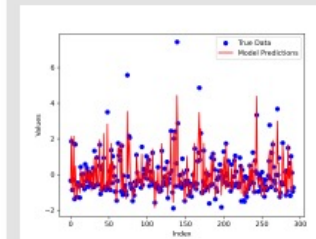
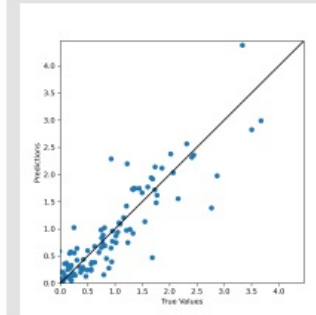
Construct Loss function and Optimizer
Loss Function is mean square error and optimizer is stochastic gradient descent.

Construct Data Loader
Batch size 64

Run Training Loop
Run loop for 100 epochs.

Results

Average Test Loss: 0.14



Conclusion

In conclusion, our model was able to capture the data reasonably well. However, it did have some trouble, especially with outlier data. Not only that, but during the training of the model, model loss seemed to fluctuate greatly indicating that the model was not able to capture the data completely. If we were to reconstruct this experiment, we may try using an embedding to see if that would allow us to better capture the non-numerical parts of the data.

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Acknowledgements

I would like to thank the FYRE program for giving me this opportunity and to Dr. Ghamarian for mentoring and guiding me through this topic.

CAD Enhanced Design of Ergonomic Laptop Stands to Reduce Work-Related Musculoskeletal Disorders

Alfonzie C. Stephney and Dr. Yingtao Liu

Aerospace and Mechanical Engineering, 865 Asp Ave. Rm. 205 Norman, OK 73019



CAD Enhanced Design of Ergonomic Laptop Stands to Reduce Work-Related Musculoskeletal Disorders

Alfonzie C. Stephney

Dr. Yingtao Liu, Aerospace and Mechanical Engineering, 865 Asp Ave. Rm. 205 Norman, OK 73019

Introduction

Recently, there has been an increasing demand for laptop stands. In fact, the market share is expected to grow to \$504.32 million by 2031 (Business Report Insights, 2024). However, with greater use comes greater risk of injury with work-related musculoskeletal disorders (WMSDs), and stands can be an effective tool in reducing these injuries.

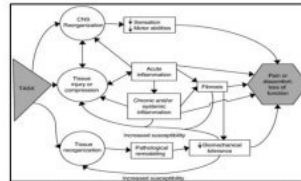


Fig. 1: A flowchart showing the ways WMSDs can occur. (Barr, Barbe, and Clark, 2004).

Background

Over the past 30 years, several studies have been done to determine how the amount, duration, and frequency of force put on one's joints can impact joint health over time. These studies revealed that consistent, hard force resulted in noticeably weaker joint strength.

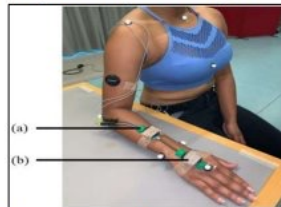
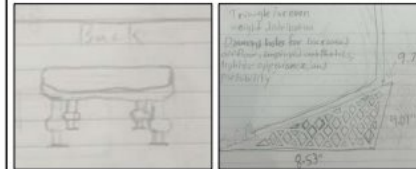


Fig. 2: A system with two sensors to measure movement in arm (Karnica and Yang, 2022).

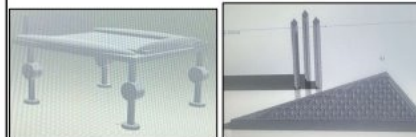
Methods

To ensure that my design was feasible, I needed to have sketches to make an initial framework for the stands. The images below (Figs. 2-3) show what the initial concept design was intended to look like. This also was a crucial step to take so that any changes I made could be done without significantly altering the final design.



Figs. 3-4: Sketches of initial (left) and final (right) designs, with sketched laptop sitting on final sketch and hinges on the initial sketch.

After the sketching process was complete, I used Computer-Aided Design (CAD) to transform the sketches into models and prepare them for 3D printing. A popular CAD software to do this is SolidWorks, and this is what I chose for the project. The images below (Figs. 4-5) show the modeling of the initial and final designs, with distinct features unique to each one.



Figs. 4-5: (left) Model of initial and (right) model of final design, with diamond rods to be placed inside the holes on the right and hinges to move a tray back and forth on the left. The rods are intended to be used for stability purposes.

Results/Discussion

At the conclusion of this project, I completed a 3D print model of the stand from a profile view. An example of this can be seen in the image below (Fig. 6). Due to resource constraints from the Bizzell Library's 3D printing lab, a full-size model could not be built. However, this project has the potential for further expansion to determine if this design can reduce WMSDs. The future plan is to discover how this design can be applicable in various settings.

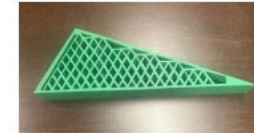


Fig.6: A side profile view of the 3D printed stand base.

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Acknowledgments

I would like to thank Dr. Liu for mentoring me throughout this project, FYRE and the Honors College for allowing me to participate in this program and do research, and finally, the Gallogly College of Engineering for allowing me to utilize their computer lab.

Designing a Smart, Modular Greenhouse for Rural India

Katy Joyce, Timi Oduleye



Team Members
Katy Joyce
Timi Oduleye

Designing a Smart, Modular Greenhouse for Rural India

OU Mentors
Farrokh Mistree
Mayank J. Bhalerao
Wesley T. Honeycutt





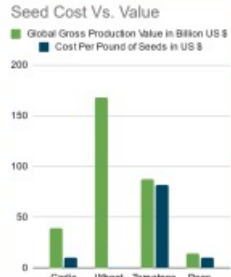


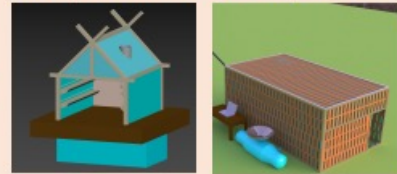


PROBLEM	<h3>Frame of Reference</h3>  <p>Indian citizens have difficulties making money in rural areas. Farming, a popular avenue towards making money in these areas, can be inefficient at times. This issue needs to be addressed promptly or local economies will continue to struggle.</p>	<h3>Existing Greenhouses</h3> <ul style="list-style-type: none"> Greenhouses are structures that allow farmers to have complete control over their crops. Greenhouse efficiency is enhanced through the use of smart systems. Smart systems use sensors to monitor conditions. Once conditions are recorded, the data are read, and the system maintains ideal conditions. 	<h3>Problem Description</h3> <p>Seed Cost Vs. Value</p>  <p>The high cost of conventional greenhouse farming limits its use to high-value crops, excluding some farmers. To address this, we propose designing and deploying low-cost modular greenhouses using local waste materials for construction, aiming to make greenhouse farming more accessible and affordable for farmers based in rural India.</p>																											
	<h3>Initial Steps</h3> <ul style="list-style-type: none"> Design development included dissecting the problem with a requirements list. Gathering information about the scope of the project refined our ability to extract knowledge gained from research. Pairing the requirements list with a randomized design system allowed us to generate four unique concepts that fit the constraints outlined before ideation. 	<h3>Concept Evaluation</h3> <ul style="list-style-type: none"> Concept generation is enhanced through critical thinking. Breaking down each design using PMI and PDPC revealed strengths/weaknesses. Better iterations were developed as we continued to grow in our research skills. Once concepts are fully evaluated, they need to be methodically filtered out based on potential for success in the outlined scenario. 	<h3>Go/No Go Analysis</h3> <table border="1"> <thead> <tr> <th colspan="7">Concept 3 (Lean Eco Machine) - Go/No Go Analysis</th> </tr> <tr> <th>Effective Self-Regulation (7 points)</th> <th>Prevent Humidity Building (6 points)</th> <th>Allow Sunlight Penetration (5 points)</th> <th>Provide Water (4 points)</th> <th>Sustainable Medium (3 points)</th> <th>Regulate Pests (2 points)</th> <th>Operate Cost-Effectively (1 point)</th> </tr> </thead> <tbody> <tr> <td>No Go</td> <td>Go</td> <td>Go</td> <td>Go</td> <td>No Go</td> <td>Go</td> <td>No Go</td> </tr> <tr> <td colspan="7">Go Total: 17 points No Go Total: 11 points</td> </tr> </tbody> </table> <ul style="list-style-type: none"> Go/No Go analyses are used in research to compare designs using certain criteria. Chosen criteria are framed and prioritized in the context of providing the greatest yield for rural India (focus on desired modularity). If a design received a "No Go", we then identified potential modifications that could be made to better the design. 	Concept 3 (Lean Eco Machine) - Go/No Go Analysis							Effective Self-Regulation (7 points)	Prevent Humidity Building (6 points)	Allow Sunlight Penetration (5 points)	Provide Water (4 points)	Sustainable Medium (3 points)	Regulate Pests (2 points)	Operate Cost-Effectively (1 point)	No Go	Go	Go	Go	No Go	Go	No Go	Go Total: 17 points No Go Total: 11 points					
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No Go	Go	Go	Go	No Go	Go	No Go																								
Go Total: 17 points No Go Total: 11 points																														
POSSIBLE OUTCOMES	<h3>Concept Comparison</h3> <p>After conducting the Go/No Go Analysis, two concepts fulfilled all functional requirements.</p>  <p>Both designs have their merits, but Concept 4 was chosen due to its ability to remain self-sufficient while enhancing the local community.</p>	<h3>Chosen Concept</h3> <p>For our chosen concept, we decided on concept 4. This design exemplifies the balance of "smart" and "modular" defined in the requirements list in several ways:</p>  <ul style="list-style-type: none"> Concept 4 utilizes a smart system that is able to properly measure and regulate greenhouse conditions. Concept 4 is almost entirely made from reusable materials, making it cost-efficient and eco-friendly. Sustainable water collection and heating methods are utilized. Companion plants keep bugs away and have the potential to be sold for profit. 	<h3>Value + Way Forward</h3> <p>There are plenty of ways the project can be developed further, including prototyping and design validation. More research needs to be done regarding monetary feasibility.</p> <p>Katy's value: I found value in getting to learn more about research and the design process. I loved touring the greenhouses and plan on contributing to other research projects in the future.</p> <p>Timi's value: I plan to apply the skills learned during this project to research in a different field regarding technological advancement for the benefit of third world countries.</p> 																											


Image Sources (In Order of Appearance):
Row 1, Panel 1: <https://c-stocks.com/a/BOFA00/z9/2542383.jpg>
Row 1, Panel 2: <https://blog.sensaphone.com/hs-fs/hubfs/Blog/Greenhouse-Sensors-1.jpg?width=1185&height=656&name=Greenhouse-Sensors-1.jpg>

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Nanovoid collapse under hydrostatic pressure: Effects of void size and material properties

William Chadwell, Mahshad Fani, Mohammad Younes Araghi, Dr. Shuozi Xu


University of Oklahoma,
Computational Materials, Mechanics,
and Manufacturing Laboratory



GALLOGLY COLLEGE OF ENGINEERING
**AEROSPACE AND MECHANICAL
ENGINEERING**
UNIVERSITY OF OKLAHOMA


Nanovoid collapse under hydrostatic pressure: Effects of void size and material properties

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Graphical Abstract


1 Graphs




2 Program used to find values for graphs, and dump files




4 Ovito Cu Crystal and Void Visualization



3 Program used for Visualizations



Simulation Program



Data & Methods

Modeling & Experimental Approach

During my research, I used MobaXterm to run LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator) simulations on Copper Crystals with different interatomic potentials as well as different void sizes for the purpose of graphing the yield strength of the copper crystals under different void sizes. The purpose of doing so is to combine the data, along with the USFE (Unstable Stacking Fault Energy) of each potential calculated by Valery Borovikov et al. to create a Machine Learning model that will predict the yield strength when given both the USFE and the Void Size.

When modeling the copper crystal, I decided to use Ovito since it would allow me to also visualize the void sphere inside of the copper crystal, and it has many helpful ways to make visualizing the copper crystal easier.

Model evaluation

It was important to my research that the porosity of the copper crystal is low enough to avoid fatigue cracks, and since Kumar et al. had found that as-printed materials had a porosity of 0.26%–1.29%, we used a uniform porosity of 0.5% as a representation.

Introduction

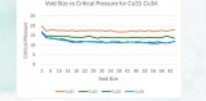


Fig. 1. Ovito Visualization of Cu34 Copper Crystal

During my research under Dr. Xu, I was tasked with graphing the Void size versus Critical Pressure, or Yield Strength, of different interatomic potentials of Copper. An interatomic potential is a function used to calculate the potential energy of a system of atoms based on its position in space and can be used to predict material properties, meaning that I was tasked with graphing the void size vs. Yield Strength of Copper crystals with different material properties.




Fig. 2. Void Sphere Size 10

Results from Ovito Visualizations




Fig. 3. Ovito Visualization of Cu32 Crystal and Void At Timestep 0




Fig. 4. Ovito Visualization of Cu32 Crystal and Void At Timestep 20000




Fig. 5. Ovito Visualization of Cu32 Crystal and Void At Timestep 30000

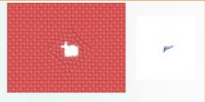


Fig. 6. Ovito Visualization of Cu32 Crystal and Void At Timestep 36000




Fig. 7. Ovito Visualization of Cu34 Crystal and Void At Timestep 0




Fig. 8. Ovito Visualization of Cu34 Crystal and Void At Timestep 20000




Fig. 9. Ovito Visualization of Cu34 Crystal and Void At Timestep 30000




Fig. 10. Ovito Visualization of Cu34 Crystal and Void At Timestep 36000

Results from LAMMPS Simulations graphed

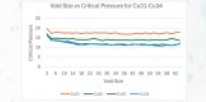


Fig. 11. Void Size vs. Critical Pressure for Cu31-Cu34




Fig. 12. Comparison between Simulated and ML Model Yield Strength vs. Critical Pressure Values

By looking at the data in the fig. 7, graph, we see that a lower Void Size in the copper crystal tends to result in a higher yield strength, as is evidenced by the downward trend the graph's different lines take. The 3d scatter plot also shows us that as the Interatomic Potential of the copper crystal goes up the yield strength of the crystal will be lower on average, the Model Fit Surface helping to exemplify this observation.

Conclusion

- 1) Before the void collapses, we see that the atoms around the void group up tighter than the atoms further from the void.
- 2) As the void starts to collapse, we see that the atoms surrounding the void will shift and be displaced from their original arrangement.
- 3) The smaller that the void size we start with is, the higher that our Critical Pressure, or Yield Strength, will tend to be.
- 4) Higher Interatomic Potentials correlate with a lower Yield strengths for all void sizes.

Acknowledgements

Mahshad Fani
Mohammad Younes Araghi
Dr. Shuozi Xu

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Contact Details:

william.b.chadwell-1@ou.edu
shuozhixu@ou.edu

Examining 700-Year-Old Large Scale Terraced Agricultural Field Systems in Northern New Mexico

Zoë Green 1, Lewis Borck 1

1 Department of Native American Studies, University of Oklahoma, OK, US



Examining 700-Year-Old Large Scale Terraced Agricultural Field Systems in Northern New Mexico

Zoë Green¹, Lewis Borck¹

¹Department of Native American Studies, University of Oklahoma, OK, US

INTRODUCTION

The research we do, the histories we tell, and the pasts we build matter. Early researchers investigating the Gallina people (~1100 - 1300 A.D.) in what is now northern New Mexico suggested that they were violent, isolated, regressive, and "backward"[1,2]. Recent investigations contradict this reconstruction, however, and demonstrate that the violence was mostly restricted to two short episodes of migrants moving through the region.[2] Other research indicates the Gallina movement into "ancient" looking housing was intentional and linked with a region-wide social movement contesting emerging inequality in the region. More, instead of being backwards, the Gallina appear to have innovated agricultural practices in the region with large scale terracing.[3] This project examines LiDAR data to detect evidence of this ancient terraforming.

METHODOLOGY

LiDAR (Light Detection and Ranging) uses a light laser, scanner, and receiver to create imagery of the Earth's surface (Figure 1).[4] The data are returned as points and these are then interpolated into a topographic surface. In archaeology, LiDAR imaging can create a clear picture of areas otherwise not visible due to either ground cover (the lasers reflect different values for vegetation and so you can essentially remove vegetation from the bedrock), or the spatial extent of the features being studied. For our research, LiDAR helps reveal massive features difficult to see on the ground (Figure 2) because of their scale, undergrowth and deep layers of pine needles (duff).[4,5] The LiDAR derived topography was divided into 0.40 km² tiles (Figure 4 & 5). Each tile was then anthroposcopically analyzed to look for evidence of these 700 to 900 year old agricultural

terraces. Potential terraces were categorized based on the quality of their identification (low, moderate, high) (Figure 3).

RESULTS

Terraces were identifiable in many of the LiDAR derived topographic tiles. This project was able to examine 60 tiles, thus conducting a detailed survey of 24 km² tiles. As these areas are inaccessible and mountainous, even if the terraces were easy to identify on the ground, the same coverage by one individual would take approximately 2 years of work based on current speed of analysis.

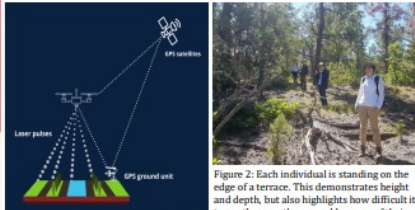


Figure 1: How LiDAR functions.[4]



Figure 2: Each individual is standing on the edge of a terrace. This demonstrates height and depth, but also highlights how difficult it is to see these on the ground because of their size, overgrowth, and scale. Image by Lewis Borck.



Figure 3: An analyzed LiDAR tile. Red indicates strong possibility of terraces. Green indicates low possibility. Note the presence of the ancient house at the upper left of the largest shape.

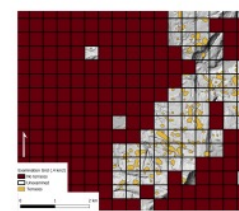


Figure 4: This FYRE project approximately doubled the number of identified terraces (in yellow). Burgundy tiles have no evidence of terracing.

CONCLUSION

- While not regularly used in the American Southwest, LiDAR is incredibly useful in this area.
- The large scale system of agricultural terracing with a concurrent lack of indications of political or economic hierarchy in surrounding dispersed communities, suggests that the Gallina people were communal and worked fields as commons environments.
- The presence of this ancient, massive, terraforming project, belies earlier interpretations and highlights how cultural bias can skew interpretations of data.

FUTURE DIRECTIONS

The LiDAR data sets will continue to be anthroposcopically analyzed and classified for their likelihood of having terracing present (Figure 5). Samples of these identified terraces will also need to be visited to do on the ground verification. This data will continue to be aggregated to examine how societies create equality and communally distribute labor practices.[7]

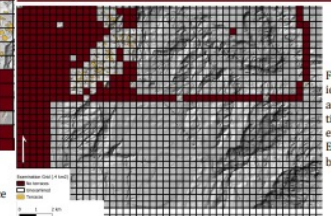


Figure 5: Study area. Identified terraces are yellow. Burgundy tiles have no evidence of terracing. Empty tiles are yet to be analyzed.

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Particle Deposition in 3D Printed Human Lung Model Under Realistic Physiological Conditions

Maya Joseph ¹, Changjie Cai ²

¹ Honors College, The University of Oklahoma, Norman, Oklahoma 73019

² Department of Occupational and Environmental Health, College of Public Health, The University of Oklahoma Health Science Center, Oklahoma City, Oklahoma 73190

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INTRODUCTION

- Particles deposit in the human lung through four main deposition mechanisms, including diffusion, impaction, interception, and sedimentation.¹
- The International Commissions on Radiological Protection (ICRP) model is a computational framework commonly used to estimate the deposition of inhaled particles in the human lungs. It is commonly used in assessing risk regarding inhalation exposure. For example, the model uses ambient temperature and humidity, which do not account for the elevation of them that in actual human lungs.
- The goal of this research was to investigate how 5300 nm particles deposit differently when tested using a 3D lung under reasonable physiological conditions compared to the ICRP-66 model calculations (Fig. 1).

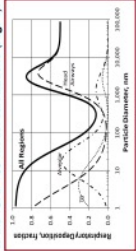


Fig. 1. ICRP model of particle deposition.²

MATERIALS

1. **3D LUNG MODELS**
 - 3D Model consists of inlet, trachea, left and right bronchus (Fig. 2).
 - The 3D lung model was made from polylactic acid plastic (PLA) (Fig. 3).



Fig. 2. Digital model of lung (Joseph, 2024)



Fig. 3. 3D printed model of lung (Joseph, 2024)

CHAMBER

2. **CHAMBER**
 - We built a human lung physiological condition chamber to simulate temperature (38 °C) and humidity (85%) (Fig. 4).
 - We also built a sealed lung chamber, which sits inside the previous chamber to measure particles after they pass through the lung (Fig. 5).



Fig. 4. Human lung physiological condition chamber (Joseph, 2024)



Fig. 5. Sealed lung chamber (Joseph, 2024)

METHODS

1. **Experimental Setup**
 - Turn on lamp heaters and humidifier and allow the temperature to reach around 38 °C and humidity to reach around 85%.
 - Connect Air Pump to Flow Control (30 liters per minute to represent normal human activity)
 - Generate particles into the lung physiological condition chamber
 - Measure the particles concentration inside and outside of sealed lung chamber using the Scanning Mobility Particle Sizer (SMPS) (Fig. 6)
2. **Statistical Analysis**
 - Used a paired t-test with a significance threshold of 0.05 to compare the differences between our measured deposition fraction and the ICRP-66 model calculations.

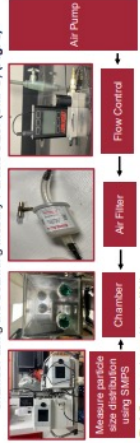


Fig. 6. Experimental set up (Joseph, 2024)

RESULTS

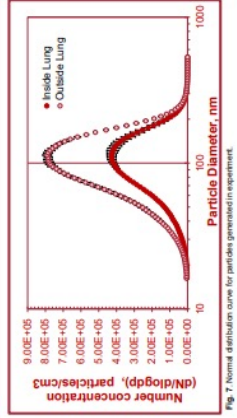


Fig. 7. Normal distribution curve for particles generated in experiment.

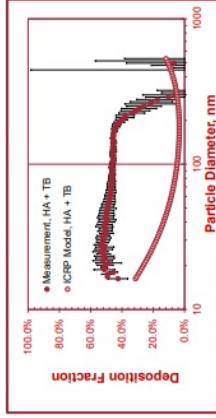


Fig. 8. Deposition fraction for particles generated in experiment.

- The results show that there is a substantial difference between the quantity of particles depositing in the head airway (HA) and tracheobronchial region (TB) found in our experiment compared to those found using the ICRP calculations.
- The quantity of particles depositing in the head airway and tracheobronchial region is far greater than the calculated quantity found using the ICRP model.

CONCLUSION

- Figure 8 shows a large difference between the deposition fraction modeled by the ICRP and the deposition fraction we obtained during our research. This is most likely due to the change in environment.
- When particles are in an environment with a higher humidity level there is a hygroscopic growth. The particles absorb moisture from the surrounding air, increasing their density, thus increasing their deposition fraction.³ When temperature increases, the density of the air decreases.³
- The combined temperature and humidity increases lead to the increased particle deposits found.

FUTURE WORK

- Our results beyond the diameter of 300 micrometers were not consistent. The number of particles at and above 300 nm would allow for more conclusive results in this specific area.

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Measuring RNA Stability with 5-EU and its Implications

Kane Hoffman¹, Jayden Lee¹, Haripriya Gupta², Je-Hyun Yoon²
1 - University of Oklahoma, 2 - University of Oklahoma Health Sciences Center



Measuring RNA Stability with 5-EU and its Implications

Kane Hoffman 1, Jayden Lee 1,
Haripriya Gupta 2, Je-Hyun Yoon 2
1 University of Oklahoma, 2
University of Oklahoma Health
Sciences Center

Abstract

RNA is intimately related to a large majority of biological processes from expression of genetic material to even structural molecules. As such, RNA decay is a topic that demands further study given its ubiquity. Given its impacts in protein creation and thus bodily function, we sought to quantify the decay of RNA over increasing periods of time. Notably, we utilized 5-ethynyl-uridine (5-EU) labeling over previously used methods such as transcription shut-off methods such as chemical inhibitors or mutants of RNA polymerase. This designed protocol allows for real-time dynamics and precise decay rate measurements due to its ability in identifying and isolating newly synthesized RNA.

Introduction

Messenger RNA (mRNA) plays a crucial role in gene expression through protein synthesis by acting as an intermediary between the information stored in DNA and the amino acid sequence and thus function of proteins (1). The decay of mRNA allows newly synthesized mRNA to replace mRNA that may possess defects and ensures rapid turnover for fast changes in the transcriptome composition (2). By understanding how mRNA degrades, we can understand more about how this process affects other cellular processes. 5-Ethynyl Uridine (5-EU) is a nucleoside that we are using to monitor RNA degradation. 5-EU permeates the cell and incorporates into nascent RNA in place of uridine, marking RNA and making it detectable via click chemistry (3).

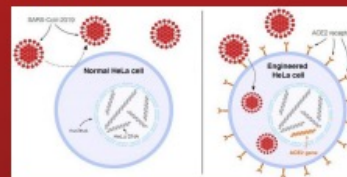


Fig. 1 (4) - a graphic showing the use of HeLa cells in COVID-19 research. We use the cells in a similar manner, by extracting a specific RNA.

- Growing + treatment of cells (Fig. 1)
 - Grow HeLa cells in 100-150mm culture dish using DMEM supplemented with 10% fetal bovine serum and 100 U/mL Penicillin/Streptomycin
 - Add 200 mL stock solution into the media and incubate cells at 37 C for 24 hours
 - After incubation change medium lacking 5-EU and harvest cells at 0, 2, 4, and 6 hours
- Harvest cells
 - Wash cells with DPBS twice and add 1mL Trizol to lyse the cells
 - Transfer the lysate to a 1.5mL tube using a scraper and pipette
 - Add 200uL chloroform and shake vigorously for 10 seconds
 - Centrifuge the sample for 15 min at 12,000 x g, 4°C.
 - Transfer 400uL of the aqueous phase containing the RNA to a new tube.
 - Add 0.5 mL of isopropanol to the aqueous phase, shake vigorously for 10 seconds and incubate for 10 min.
 - Centrifuge for 15 min at 12,000xg, 4°C and discard the supernatant.
 - Resuspend the pellet in 1mL cold 75% ethanol.
 - Invert the sample, then centrifuge for 5 min at 7,500 x g, 4°C and discard the supernatant.
 - Air dry the RNA pellet for 10 minutes and add 100 uL deionized water.
 - Measure the RNA concentration and dilute with deionized water to make the total RNA concentration 1-5 ug/uL for the click reaction and save at least 10 ug for input RNA.

- Biotinylation (Fig. 2)
 - Thaw the 10 mM Biotin Azide and Click-IT reaction buffer
 - Use 5 ug of RNA (if possible, use the highest RNA amount filled in 50 uL volume) and 2.5 uL of Biotin azide
 - Prepare the Click-IT reaction mixture cocktail in 50 uL volume per reaction as mentioned below:
 - Deionized water - 14.75uL
 - EU Buffer 2x - 25uL
 - CuSO4(25mM) - 4uL
 - Biotin Azide - 2.5uL
 - 5-EU RNA 1' 5ug - 1uL
 - Buffer additive 1 - 1.25uL
 - Gently pipette up and down to mix the cocktail after adding each component
 - Add buffer additive 1, then immediately mix the cocktail by gently pipetting it up and down and incubate it for 3 minutes. This step initiates the click reaction between the 5-EU-RNA and biotin azide.
 - Add buffer additive 2 after 3 minutes of incubation of cocktail with buffer additive 1. It should turn dark brown.
 - Incubate this reaction cocktail for 30 minutes by gently vortexing.
- Precipitation of Biotinylated RNA
 - Add 1 uL of Glycoblue, 50 uL of 7.5M ammonium acetate, and 700 uL of chilled 100% ethanol to the biotinylated RNA sample. Mix it by inverting the tubes or gently pipetting up and down.
 - Incubate the tube overnight at -70 to -80°C.
 - Centrifuge the tube at 13,000 g for 20 min at 4°C.
 - Remove the supernatant from the tube without disturbing the pellet and add 700uL of 75% ethanol. Vortex the tube briefly and centrifuge it at 13,000 g for 5 min at 4°C.
 - Repeat step 4 once and discard all the supernatant without disturbing the pellet. Let the pellet dry for 10 min at a clean bench and resuspend it in 30uL of deionized water.

Methodology

- Binding of Biotinylated RNA to Magnetic Beads
 - Prepare 20 uL Dynabeads in 1.5mL tubes.
 - Centrifuge the beads mix at 2,000 g, 1min, 4°C and remove the supernatant.
 - Wash the beads mix 3x time.
 - Add 500uL wash buffer2 (Component J) and resuspend it.
 - Place the tube on a magnet for 2 min and discard the supernatant.
 - Remove the tube from the magnet and resuspend the washed beads in 500uL wash buffer2 (Component J).
 - Repeat steps ii and iii twice, for a total of 3 washes
 - After the final wash, add 500 uL of wash buffer2 to the beads are resuspend it.
 - Prepare RNA binding reaction mix per condition in 0.5 mL eptube as below:
 - RNA binding buffer, 2X - 75uL
 - RNase inhibitor - 1uL
 - RNA - 30uL
 - Deionized water - 44uL
 - Heat the binding reaction mixture at 70°C for 5 minutes.
 - Add 20 uL of resuspended bead suspension to heated RNA binding reaction.
 - Incubate the RNA binding reactors at room temperature (RPM 300, at 21-25°C) for 2 hr while gently vortexing them on a vortex mixer. This will prevent settling of the beads.
 - After incubation, immobilize the beads using the DynaMag-2 magnet or the DynaMag-Spin magnet and wash the immobilized beads with 200uL (10 fold volume of resuspended beads in wash buffer1. Spin down and discard the supernatant.
 - Wash the immobilized beads with 200uL wash buffer 2 (Component J). Spin down and discard supernatant. Resuspend the beads in 500 uL of wash buffer 2.
- Elution of Captured Beads from RNA
 - Elute RNA by re-suspending the beads in 30uL of elution buffer (10mM Tris pH 7.4, 1mM EDTA pH 8.0) then incubate at 92°C for 4 minutes.
 - Place the tube on a magnet for 1 min and save the supernatant which includes your 5-EU labeled RNA.
- cDNA synthesis (Fig. 3)
 - Add these components to a PCR tube:
 - 5-EU RNA - 12uL
 - dNTP - 0.5 uL
 - Hexamer - 0.5uL
 - Nuclease-Free Deionized water - 2uL
 - Incubate 5 min at 65°C and then 5 min at 4°C.
 - Add cDNA synthesis reaction components together:
 - Solution from step 9a - 15uL
 - 5x buffer - 4uL
 - Reverse Transcriptase - 0.5uL
 - RNase inhibitor - 0.5uL
 - PCR - cycle PCR tubes at:
 - 50°C 2 min
 - 95°C 10 min
 - 95°C 15 sec, 60°C 1 min - 40 cycles

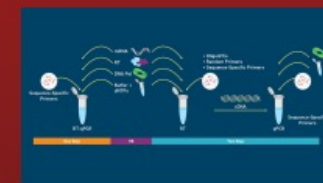


Fig. 3 (6) - the process of qPCR

Results/Conclusion

For this experiment, we neglected to utilize controls, an essential component of any experiment. Without positive or negative controls, interpretation of the data cannot be made, rendering all other work null. Further, critical errors in the protocol resulted in insufficient concentrations of genetic material as a product. We suspect the error may have arisen during an incubation stage that required mixing at 92 C.

This protocol demonstrates the principle of specificity and reactivity. As specificity increases, a molecule or compound is less likely to react to other molecules around it. By utilizing our protocol, labeled and isolated RNA undergoes specificity increases, increasing its stability over longer periods of time. Although the experiment itself did not progress as planned, we remain hopeful that, after correcting our experimental errors (by, for example, including a control such as a housekeeping gene), that this protocol will provide more precise measurements and analysis, especially in real time. This may provide more insight and importantly, context, which is extremely valuable in better understanding how these essential molecules interact. Notably, we failed to include a control and may not have sufficiently allowed the reaction to progress during incubation.

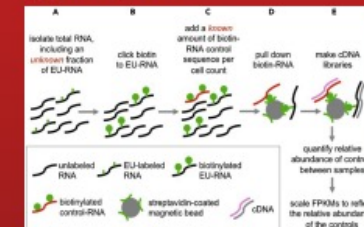


Fig. 2 (5) - the process of biotinylation and how it helps us to differentiate between labeled and unlabeled RNA

References and Acknowledgements

- OU FYRE Program
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References

Role of MAP4k4 in Metabolic Dysfunction-Associated Fatty Liver Disease

Aimee Truong, Felix Ampadu B.S.,
Aditya Joshi Ph.D.

Role of MAP4K4 in Metabolic Dysfunction-Associated Fatty Liver Disease

Aimee Truong, Felix Ampadu B.S., Aditya Joshi Ph.D.



Contact Information

Aimee Truong | aimeetruong@ou.edu | (405) 738-6936

INTRODUCTION

MAP4K4 (Mitogen-Activated Protein Kinase Kinase Kinase Kinase 4) is a protein-coding gene that plays a role in various cellular processes, including inflammation and cell proliferation (1). In the context of fatty liver diseases, MAP4K4 has been implicated in the development and progression of metabolic dysfunction-associated fatty liver disease (MAFLD) and metabolic dysfunction-associated steatohepatitis (MASH), which are characterized by the accumulation of fat in the liver and can lead to inflammation, fibrosis, and liver damage (2).

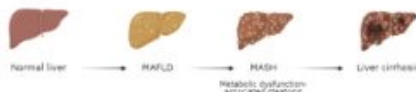


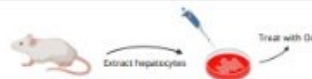
Figure 1. Progression of MAFLD

OBJECTIVE

To determine the effects of a pharmacological MAP4K4 inhibitor, Glucosyl pyrolysis-pyrimidinone (GPPD), on the progression of MAFLD

Hypothesis: GPPD will decrease the production of fat deposits within hepatocytes (liver cells).

METHODS



Oleic acid (OA) was used to induce steatosis (production of fat) within the mice hepatocytes (liver cells).

Oil Red O

Cells were washed with PBS, incubated in propylene glycol for 5 minutes, then incubated overnight in Oil Red O solution (Abcam, Waltham, MA). The stained slides were treated with 85% propylene Glycol for 1 minute, rinsed with distilled water, incubated in hematoxylin solution for 2 minutes to counterstain the nuclei, then rinsed again for imaging.

RESULTS

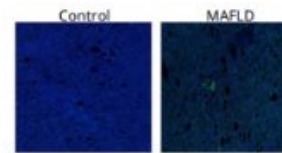


Figure 2. Human Tissue Sample of Normal vs. MAFLD-Affected Liver

The greenish hue in the MAFLD sample represents MAP4K4 expression, thus we can conclude that MAP4K4 is a prominent gene that aids in MAFLD progression.

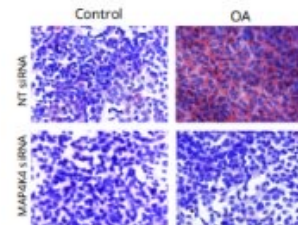


Figure 3. Inhibition of MAP4K4 Gene

The Oil Red O-staining allows us to assess fat content within cells by staining the fat pink. In inhibiting the MAP4K4 gene (MAP4K4 siRNA), the production of fat ceases completely compared to our non-targeting treatment (NT siRNA).

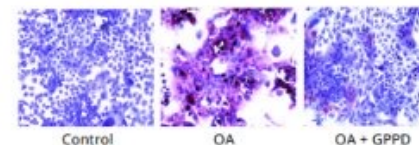


Figure 4. Oil Red O-stained Hepatocytes

Our Oil Red O-staining results show that GPPD is a successful MAP4K4 inhibitor and reduces the production of fat significantly.

RESULTS CONT.

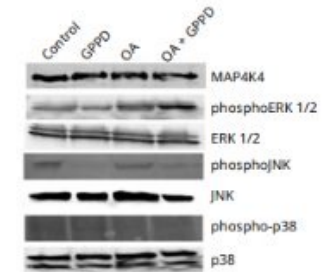


Figure 5. Western Blot of Hepatocytes

Immunoblotting did not show significant decrease in MAP4K4 expression, but a reduction of MAP4K4 activity. Increased MAP4K4 activity led to higher levels of MAFLD and MASH gene expression.

CONCLUSION

- The MAP4K4 gene aids in the progression of MAFLD
- Inhibiting MAP4K4 stops the production of fat
- GPPD is a successful drug that inhibits MAP4K4
- MAP4K4 expression decreased significantly with GPPD treatment

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Modeling Strontium Rydberg Atoms Using Quantum Defects

Christian Vaz

Department of Physics and Astronomy, Center for Quantum Research and Technology

Advised by: Dr. Doerte Blume, Dr. Anal Bhowmik



Modeling Strontium Rydberg Atoms Using Quantum Defects

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Background

- The valence electrons of atoms have energy values that are labeled by the principal quantum number n .
- To effectively trap and use Strontium in certain applications, accurate knowledge of the energy levels of Strontium's valence electrons is important.
- In "bigger" atoms, the finite charge distribution results in a measurable energy shift from the Coulomb potential. This difference is defined as the quantum defect δ .
- Electron interactions "throw off" the model for small n , but it is still useful for highly excited states where $n \gg 1$. These are called **Rydberg atoms**.

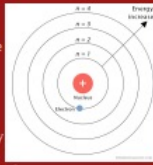


Fig. 1. Bohr model of the atom [1]

Motivation

- Optical atom trapping is useful in a variety of applications, including atomic clocks. The world's most accurate clock is currently based on the Strontium atom [2]. The first step in this process is determining energies, which finding the quantum defect will do.

Quantum Defect Application

- Once the quantum defect is found, calculation of the energy levels follows readily.
- By subtracting the quantum defect δ from the quantum number n , we define a corrected non-integer value n^* .
- Using n^* in the Coulomb model provides accurate energy levels.
- In Hydrogen, energy relative to the ionization threshold is given by $-\frac{E}{n^2}$, where E is the ionization energy of hydrogen (13.6eV).

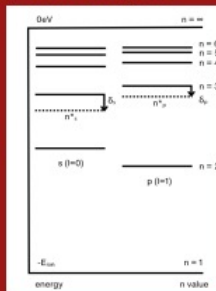


Fig. 2. Illustration of quantum defect.

- For Rydberg states of heavier atoms, the energy is given by $-\frac{E}{(n-\delta)^2}$.
- Writing $n - \delta = n^*$, the energy is given by $-\frac{E}{(n^*)^2}$.
- Thus, we can determine the energies of various Rydberg states by knowing the quantum defect of each state.

Quantum Defect Calculation

- Calculation of the quantum defect proceeds through use of the following expression:

$$\delta(n, l) = \delta_0(l) + \frac{\delta_2(l)}{[n - \delta_0(l)]^2} + \frac{\delta_4(l)}{[n - \delta_0(l)]^4}$$

where n is the principal quantum number and l the angular momentum of the electron. The constants δ_0 , δ_2 , and δ_4 are functions of l and determined experimentally; the values used in our work can be found in Brienza *et al.* [3].

- I developed a python script to plot the values of the quantum defect for $n=5$ (Strontium's ground state) to 50. The results are shown in Figure 3.

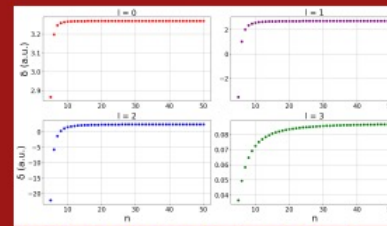


Fig. 3. Quantum defect in atomic units as a function of n . Values at $n = 50$ for the l values from 0 to 3 are 3.2688, 2.7292, 2.3642, and 0.0868, respectively.

Observations and Energy

- As n increases, the quantum defect appears to approach a constant.
- As l increases, the quantum defect's influence decreases.

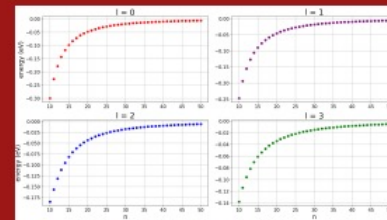


Fig. 4. Energy in electron volts as a function of n . In this case, 0 is the ionization threshold.

Electron Wavefunctions

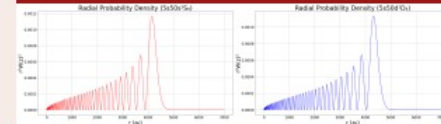


Fig. 5. Probability to find the electron at radius r . This is given by the square of the electron's wavefunction, denoted here as $W(r)$. Values are in good agreement with Scholz [4].

- Wavefunctions are obtained using the Whittaker function for $z = \frac{2r}{n - \delta_0}$.
- The maximum probability is shifted to larger r for higher l values.

Outlook and Next Steps

- The use of quantum defect theory gives accurate results for the energy values of Strontium.
- Utilizing this information, dipole matrix elements can be calculated. Using these, the polarizability, which determines frequencies that should be used in optical traps, can be found. We have created an example polarizability plot for the $5s5p^3P_1^0$ low-lying state of Strontium (which are more widely studied) using values from Porsev *et al.* [5] in Figure 6 below.

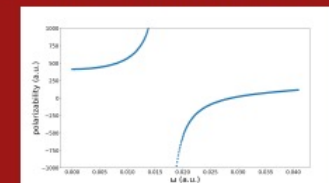


Fig. 6. Polarizability as a function of light frequency ω .

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Quantum Chaos and Thermalization in a Spin Chain

Mason Beaty, Abhik Kumar Saha, Dr. Bihui Zhu

Homer L. Dodge Department of Physics and Astronomy and Center for Quantum Research and Technology

University of Oklahoma, Norman, OK, 73071

Contact: mason.g.beaty-1@ou.edu



Quantum Chaos and Thermalization in a Spin Chain

Mason Beaty, Abhik Kumar Saha, Dr. Bihui Zhu

Homer L. Dodge Department of Physics and Astronomy and Center for Quantum Research and Technology University of Oklahoma, Norman, OK, 73071

Introduction

- Particles have an intrinsic spin, which is a form of angular momentum that is not associated with rotation as in classical mechanics and provides particles with magnetic and thermal properties
- Spins can either be in "up" or "down" states that can exist in a quantum superposition and follow the Pauli Exclusion Principle if they are fermions
- Spin systems, or spin chains, provide a model to help determine how spins between particles interact with each other
- Spin systems can be integrable, meaning they have several conserved quantities that constrain the system to be non-chaotic, or non-integrable, meaning the system exhibits quantum chaotic behavior [1]



Schrödinger's Cat, a thought experiment which describes the superposition of quantum states, such as spin states [5]

Hamiltonians and the XXZ Model

- In Schrödinger's wave equation the Hamiltonian operator corresponds to the total energy of a quantum system. Finding the energy spectrum of this Hamiltonian is key to understanding both integrability and thermalization of a system
- The XXZ spin Hamiltonian model is often used for analyzing spin dynamics in many-body systems, including spin chain models [2]

$$\hat{H} = \sum_{n=1}^{L-1} \left[J \left(\hat{S}_n^x \hat{S}_{n+1}^x + \hat{S}_n^y \hat{S}_{n+1}^y \right) + J_z \hat{S}_n^z \hat{S}_{n+1}^z \right]$$

- The energy spectrum of a system can be found through solving for the eigenvalues of the Hamiltonian

$$S^x = \frac{1}{2} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad S^y = \frac{1}{2} \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \quad S^z = \frac{1}{2} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}, \quad S^+ = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}, \quad S^- = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

Pauli matrices define the spin operators within the Hamiltonian model [2]

Spin Chain Interactions and the Energy Spectrum

- Spin chains are composed of an L number of sites, each with a fixed particle having a spin value. The XXZ model describes particle interactions using both spin operators and the coupling constant J, which determines the strength of force between nearest neighboring particles. Next to nearest neighbor interaction is possible but could cause the system to become non-integrable [2]
- The Hamiltonian also contains within it the anisotropy meter Jz. This determines the interaction of spins in the z-direction and the magnetic properties of the system, which is a thermodynamic property
- The energy spectrum can be changed based on varying the anisotropy parameter and has implications for the behavior of quantum systems



Level Statistics of the Energy Spectrum

- Using Random Matrix Theory (RMT) as a basis, that is treating the energy states as random matrix variables where the density of states is constant, the statistical properties of the system are focused on to explain dynamic and thermodynamic behavior of the spin chain [1]
- Such a statistical property is the level statistics of the energy spectrum, which is the energy spacing between nearest neighbor energy states

Symmetries of the Hamiltonian

- The XXZ model experiences certain symmetries in relation to the spin chain due to the conserved quantities of the Hamiltonian [2]
- Some symmetries include the conservation of total magnetization, parity or reflection about the middle of the chain, and z-spin inversion for a zero-magnetization sector
- Implementing symmetries helps reduce the number of possible basis states or invariant subspaces which is helpful when numerically solving for eigenvalues of the Hamiltonian

Translation into QuSpin Package of Python

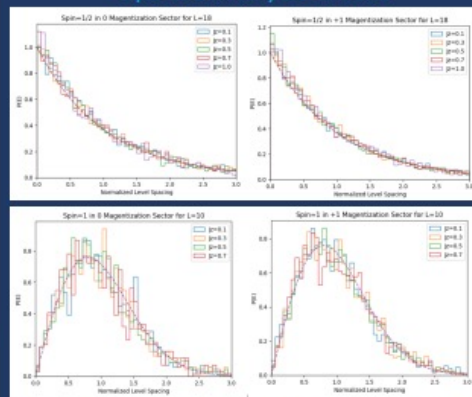
- Using QuSpin, an open-source Python package, simulations can be run to test for certain energy levels [3, 4]

```

# Create a number of sites
N=10 # spin interaction strength Jz for Is and Jx
Nz=10 # spin interaction strength Jz and Jz an anisotropy parameter
Nz=10
# Create the spin chain with nearest-neighbor interaction
# and Jz interaction on the z-direction per site, define the spin basis with parity symmetry, N/2 for even parity, -1 for odd parity
# and a random matrix for the spin interaction
# Create the Hamiltonian
# Define the spin chain in terms of number of spin sites, spin interaction strengths, and spin basis through implementing symmetries
# Define the XXZ model and nearest neighbor interactions

```

Numerical Results for Spin Chain with Open-Boundary Conditions



- Displayed level statistics chose values from the middle of the energy spectrum to avoid excitations that occur at the edge of the spectrum as well as to help exhibit RMT behavior
- Anisotropy parameter of 1.0 taken out for spin-1 since it causes the Hamiltonian to act as the XXZ model, making the statistics Poisson

Poisson and Wigner-Dyson Distributions

- The level statistics for the spin-1/2 chain appear in the form of a Poisson distribution, while the level statistics for the spin-1 chain appear as a Wigner-Dyson distribution
- The Berry-Tabor conjecture states that if the classical dynamics of a quantum system are integrable, then its level statistics it will appear in a Poisson distribution as with the spin-1/2 chain [1]
- If a system is non-integrable and experiences quantum chaos, it will appear as a Wigner-Dyson distribution as seen with the spin-1 chain

Integrability and Thermalization

- Though the XXZ model itself is integrable, spin-1 chains appear to experience quantum chaos when this Hamiltonian is implemented. This could occur for several reasons such as eigenstate energy repulsion or increased possible spin states interacting beyond the nearest neighboring particle
- The integrability of a many-body system has direct implications for the thermalization of said system [1]



The Eigenstate Thermalization Hypothesis and Generalized Eigenstate Thermalization

- Quantum thermalization occurs in isolated systems. This can occur by causing a quench and changing the total work done on the system by changing a parameter in time, such as the anisotropy parameter
- The Eigenstate Thermalization Hypothesis (ETH) describes how a quantum system will approach a thermal equilibrium state based on the matrix elements of observables, such as the energy states from the XXZ Hamiltonian [1]
- ETH only applies to nonintegrable systems that experience quantum chaotic behavior
- For integrable systems, if all conserved quantities are known as with the XXZ model, then a Generalized Gibbs Ensemble (GGE) can be constructed to describe thermal relaxation
- Following a quench, GGE can describe thermalization of different thermodynamic observables if the eigenstates of an integrable Hamiltonian are similar to the expectation values of the latter observables

Future Direction

- Observing the energy states and level statistics of a Hamiltonian operator reveal how many-body quantum systems like spin chains behave dynamically and thermodynamically. This helps further connect classical and quantum physics, helps describe how observables react to time evolution in quantum systems, and paves the way for future research on much more complex many-body systems with much higher spin degrees.

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2020 Youth Attitudes on American Democracy Survey | FYRE

Sam Hunt and Avery Ravech
Political Science, College of Arts and Sciences, University of Oklahoma, OK

2020 Youth Attitudes on American Democracy Survey

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Background

What is the Youth Attitudes on American Democracy Survey?

- ◆ The Youth Attitudes on American Democracy survey is a survey that is given each year to students in the Intro to American Federal Government class (P SC 1113).
- ◆ It is designed to capture the beliefs of OU students on democracy and on national and local policy questions.
- ◆ It measures levels of civic engagement and political participation among the student body.
- ◆ The survey is designed to be cross-sectional, meaning that it measures a new sample of students each year, allowing it to identify trends across time and throughout different demographics.

What is our project?

- ◆ For our FYRE project we researched survey methodology to create the survey instrument for the 2024 version of the Youth Attitudes survey.
- ◆ Unfortunately, as these surveys are conducted with human respondents, they require approval by an Institutional Review Board before they may be administered, and due to time constraints, we were not able to get such approval.
- ◆ To complete our project, we instead analyzed the results of the 2020 survey, which had not previously been used.
- ◆ Our analysis looked at trends in support for political violence, religious nationalism, defunding police, and more using Excel and Stata to find trends within the OU student body.

Sample Question

In general, how would you rate your mental health?

Terrible

Poor

Average

Good

Excellent

Above is an example of a multiple-choice Likert scale question which is a very common question type on our survey. The Likert scale is a method of rating that poses a question or statement and offers a scale of different degrees of response. There are typically two extreme options at opposite ends of a spectrum, and then intermediate options in between to precisely identify respondent's opinions.

Methodology

Survey Instrument Creation

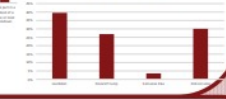
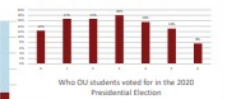
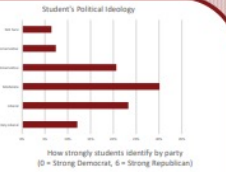
The survey was created in Qualtrics, a free survey creation tool that allows researchers to easily publish and share their surveys, as well as analyze the resulting data. Questions were designed to accomplish several goals, including providing demographic information about respondents and gauging opinions on political topics or ideas. Different types of questions required different types of answering methods, and questions were designed using multiple choice, open response, the Likert scale, and 1-10 rating scales. To reduce possible bias in our survey, questions were inspected to remove leading language, loaded questions, and overly complicated wording. We also looked to past surveys at OU and nationally to see what question wordings are successful in receiving quality responses. To ensure that as many respondents completed the whole survey as possible, survey depth had to be balanced with length to achieve the most concise yet comprehensive data. Questions were valued based on their relevance to current political trends, their ability to be renarrowed over time, and their importance in understanding the beliefs of the OU student body.

Survey Administration

The 2020 survey was presented during class to students of Intro to American Federal Government (P SC 1113). The survey was not required, and students were required to consent before they could take the survey. Students were additionally allowed to stop at any time or choose not to answer any individual question they found uncomfortable.

Data

- ◆ The survey received 573 responses, 564 of which consented to take the survey. Giving the survey a large sample size.
- ◆ Through Qualtrics, the survey data was automatically processed into an excel sheet that coded each response as a number. By coding qualitative data into quantitative data, it is far easier to analyze, allowing researchers to run complex analysis like finding the relationship between questions.
- ◆ These graphs represent a brief overview of some of the primary results.



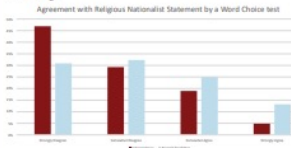
This graph represents another experiment that was implemented into the survey, in which questions surrounding police, police funds, and social services funds were asked four different ways varying in their political extremeness. Although each question asked a substantively similar question, we found that the way the question was worded led to massive differences in support for the proposed policy change.



This graph represents the likelihood a respondent answered that "sometimes you must use violence against the government to get what you want" given different levels of conspiracy belief. We hypothesized that there would be a correlation between political violence and conspiratorial thinking, and the results back that, showing that people who believe in many conspiracy theories more often support using violence against the government.

Results

- ◆ This survey contained numerous interesting experiments and results, however for the sake of presentation we will present the most interesting of our findings.



The first result we would like to highlight compares two of our questions. The first asks respondents their level of agreement with the idea that "the vast resources of the U.S. indicate that god has chosen it to lead other nations". This is a question designed to assess agreement with religious nationalist ideas. The second question asks respondents to identify which word sounds best to them "respect for elders" or "independence". In accordance with our hypothesis, those who chose "respect for elders" had higher levels of agreement with the religious nationalist statement.

Conclusion

- ◆ The Youth Attitudes on American Democracy Survey is an incredibly useful and unique tool that lets political science researchers identify political attitudes and trends among the OU student body.
- ◆ The survey allows for the unique ability to compare results between years. The survey also lets you perform experiments on how things like phrasing and word choice can influence and predict support for policies and political attitudes.
- ◆ Creating a good survey instrument is a difficult but necessary part of conducting a survey, and effort must be taken to reduce bias in the format and within questions.
- ◆ The OU student body has a very diverse set of political beliefs, although there is still room for growth in voter turnout and civic engagement on campus.

Literature Review

The Total Survey Error Approach (Weisberg 2009)

- ◆ Comprehensive look at survey error in all stages of the survey process
- ◆ Explains how to avoid possible biases in the survey structure, questions, respondents, and even the sample
- ◆ Importance of survey ethics

So you want to do a survey (Bernier, Bowers, & Heyman 2002)

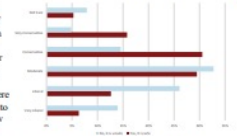
- ◆ Explains the history of the survey as well as multiple types of surveys with an analysis of their benefits and drawbacks
- ◆ Explains how to use your data, sample size, bias
- ◆ Outlines the key steps in how to create a survey

Writing Survey Questions (Pow Research Center 2021)

- ◆ Outlines the basics of questionnaire design
- ◆ Shows the advantages of certain types of question design and how to use intentional word choice
- ◆ How to avoid bias within your questions and how to create the ideal question order

Is it safe to attend indoor social justice demonstrations during Covid-19?

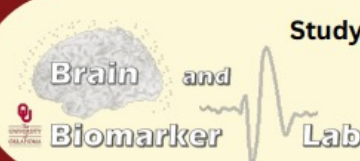
These graphs showcase an experiment that was designed into this survey. Half of the respondents would get a question asking if it was safe to attend religious gatherings during Covid while the other half was asked if it was safe to attend social justice demonstrations during Covid. The results for each question were compared to the respondent's ideology to see if there would be differences in how the two questions were answered. In general, liberals viewed all events as less safe and conservatives viewed all events as more safe. However, As we hypothesized, a higher percentage of conservatives considered religious services safe than social justice demonstrations, and a higher percentage of liberals considered social justice demonstrations safe than religious services.



Studying the Effects of Free Play on the Wellbeing of 1st-5th Graders

Mark Selliman 1, Jordan Norris 1, Brenna Arledge 1, Erin Casey 2, Devon Carlson 2, and Lauren Ethridge 1


1 University of Oklahoma Department of Psychology, 2 University of Oklahoma Jeannine Rainbolt College of Education, 3 University of Oklahoma Department of Political Science.



Studying the Effects of Free Play on the Wellbeing of 1st-5th Graders

Mark Selliman¹, Jordan Norris¹, Brenna Arledge¹, Erin Casey², Devon Carlson², and Lauren Ethridge¹

¹University of Oklahoma Department of Psychology, ²University of Oklahoma Jeannine Rainbolt College of Education, ³University of Oklahoma Department of Political Science.



Introduction


- Public schools should nurture the development of the whole child, encompassing academic, emotional, physical, and moral dimensions.
- Play is crucial for whole-child development, influencing neural growth, regulation, and repair.
- Free play, devoid of predetermined objectives, is essential for children of all ages to thrive.
- However, free play opportunities are often limited due to pressures from standardized testing in schools.
- Administrators may underestimate the academic, emotional, and physical benefits of play compared to structured learning activities.

Methods

- OU Free Play Lab was designed for 1st-5th graders (n=225) to engage in constructive, dramatic, sensory, gross motor, and game play.
- Weekly 45-minute sessions in the lab, with two trained play facilitators/researchers observing student activities.
- Midpoint trial: Half of the students from each grade level attend in fall (14 weeks) and the other half in spring (14 weeks) to serve as their own controls and account for developmental processes.
- Multi-disciplinary was approach implemented to investigate changes in child well-being using behavioral, neural, self-, and teacher-report data measurements.

Data Collection

- Subset of 50 (10 from each grade, gender balanced) children underwent a computerized action observation task while wearing a mobile, wireless, 24-channel EEG cap.
- Trained researchers conducted behavioral observations during the lab, coding cooperative play and conflict management.
- Consent/assent from classroom teachers and children for emotional well-being and classroom environment reports using standardized questionnaires at baseline, midpoint, and end of study.




Hypotheses

We hypothesize that free play opportunities with an emphasis on cooperative play will have three Target Outcomes -

- enhance development of goal orientation and inference in young children, thus enhancing neural beta suppression during the action observation task;
- improve positive affect and prosocial behaviors, and
- reduce internalizing and externalizing problems

Discussion

- This pilot study has revealed interesting patterns in the data. Specifically, greater relative power was observed in the baseline data compared to the midpoint data. This may be related to a change in the children's well-being or self-perception as they experience the playlab.
- we intend to use the pilot study results to secure further funding for larger-scale research.
- It emphasizes dissemination of research findings to both academic and policymaking communities.
- Finally, it seeks to advocate for policy changes that promote regular play in schools to support healthy child development and future citizenship



A paired t-test was run to examine differences in relative power across timepoints for frontal and posterior regions. Significant differences were observed for frontal theta ($t(1,14)=2.15, p=0.049$) and posterior gamma ($t(1,14)=2.36, p=0.033$).

Paired Differences	95% Confidence Interval of the Difference				t	df	One-Tailed p	Two-Tailed p
	Mean	Std. Deviation	Std. Error Mean	Lower				
Pair 1. Δ theta_HL_delta_TMO2	.00392	.01727	.00448	-.02039	.08998	14	.817	.657
Pair 2. Δ theta_HL_gamma_TMO2	-.00074	.00987	.00177	-.00454	.00307	14	.342	.684
Pair 3. Δ theta_HL_delta_TMO2	.00100	.00387	.00190	-.00114	.00315	14	.180	.332
Pair 4. Δ theta_HL_gamma_TMO2	.00309	.00916	.00180	.00029	.00579	14	.019	.037
Pair 5. Δ theta_HL_delta_TMO2	.00037	.00256	.00141	-.00056	.00130	14	.011	.023

A paired t-test was run to examine differences in relative power across timepoints for the temporal region. Significant differences were observed for temporal delta ($t(1,14)=-2.36, p=0.033$), beta ($t(1,14)=2.30, p=0.037$), and gamma ($t(1,14)=2.56, p=0.023$).

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Saccharomyces cerevisiae Culturing, Spheroplasting, and Lysing for Top-Down Proteomic Analysis

Kendalyn Firenza¹, Alyssa Williams², Jake T. Kline¹, and Luca Fornelli²

¹Luca Fornelli Lab, Department of Chemistry and Biochemistry, University of Oklahoma, OK

²Luca Fornelli Lab, School of Biological Sciences, University of Oklahoma, OK

DODGE FAMILY COLLEGE OF ARTS AND SCIENCES
DEPARTMENT OF CHEMISTRY
AND BIOCHEMISTRY
UNIVERSITY OF OKLAHOMA

Background and Motivation

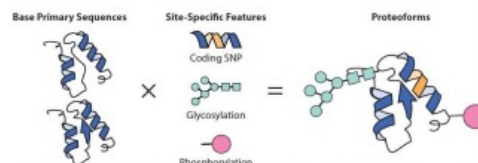


Fig. 1 – Site specific features are retainable in TDP for analysis versus alternative methods.

- *Saccharomyces cerevisiae*, more commonly known as baker's yeast, is often used for research on eukaryotic cells and the production of beer, bread, medicine and biofuel (Parapouli, 2020).
- A proteoform (Figure 1) is a polypeptide gene product that has genetic and chemical modifications that are specific among protein groups. Top-Down Proteomics (TDP) uses mass spectrometry to detect and characterize intact proteoforms (Smith, 2013).
- Our objective was to accurately identify the maximum number of proteoforms from *S. cerevisiae* utilizing TDP.

Yeast Culturing and Harvesting

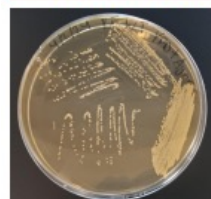


Fig. 2 – Inoculated YPD/Agar Plate from *S. cerevisiae* parental stock (BY4742).

Culturing – Grew parental strain, BY4742 (MAT α only, heterothallic), using Yeast Peptone Dextrose (YPD) media and agar (Figure 2). Grew saturated cultures to 1.5-2.0 Abs @ OD600 and harvested cells by centrifugation (Figure 3).

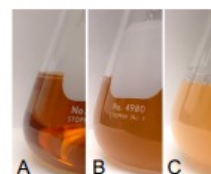


Fig. 3 – 100 mL YPD ;
A) No inoculation
B) Target Growth - 1.58 OD600
C) Overly inoculated - >3.0 OD600

Spheroplasting & Lysing – Used Goldbio (GB-178) kit according to manufacturer protocol (substituted 5mM dithiothreitol (DTT) for Beta-mercaptoethanol) and quantified protein concentrations in an Bicinchoninic Acid (BCA) Assay (Figures 4 and 5).

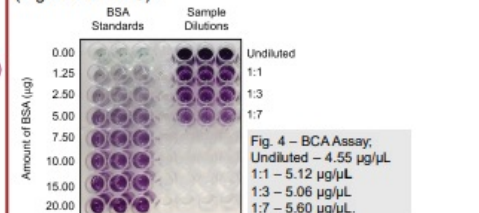


Fig. 4 – BCA Assay;
Undiluted – 4.55 μ g/ μ L
1:1 – 5.12 μ g/ μ L
1:3 – 5.06 μ g/ μ L
1:7 – 5.60 μ g/ μ L

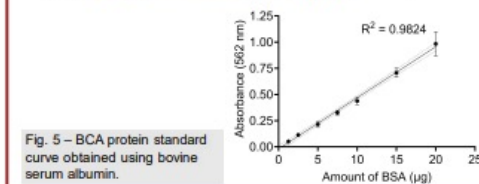


Fig. 5 – BCA protein standard curve obtained using bovine serum albumin.

Separation and MS Analysis

PEPPI – 200 μ g yeast lysate was used to perform Polyacrylamide-Gel-Based Prefractionation for Analysis of Intact Proteoforms (PEPPI), using a 12% SDS-PAGE gel and targeting 0-30 kDa proteins for extraction (Figures 6 and 7). A methanol/chloroform/water precipitation step was then performed prior to LC separation for sample clean up.

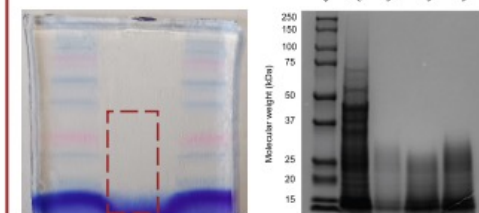


Fig. 6 – PEPPI Gel; lane 1 – Ladder, lane 2 – sample, lane 3 – ladder; dash line represents 0-30 kDa sample that was excised for LC separation and MS analysis.

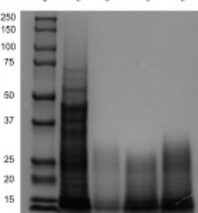


Fig. 7 – Confirmation Gel; 5% of recovered material was run on SDS-PAGE and Coomassie stained for total protein content.

Mass Spectrometry (MS) – Samples were separated by liquid chromatography and then analyzed in an Orbitrap Eclipse mass spectrometry with gas phase fractionation via FAIMS (field asymmetric ion mobility spectrometry).

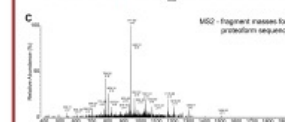
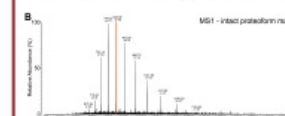
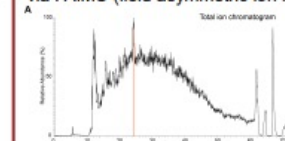


Fig. 8 – MS analysis of yeast lysates. (A) Chromatogram of intact species. Tan box represents region examined in (B). Mass spectrum of intact species. Brown box indicated isolated precursor that is fragmented resulting in (C), fragmentation spectrum from collision-based dissociation.

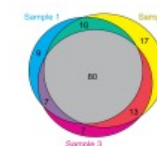


Fig. 9 – Overlap of proteoforms identified in each sample.

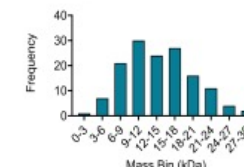


Fig. 10 – Distribution of proteoform masses identified across all samples.

Future Directions

143 proteoforms were identified from mass spectrometry-based TDP analysis. Future goals include sample preparation optimization, for maximizing protein extraction and cleanup efficiency, and organelle fractionation for subcellular localization of proteoforms.

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Saccharomyces cerevisiae Culturing, Spheroplasting, and Lysing for Top-Down Proteomic Analysis

Kendalyn Firenza 1, Alyssa Williams 2, Jake T. Kline 1, and Luca Fornelli 2

1 Luca Fornelli Lab, Department of Chemistry and Biochemistry, University of Oklahoma, OK, 2 Luca Fornelli Lab, School of Biological Sciences, University of Oklahoma, OK



Isolation and Identification of a *Leuconostoc* sp. from local produce for university culture collection

Meghana Nuthi¹ Jacobey King¹, Dr. Paul A. Lawson¹

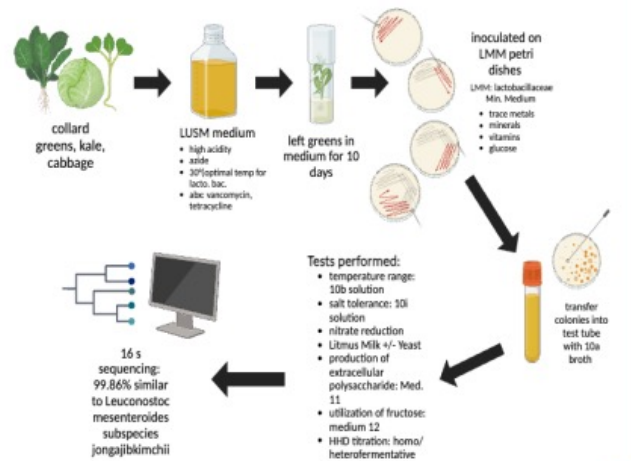
¹Department of Microbiology, University of Oklahoma, Norman OK 73019, Center for Microbial Identification and Taxonomy

Introduction/Background:

The family *Lactobacillaceae* encompasses a diverse group of lactic acid bacteria (LAB) known for their pivotal role in food fermentation and mammalian microbiomes. LABs are renowned for their ability to convert sugars into lactic acid, which contributes to the preservation, flavor, and texture of fermented foods (1). Among LAB, species of the genus *Leuconostoc* are particularly significant in the context of food science, especially in the production of cheeses and other dairy products. In the senior capstone course at our university, there was a notable absence of a *Leuconostoc* reference strain. To address this gap, the present study aimed to isolate and identify a strain of *Leuconostoc* from local produce, specifically collard greens. Collard greens are a common leafy vegetable known for their nutritional value and culinary versatility. They are also known to harbor a diverse microbiota, including various LAB species. Therefore, they represent a promising source for the isolation of *Leuconostoc* strains. In this study, we describe the isolation and identification of a *Leuconostoc* sp. from local collard greens, which will serve as a valuable addition to the university's culture collection. This strain will not only fill the gap in the senior Capstone course but also contribute to the broader field of microbiological research undertaken at the university.

Methods:

To isolate and identify a *Leuconostoc* species from local produce, we employed a series of methodological steps. Initially, our samples were sourced from environmental settings, specifically fresh collard greens, kale, spinach, and cabbage. Subsequently, we subjected these samples to enrichment in LUSM broth, a selective medium optimized for the growth of lactic acid bacteria (LABs) belonging to the family *Lactobacillaceae*. Following enrichment, we inoculated the broth onto LMM plates, which are both selective and differential. LMM plates are designed to inhibit the growth of gram-negative organisms while facilitating the differentiation of colonies via the formation of clear zones, or halos, around colonies. These methodologies were employed with the aim of isolating *Leuconostoc* from the produce samples. Subsequently, a variety of tests were conducted to confirm the identity of the isolated bacteria as illustrated by the diagram below.



Results:

TEST PERFORMED:	RESULTS:
Temperature Range	25-36 degrees Celsius
Salt Tolerance	Positive
Nitrate Reduction	Negative
Litmus Milk +/- Yeast	Positive w/ yeast, Negative w/o
Production of extracellular polysaccharide	Positive
Utilization of Fructose	Positive
HHD titration	Heterofermentative

Fig 1. Tests performed and corresponding results



Fig 2. Positive Result of Extracellular Polysaccharide Production

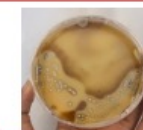


Fig 3. Bacterial colonies after inoculation on LMM petri dishes

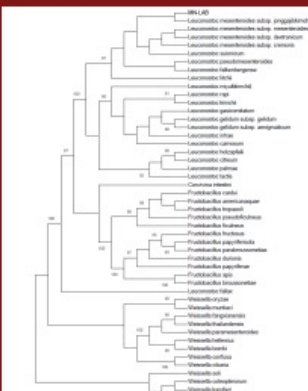


Fig 4. Evolutionary Tree with clades that show *Leuconostoc mesenteroides* subsp. *jongajbikimchii* and its closest relatives

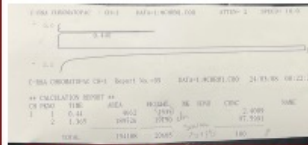
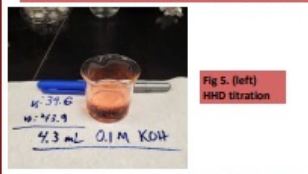


Fig 5. (left) HHD titration
Fig 6. Gas chromatograph displaying what gasses were made from our organism

Discussion/Conclusion:

The successful isolation and identification of *Leuconostoc mesenteroides* subsp. *jongajbikimchii* from local produce highlights the efficacy of a polyphasic approach in bacteriology. By combining traditional microbiological techniques with molecular methods, we were able to comprehensively characterize the isolated strain. The inability of the bacterium to utilize litmus milk without a yeast supplement and its lack of nitrate reduction activity are consistent with the known characteristics of *Leuconostoc* spp. The optimal temperature range of 25-36 degrees Celsius further supports the identification of the strain as a *Leuconostoc* species, as does its salt tolerance, aerotolerance, extracellular polysaccharide production, and heterofermentative fermentation type. Sequencing of the bacterial sample and subsequent analysis using specialized software confirmed its identity as *Leuconostoc mesenteroides* subsp. *jongajbikimchii*, with a high degree of similarity (99.86%). This demonstrates the power of molecular techniques in providing precise taxonomic information, complementing the phenotypic characterization obtained through traditional methods. In conclusion, the successful isolation and identification of *Leuconostoc mesenteroides* subsp. *jongajbikimchii* from local produce exemplify the utility of a polyphasic approach in microbiology. This approach not only allows for the accurate identification of bacterial species but also provides a comprehensive understanding of their phenotypic and genotypic characteristics.

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Meghana Nuthi 1, Jacobey King 1, Dr. Paul A. Lawson 1

1 Department of Microbiology, University of Oklahoma, Norman OK 73019, Center for Microbial Identification and Taxonomy