

**STRATEGIC INITIATIVE**  
**Undergraduate Research Funding for**  
**STEM Majors at the University of Idaho**  
**FINAL PROJECT REPORT**

*FY 2024*

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*Higher Education Research Council*  
*Idaho State Board of Education*  
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*Submitted by:*  
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**University of Idaho**  
Office of Undergraduate Research

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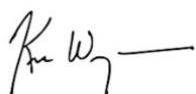
## Executive Summary

Undergraduate research is recognized as a high-impact educational practice that increases the rates of student retention and engagement. At the University of Idaho, it is practiced throughout all units on campus, and it is centrally placed in the institution's strategic plan. The Office of Undergraduate Research (OUR) is taking the lead in enabling research opportunities for undergraduates at UI as it manages various competitive student grant programs that directly support student research.

During AY 2023-24, generous funding from the State Board of Education (SBoE) permitted UI to continue its Summer Undergraduate Research Fellowship (SURF) Program. This intensive 10-week summer research experience actively engages undergraduates in faculty- mentored, independent research. Over the course of the program, students are mentored toward increased independence on their projects. Each student was provided with a \$5,000 stipend in the form of a fellowship which allows them to devote full time effort to their projects. Each student was also provided with \$1,000 to help offset materials and supplies and other project-related expenses. Selection of student participants is a competitive process in which students submit research proposals to the Office of Undergraduate Research and the Director utilizes faculty affiliates in each college to review the proposals and provide selections. **This year there were 42 applications!** The Director then makes sure that projects all well-represented across colleges. It is important to note that not all projects this cycle required a supply budget. This allowed for us to fund additional students with SBoE funds. For FY24, the SBoE funding supported **11 OUR SURF** awards. All these students supported by SBoE funds attended and presented the results of their projects at the 2024 Idaho Conference on Undergraduate Research in Boise, ID on July 17-18, 2024. These students will also be required to present their results at the UI Undergraduate Research Symposium on April 21, 2025. In addition to the projects supported by SBoE funds, the OUR was able to fund **4 additional awards** to allow further participation beyond STEM disciplines.

End of project feedback from students and their mentors was overwhelmingly positive. Significantly, none of the undergraduate research projects described here would have been possible without the support provided by the State Board of Education. We sincerely thank the Higher Education Research Council and the Idaho State Board of Education for making these experiences possible for our students.

Sincerely,



Kristopher V. Waynant  
Director, Office of Undergraduate Research  
Associate Professor, Chemistry  
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*Enhancing Comfort and Repeatability of Human-Robot Attachment Systems: Comparison of Compliant Orthoses for BLUE SABINO*

**Emile Johnson (College of Engineering)**

**Mentor: Dr. Chris Bitikofer (Mech Eng)**

**Abstract:** The human-robot attachments (HRA) connecting humans to exoskeleton robots should facilitate user independence, efficient donning/doffing, and maintain alignment while balancing comfortable interface compliance against structural rigidity. This report presents a proof-of-concept comparison of innovative self-aligning, size-adjustable HRA components, specifically as applied to the upper arm. A novel compliant orthotic mechanism was developed, consisting of a cable-driven mechanism 3D printed out of flexible TPU filament with PLA inserts for added support and rigidity. This design was compared to the existing rigid components often used for exoskeleton applications, specifically the solid design currently used on the BLUE SABINO. Experimentation included a ballistic-gel simulated human arm fitted with an array of force-sensitive resistor (FSR) sensors to measure applied forces. Kinematic alignment was assessed across 5th percentile female to 95th percentile male sizes using 3D printed arm cross-sections. Findings provide evidence-based recommendations for the design of HRA.

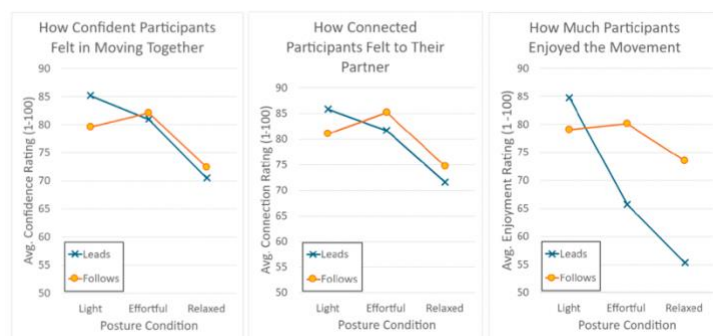
**Results:** Pressure sensor tests comparing the developed compliant orthosis to the currently used solid orthosis revealed that a compliant approach can create a more even pressure distribution. The pressure distribution improves as it's tightened. Further, the proposed complaint design has been shown to have the potential to significantly reduce kinetic misalignment in preliminary laser alignment tests. These factors are important in ensuring patient comfort and usability in exoskeleton devices that might employ an orthosis like these. While these results indicate that the compliant design achieved improved pressure distribution over the arm mock's circumference, it's evident in the polar plots that the compliant orthosis didn't distribute pressure as evenly as would be ideal, with significant high points on the top and bottom sensors. This result is potentially a consequence of mismatch between the orthosis shape (circular) and the arm mock (oval), forcing the arm into a circular shape. Further research should investigate designing the natural profile of the compliant orthosis to match the arm's oval shape and to consider any other reasons why the low-pressure points are observed. Furthermore, future work should intentionally design in lower pressure areas around bony or sensitive areas of the arm to improve comfort and ensure safe blood flow even when the orthosis is completely tightened. Future development will seek to improve these factors while also increasing usability. Application of the recommendations from the material testing conducted in this study for a future full-scale prototyped device, consisting of an outer shell cast using Dragon Skin 30 (Smooth-On, Inc) with filled gaps cast using Ecoflex 00-10(Smooth-On, Inc.) could improve pressure spread and comfort further. A complete mounting system compatible with BLUE SABINO should also be developed to enable misalignment-free exoskeleton application. Finally, to ensure user independence, the closure system should be refined to achieve better ease of use.



*Figure 1: BLUE SABINO Exoskeleton Concept*

**Abstract:** This study will investigate the influence of postural instructions on dynamic partnered movements and quality of dance experience for older adults learning social swing dancing. Older adults face increased health risks due to social isolation. Partner dancing, which includes ballroom, Latin, and swing dances, fosters community while using non-verbal cues and physical touch. While the value of a body configuration that facilitates sufficient tension in the physical contact between dance partners is widely appreciated in the dance world, this concept has not been studied scientifically. This study will use a repeated measure design with 30 pairs of participants to investigate how postural instructions impact dance experience. The study will comprise a multi-stage dance lesson, with each stage including a baseline trial followed by three experimental trials using Effortful, Relaxed, and Light postural instructions. Participants will fill out surveys to evaluate their connection, confidence, and enjoyment after each trial. Increased enjoyment throughout the experiment is predicted, with the Light condition having the highest connection, confidence, and enjoyment ratings. Long-term potential benefits of this innovative new line of work include increasing well-being in older adults through improving the quality of dance instruction and understanding how posture affects quality of touch.

**Results:** Preliminary findings from 11 dyads suggest that Leads prefer the Light instructions, while the Relaxed instructions result in the lowest ratings from both Leads and Follows regarding how confident participants felt in moving together, how connected participants felt to their partner, and how much participants enjoyed the movement. When averaging across stages using a scale of 1-100 with 1 being the least and 100 being the most, Leads rated Light at 85.8 ( $p=0.44$ ), Effortful at 81.7 ( $p=.10$ ), and Relaxed at 71.5 ( $p=0.05$ ) for Connection; Light at 85.2 ( $p=0.46$ ), Effortful at 80.9 ( $p=0.02$ ), and Relaxed at 70.5 ( $p=0.09$ ) for Confidence; and Light at 84.8 ( $p=0.04$ ), Effortful at 82.1 ( $p=0.06$ ), and Relaxed at 72.4 ( $p=0.16$ ) for Confidence; and Light at 79.1 ( $p=0.71$ ), Effortful at 80.2 ( $p=0.17$ ), and Relaxed at 73.5 ( $p=0.20$ ) for Enjoyment. See Figure 1.



*Figure 1: Average ratings for Confidence (left), Connection (center), and Enjoyment (right) for both Leads and Follows during Light, Effortful, and Relaxed posture conditions.*

### **Preliminary Conclusions**

Our clearest initial result is that both Leads and Follows experienced the least connection, confidence, and enjoyment when the Lead uses an intentionally Relaxed approach. When the arms are very relaxed, they cannot efficiently transmit information about the movement of the rest of the body. This supports the importance of teaching the “frame” to beginners in partner dancing. A limitation of this study is the use of subjective self-report measures. Next steps include testing the remaining 19 dyads, analyzing the data using 4x4 AVOVAs, reviewing video footage of partner movement, and writing a research paper. Future work will include objective assessment of how well the partners move together.

**Barrett Abendroth (College of Science)**

**Mentor: Onesmo Balemba (Biology)**

**Abstract:** Type 2 diabetes (T2D) is associated with debilitating disorders and poses serious healthcare burdens. The total estimated cost of diagnosed diabetes in the U.S. in 2022 is \$412.9 billion, including \$306.6 billion in direct medical costs and \$106.3 billion in indirect costs. Gut movement-related diseases are among the major debilitating conditions affecting patients. With rising prevalence, mortality, and financial costs, it is essential to combat this disease effectively. Previous research shows that mice fed a high-fat diet (HFD) have neuropathy and gastrointestinal dysmotility before symptoms of T2D. Studies of intestinal contents of HFD suggest that they accumulate proteases and toxic substances that damage gut nerve cells and inhibit muscle contractions before T2D develops. We, therefore, postulate that *Phocaeicola vulgatus*—the protease-producing gut bacterium, which is increased in T2D patients, plays a key role in instigating the development of neuropathy, dysmotility, and T2D. The goal of this proposal is to determine whether four strains of *P. vulgatus* isolated from human feces produce molecules that cause gut movement-related diseases by injuring gut nerve cells and inhibiting muscle contractions. We will achieve this by testing whether culture supernatants of these bacteria damage nerve cells and inhibit contractions of cultured duodenal muscle preparations from healthy mice. We expect to identify at least one species that reduces gut movement by damaging myenteric neurons, causing constipation, which is a common disorder in T2D patients. This research will further our knowledge of the specific cause of gastrointestinal dysfunction in diabetic patients and lead to the development of potential biomarkers for early disease detection and treatments.

**Results:** All four strains of *Phocaeicola vulgatus* (PV) inhibited muscle contraction after 24 hours of culture. Noteworthy, culture supernatants of one strain of PV (*P. vulgatus* DSM-3289) significantly inhibited muscle contractions after 12 hours. Bacteria culture medium and the tissue culture medium did not affect gastrointestinal muscle contractions. Our data also suggested that *P. vulgatus* DSM-3289 activated the expression of TNF-alpha in myenteric neurons and enteric glia. Similarly, *P. vulgatus* DSM-108234 activated the expression of TNF-alpha in myenteric neurons and enteric glia. However, quantitative analysis of our data indicated that *P. vulgatus* DSM-3289 significantly increased TNF-alpha expression in myenteric neurons while *P. vulgatus* DSM-108234 increased TNF-alpha expression in enteric glia. Qualitative analysis indicates a similar pattern with Caspase-11 expression, where *P. vulgatus* DSM-3289 activated caspase-11 expression in myenteric neurons, while *P. vulgatus* DSM-108234 activated caspase-11 expression in enteric glia. We are performing quantitative analysis of Caspase-11 expression to confirm these observations.

**Conclusions:** The gut microbiome is linked with causing motility-related disorders in diabetes patients by damaging nerve cells in the gut. However, molecules responsible for causing these effects and the exact bacteria strains are not known. Here we show for the first-time findings suggesting that exudates and transudates of *P. vulgatus* strains, especially *P. vulgatus* DSM-3289 decrease gastrointestinal motility by inhibiting muscle contractions and damaging myenteric neurons.

Damage to myenteric neurons play the primary role in driving diabetic gastrointestinal disorders (gastroparesis, constipation, diarrhea and pain). We have previously shown that fecal supernatants of mice fed high-fat diets to model obesity and type 2 diabetes contain unknown water-soluble molecules that damage myenteric neurons *ex vivo* by activating inflammation and oxidative stress. The findings that *P. vulgatus* DSM-3289 activated TNF- $\alpha$  expression in myenteric neurons, while *P. vulgatus* DSM-108234 activated TNF-alpha expression in enteric glia, supports the view that the byproducts of *P. vulgatus* DSM-3289 and DSM-108234 are toxic to enteric neurons and glia. Likely the byproducts underlie the significant differences between *P. vulgatus* strains in decreasing intestinal muscle contractions and activating inflammation in myenteric neurons and glia and could trigger cell death.

**Emma Macon (College of Natural Resources)**

**Mentor: Karen Launchbaugh (FRFS)**

**Abstract:** Virtual fence is a promising tool for adaptive management of livestock grazing. Currently, there are several companies offering neck-collar devices, similar to the invisible fence used for dogs. Based on rancher input, a push is being made to see if virtual fence technology can be transitioned from neck collars to an ear-borne device. One of the biggest challenges in this transition is identifying a sustainable weight for the devices that allows proper healing of the ear piercing and minimal long-term irritation. Other research with ear-borne devices on cattle has suggested maximum weights anywhere from 30-250 grams. Previous research conducted at the University of Idaho suggests that 60 grams may be a realistic target weight when using two-prong ear tags (EnduroTags). The goal of this proposed research is to 1) determine whether a healing period before weight application is optimal for ear health; 2) establish where it is best to place weight on the ear that promotes good ear health; and 3) determine the effects of combined weight and probe configuration on ear health.

**Results:** A 2-week healing period after tags were applied but before additional weight was added, resulted in lower scores indicating greater levels of healing (Fig. 3). Further analysis supported that the majority of animals with a healing period ranked in the lower half of our overall rank ( $Z=\pm 2.731$ ,  $p=0.0063$ ) meaning less crust, scar tissue, and blood was observed at the end of this experiment.

Secondly, weight placement on the ear tag did not affect ear droop (orientation) and mobility ( $p>0.05$ ) and there was no statistical difference in irritation between treatments, but 83% of animals in the “Front-Bottom” treatment exhibited irritation while in the “Front + Back” and “Front-Post” treatments, 67% and 50% of animals exhibited irritation, respectively and there was a difference in the pendulum effect between treatments ( $p=0.0000617$ ). The degree to which the ear tag swung when animals moved their head was scored with increasing severity. Initial analysis showed a difference in swing between treatments ( $H=12.538$ ,  $df=2$ ,  $p=0.00189$ ). Further analysis revealed ears with tags that had weight near the posts showed less swing than ears with tags that were weighted near the bottom ( $p<0.05$ ), however there was no difference when weight was located at the bottom of the tags ( $p>0.05$ ; Fig. 4).

**Conclusions**

A 2-week healing period before the application of weight to an ear tag is effective in decreasing ear irritation and allows for greater healing once weight is applied. This information is valuable for developing devices applied to livestock ears. Weight placed near the ear tag posts limits the swing and pendulum effect of the ear device which may reduce irritation. Our observations indicate a developing trend between irritation and swing severity; however, a longer study would be necessary to make a conclusion. Finally, electrode configuration and construction will be an important factor in promoting good ear health. We suggest that airflow around the electrode site will be important to minimize adverse effects of electrodes and weight configuration.

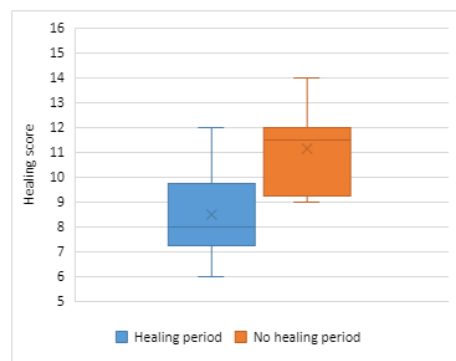


Figure 3. Average healing score that each treatment was given upon the final observation.

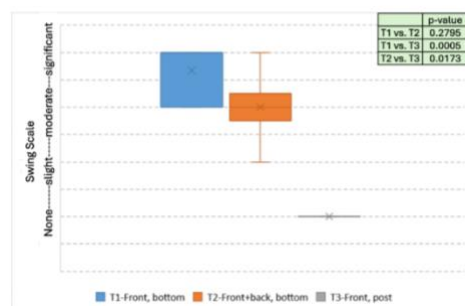


Figure 4. The range of scores recorded in each treatment

## *Protease Involvement in Prophage Induction Therapy*

**Loretta Rodman (COS/CALS)**

***Mentor: James Van Leuven (AVFS)***

**Abstract:** *Paenibacillus larvae* is a bacterial pathogen that infects honeybee larvae, causing American Foulbrood disease. Options to treat and control *Paenibacillus larvae* infections are limited due to this bacteria's resilience and swift emergence of antibiotic resistance, thus, research to identify and test alternative therapies is a significant priority. The purpose of this research proposal is to test the effectiveness of prophage induction therapy to control *P. larvae*. Prophage induction therapy includes exposing a bacterial culture to an inducing agent, resulting in cellular production of phage virions and synchronized lysis of the bacterial cells. Genomic analysis of *P. larvae* strains revealed that the majority of strains carry two or more prophages in their genomes, indicating prophage induction therapy could be a useful approach. Although preliminary prophage induction testing using classic inducing agents such as ultra-violet light and mitomycin C have not been successful, our lab was able to successfully induce prophage production from *P. larvae* using proteinase K. There are currently no reports describing induction of prophage with proteinase K. Thus, the aim of this proposal is to test the effectiveness of various proteases for inducing prophage from *P. larvae*, which may uncover novel prophage inducing agents.

**Results:** After multiple failed attempts of trying to induce prophage with the tailocin stability testing and not getting inducing prophage it was determined that further investigation in the experiment was deemed necessary. After investigating the original parameters that induced prophage with Proteinase K, it was determined that standard procedure was not being followed and would most likely be unable to be replicated. It was determined in a meeting that the project be switched to another experiment that would be able to have obtainable data that would still fit the budget parameters. After some trial and error, it was concluded to test different phage-resistant strains of 3650 *P. larvae* on honeybee larvae to test if the mutations that made the bacteria resistant to the phage caused any changes in its virulence. Streak plates of the phage resistant bacteria that were obtained were: Heath X, Scottie r, Scottie y, Wa alpha, and XIII Ba. They were named after the phage that they were resistant to. Before testing these strains on larvae, a dilution test was conducted on the strains to be able to determine the cell count in relation to a certain Optical Density (OD) where the OD range for experiments were 0.7-1.0.

Note that due to difficulty growing the dilution tests for Wa alpha and XIII Ba there is no data yet. A growth curve was also conducted on each strain by adding a single colony into 3mL of BHI broth and letting it incubate for 7 days in a 37° C incubator. Each day 200uL of the solution was used to test the OD. For the first virulence test a 48-well plate of 0-3 day old larvae (0-3 days after hatching) were grafted from the same frame. 3650, one resistant strain, the same resistant strain at a higher cell count, and a control were all kept in one plate. The plate was fed 1uL of cells and 10uL of feed. They were then fed every day at the same time with the feeding regiment advised in the Coloss bee guide.

### **Conclusion**

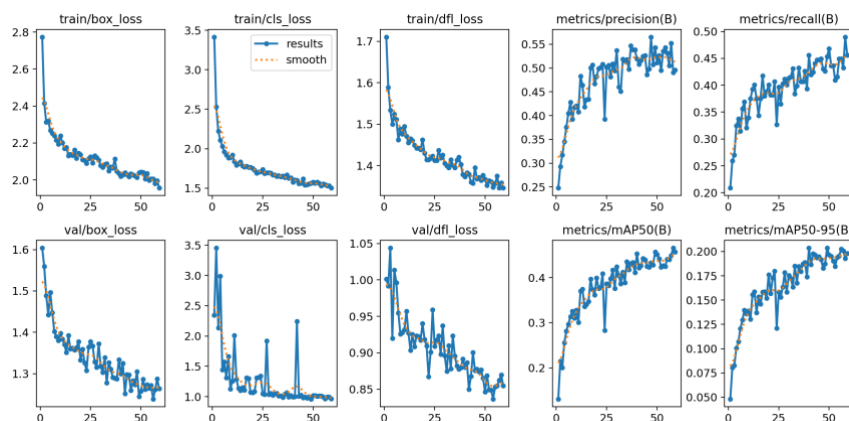
The first, and so far, only survivability test has inconclusive results because by day 4 all of the larvae were dead even the control. This could be due to possible contaminants. There will be more replicates with all the strains to allow for a more accurate representation. Graphing error killing 25% of controls is to be expected but this is much higher. The growth curve of 3650 has a much higher OD at day 1 compared to the other phage-resistant strains which then slowly tapers off. The phage-resistant strains take longer to get to higher ODs which means they have a slower replication rate than the wild type 3650. This change could cause the phage-resistant strains to be less virulent since this bacterium is not as deadly to larvae infected at ages older than 4 days after hatching.



**Kevin Wing (College of Engineering)****Mentor: John Shovic (Comp Sci.)**

**Abstract:** This project aims to perform a comprehensive study focused on enhancing reforestation efforts through the application of machine vision and plant-identification algorithms in agricultural robotics. With the urgency of environmental restoration underscored by initiatives like the REPLANT Act, this research aligns with Project Evergreen’s objectives to optimize weed identification and eradication, thus promoting healthier forest regeneration. By researching plant identification algorithms and leveraging machine vision for precise weed and seedling differentiation, the project aims to advance autonomous weeding robots’ capabilities, reducing manual labor and improving seedling growth environments. This endeavor not only supports efficient reforestation but also offers a scalable, technology-driven model for environmental conservation, addressing the distinct challenges associated with sustainable agriculture and forestry.

**Results:** A convolutional neural network (CNN) was determined to be the ideal solution for detecting various weed species in a nursery setting, with the YOLOv8 architecture chosen specifically for its real-time capabilities. The decision to train on a diverse dataset comprising multiple weed types aimed to improve the model’s generalization and applicability in real-world conditions. The model achieved a precision of 0.52 and a recall of 0.47, resulting in an F1 score of 0.49. These results indicate a moderate ability to correctly identify weeds, highlighting the challenges of achieving a balance between precision and recall across different weed species. Further analysis showed variability in detection performance across weed types, suggesting the need for targeted improvements.



*Figure 3: Model Accuracy over Training*

**Conclusions:** The deployment of a YOLOv8-based model for detecting various weed species in a nursery setting has shown moderate success. The model achieved a precision of 0.52 and a recall of 0.47, leading to an F1 score of 0.49. These results suggest that while the model can identify weeds to some extent, improvements are needed to enhance both precision and recall. The variability in performance across different weed types highlights the need for further refinement of the model and dataset. Future work will focus on optimizing the model’s architecture and expanding the training dataset to improve detection accuracy under diverse environmental conditions. Integrating this technology into an autonomous weeding robot continues to hold promise for improving seedling survival and reducing manual labor costs in the nursery.

## Effects of Beaver Dams on Songbird Diversity in Semi-Arid Western Rangelands

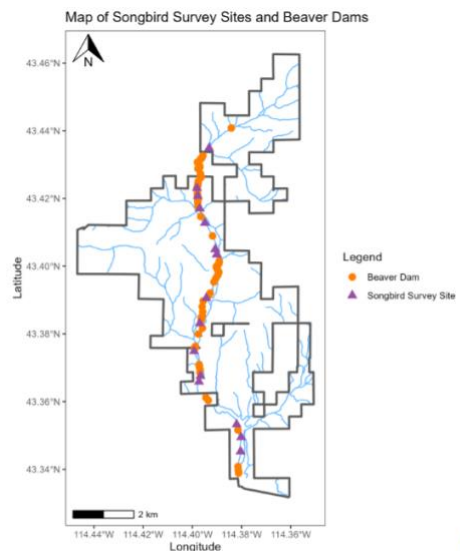
**Annie Vaage (College of Natural Resources)**

**Mentor: Simona Picardi (FWS)**

**Abstract:** Semi-arid western rangelands are commonly known to be moisture limited, and riparian habitats are vital for wildlife in these regions. Within riparian habitats, beavers are ecosystem engineers that can modify the landscape by building dams along rivers and creeks. Past studies have shown that beavers can positively impact other wildlife, including songbirds. In this study, we will examine songbird occupancy in relation to dam presence and characteristics at Rinker Rock Creek Ranch (semi-arid sagebrush steppe traversed by a riparian corridor). The objective of this study is to test the hypothesis that beaver activity increases songbird occupancy in riparian habitats in western rangelands. We predict that songbird occupancy will be inversely correlated with distance to beaver dams and positively correlated with their size and density. To test this hypothesis, we will collect occupancy data on songbirds to relate with the beaver dam data, while controlling for cattle presence and density. This research will provide valuable information to managers at Rinker Rock as they implement the construction of artificial beaver dams along the creek in the future. Field research was completed from May to July.

### ***Preliminary Results:***

I finished the songbird field data collection on July 26th, 2024. I worked Monday through Friday and performed 135 site visits to 15 distinct survey sites (9 visits per site). I spent a total of 405 minutes conducting songbird surveys (3-minutes per survey). Overall, I detected 66 bird species (53 songbird species). Red-winged Blackbirds (225), Song Sparrows (198), Yellow Warblers (154), and Western Meadowlarks (113) were the most commonly detected species. There were 1,416 total bird detections (including repeated counts of the same species). This summer we censused a total of 286 dams along Rock Creek and its tributaries. Of those 286 dams, 217 are natural and 69 are man-made (BDAs). 28 dams were classified as active, 93 as inactive, and the remaining 165 as breached. In Fall 2024, I will analyze the songbird and beaver dam data using occupancy models to answer my research question, hypothesis, and prediction.



### **Outcomes of this work include:**

- Scientific outcome: an improved understanding of the role of beavers in creating habitat for other wildlife in arid rangelands, particularly songbirds;
- Management outcome: inform the implementation of BDAs as a management tool to enhance wildlife habitat at Rinker Rock Creek Ranch;
- Data generation outcome: a complete census of beaver dams at Rinker Rock Creek Ranch, which will be used in this project as well as other research projects based at the Ranch (including a graduate project led by a MS student supervised by Dr. Simona Picardi);
- Educational outcome: gain experience in the process of conducting research, from field data collection to analysis to communication.

**Conclusions:** *An improved understanding of the role of beavers in creating and facilitating habitat for other wildlife in moisture-limited systems, particularly songbirds. This research provides valuable information to managers at Rinker Rock as they implement the construction of artificial beaver dams (BDAs) along the creek in the future.*

**Aayushree Lama (Virtual Tech and Design)**

**Mentor: Lori Wahl (Textile Design)**

**Abstract:** The fashion industry annually disposes of 92 million tons of textiles in landfills and is ranked third in the world for emissions. The industry has a projected increase of 50% in global emissions alone by 2030. Sustainable practices must be explored and implemented to reduce waste and use resources more responsibly. 3D printing offers a way of producing fantastical digital designs that may require new approaches to construction rather than traditional cut-and-sew methods using fabric and a sewing machine. By integrating sustainable filaments and fabrics in a single garment, this research developed a sustainable method of producing garments using a combination of cut-and-sew techniques and 3D printing. I developed a two-piece, wearable garment for the physical world and a virtual, digital version for virtual applications.

### Results

I created seven small-scale prototype 3D prints and two full-scale prototype prints, along with three virtual prototypes before moving into physical prototypes. Two physical garment prototypes were constructed before the final garment, with three test prints used to develop the application of Cromafácil and varying surface smoothing techniques. Experimentation with and without clear gloss varnish helped achieve a metal-like finish, and sanding was used to enhance smoothness. Challenges arose with the adhesion of Cromafácil, requiring 7-8 layers of repainting for proper coverage. An initial design intended to attach around the body was incompatible with the filament's properties, leading to the creation of small notches that served as loopholes to sew the 3D printed attachment onto the base garment. The project primarily focused on refining the finish and attachment systems for the top, ensuring a secure and aesthetically pleasing outcome. Early prototype prints posted to Instagram garnered over 57,000 views, attracting significant interest in the designs and potential future accessories.



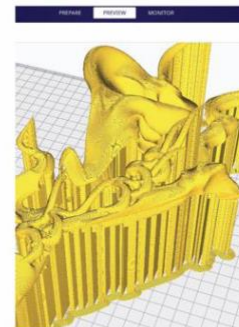
3D Modeling prototype on nomad and 3Ds max.



Digital base garment prototype in Browzwear.



Attachment on the 3D printer in PLA filament. Buildplate dimensions are 420 x 420 x 500 mm



3D model in the slicing software with supports visible.



Cromafácil on the test prints.



Physical base garment prototype.

# Beyond Negotiation: Unveiling the Economic Impact of Unionization on automotive industry performance

**Anna Bliss (College of Business and Economics)      Mentor: Shenghan Xu (Supply Mgmt.)**

**Abstract:** This research project examines the relationship between CEO compensation and company performance within the context of corporate governance. It outlines the structure of corporate governance, the process of becoming a CEO, and the role CEOs play in leading companies. The study explores the factors that determine CEO pay, including performance-based incentives and board decisions. Using regression analysis on data from S&P 500 companies, the research assesses whether CEO compensation is justified by key performance metrics like Return on Assets (ROA) and Return on Equity (ROE). The findings highlight the ongoing debate surrounding CEO pay, with mixed evidence on whether it aligns with company performance. The study concludes that the justification of CEO compensation depends on various factors, including how pay is structured, the effectiveness of corporate governance, and broader economic and social considerations. While performance-based pay can align CEOs with shareholder interests, concerns about pay disparity and governance issues continue to drive debate.

**Results:** To quantitatively assess the relationship between CEO compensation and company performance, regression analysis was employed. The dependent variable in the regression model was CEO compensation, while the independent variables included the financial performance metrics derived from the DuPont Model—specifically ROA and ROE. This statistical approach aimed to determine whether there was a significant relationship between CEO pay and these performance indicators.

A comprehensive literature review was conducted to provide qualitative insights that complement the quantitative analysis. The review focused on existing research on CEO compensation, particularly studies that explore the connection between executive pay and company performance. It also examined the role of corporate governance in setting CEO compensation, ethical considerations surrounding pay disparities, and the strategic and operational factors that influence CEO effectiveness.

**Summary:** The project underscored the complexity involved in determining CEO compensation. While performance metrics like ROA and ROE are often cited as justifications for high pay, the weak correlation observed suggests that other factors—such as the CEO’s role in strategic decision-making, crisis management, and market positioning—are also critical in shaping compensation packages. Also the role of corporate governance emerged as a pivotal factor in CEO pay determination. The literature review and data analysis both pointed to the influence of board oversight and shareholder activism in setting compensation. Effective governance can ensure that CEO pay is aligned with company performance and shareholder interests, while weak governance can lead to excessive pay that is not justified by results.

Pay Rank	CEO	Company (TICKER)	Total Pay (MILLIONS)	Cash Pay (MILLIONS)	Change From 2022	Pay Vs. Industry	Return vs. Industry	1-Year Return	Total Pay (MILLIONS)	Median Employee Pay	Industry
1	Hock Tan	Broadcom (AVGO)	\$161.83	\$1.20	▲ 167%	\$\$\$\$\$	▲ 83.70%	▲	161.83	317199.00	Semiconductors & Semiconductor Equipment
2	Nikesh Arora	Palo Alto Networks (PANW)	\$151.43	\$2.25	▲ 1355%	\$\$\$\$\$	▲ 50.20%	▲	151.43	206035.00	Software & Services
3	Stephen Schwarzman	Blackstone (BX)	\$119.78	\$0.35	▼ -52.70%	\$\$\$\$\$	▲ 82.80%	▲	119.78	245000.00	Financial Services
4	Christopher Winfrey	Charter Communications (CHTR)	\$89.08	\$5.20	▲ 470%	\$\$\$\$\$	▲ 14.60%	▲	89.08	54476.00	Media & Entertainment
5	Will Lansing	Fair Isaac (FICO)	\$66.35	\$1.95	▲ 251%	\$\$\$\$\$	▲ 110.80%	▲	66.35	101674.00	Software & Services

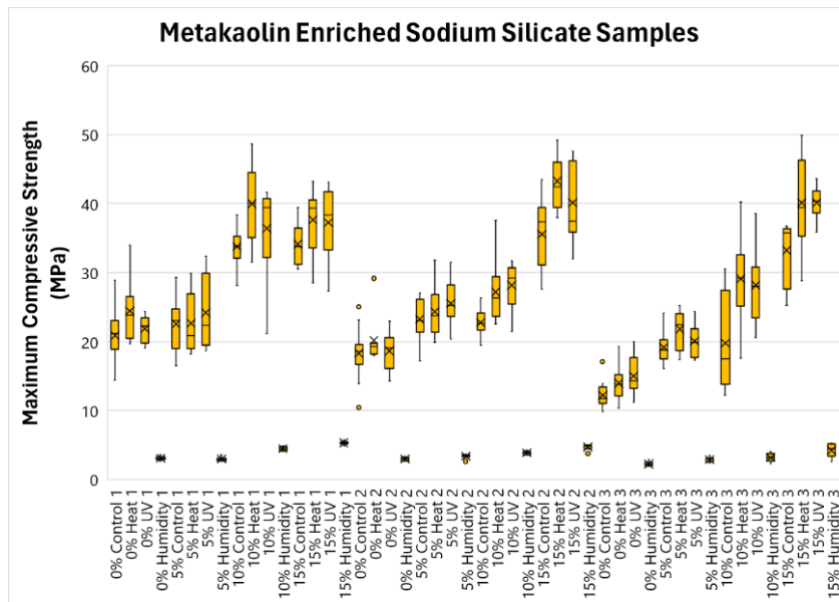
*Organized Collection of Data (Collected through Web Scraping)*

# Metakaolin Modification for Enhanced Durability: Evaluating the Longevity of 3D Printed Wood Material

**James Setters (College of Engineering)**

**Mentor: Mike Maughan (Mech. Eng.)**

**Abstract:** Our research group aims to use additive manufacturing to make biobased wood houses. To assess the real-world durability of our environmentally friendly 3D printed material, we are addressing concerns such as ultraviolet light, humidity, and extreme temperatures. These conditions were simulated using two testing chambers including the COOSPIDER UV resin curing light lamp and the TestEquity 1000H Series. I propose to conduct experiments to analyze the effects of aging on our material and explore the impact of adding an alkali activator, metakaolin, to enhance water resistance in the wood composite. The testing involves extruding rods of sodium silicate wood (SSW) mixture and sodium silicate metakaolin wood (SSMW) mixture. Specimens were cut and tested, with multiple specimens from each group serving as the control groups. The remaining specimens will be divided into groups of 8, exposed to various weathering events, and then tested for compressive strength using the Instron 5500R. The metakaolin-enriched samples outperformed the others, demonstrating resilience against the environmental challenges applied.



**Results:** As shown in the Figure a trend is apparent that indicates the more metakaolin you add to the mixture of sodium silicate and wood flour the higher the compressive strength is expected to be. Within the SSMW mixtures groups, the 15% metakaolin group outperformed the rest. My hypothesis was that the infusion of additional 3D networks of silica into our material could usher in a marked enhancement in both weather resistance

and compressive strength. This was only partly correct, the samples that were enriched with metakaolin did perform better with compression, but the humidity test samples performed 85% worse, proving that the metakaolin did not enhance water resistance in our material.

**Conclusions:** Adding metakaolin improved the mechanical properties of our material by increasing the number of 3D networks of silica but did not notably improve its water resistivity. Going forward we will need to find a new additive, a different resin or a new curing method that can provide water resistant qualities while still maintaining its compressive strength. This is an important factor in making sustainable housing for future generations and because of this study we now know how to increase the compressive strength of our material by up to 5 times more than the control groups.

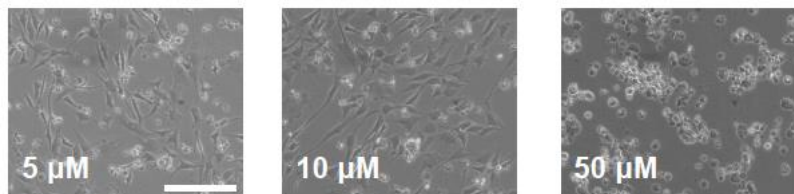
Exploring the role of MRTF-SRF signalling in the regulation of collagen crosslinking enzyme production by stem cells

**Andrea Cernuda Herraiz (College of Engineering)**

**Mentor: Nate Schiele (Biol. Eng.)**

**Abstract:** The reduced ability of tendon tissue to regenerate and heal following damage or rupture, alongside the financial burden associated with treating these tendon pathologies, highlights the potential of tissue engineering using mesenchymal stem cells (MSCs) as a therapeutic route to approach this clinical issue. However, many gaps in knowledge exist pertaining to MSCs ability to differentiate into functional tendon tissue, or tenogenesis. Understanding tenogenesis is crucial in tissue engineering and regenerative medicine approaches. To investigate this, this study tests the myocardin-related transcription factor (MRTF) - serum response factor (SRF) cell signaling pathway, known to regulate gene expression in response to changes in the cytoskeleton. Additionally, lysyl oxidase (LOX) is a critical enzyme involved in the cross-linking of collagen and elastin fibers in the extracellular matrix (ECM), and appropriate collagen cross-linking is essential for maintaining tendon structural and mechanical properties. This project will investigate LOX production, its regulation via transforming growth factor (TGF) $\beta$ 2 and its relationship with the MRTF-SRF pathway. The objective is to explore the effect of the activation of the MRTF pathway on LOX production by 1) testing whether TGF $\beta$ 2 activates MRTF-SRF and 2) evaluating the chemical inhibitor CCG-1423 to assess whether MRTF is the mechanism of LOX production.

**Results: TGF $\beta$ 2-induced tenogenic growth of MSCs proceeds despite CCG-1423 treatment.** Initial cytotoxicity tests were conducted to evaluate the optimal concentration range of CCG-1423 optimal for cell viability and effectivity in inhibiting MRTF-SRF pathway signaling during TGF $\beta$ 2-induced tenogenesis. MSCs were treated with TGF $\beta$ 2 at 50 ng/mL and CCG-1423 at 5, 10, and 50  $\mu$ M (left to right) and were collected on day 3. With increasing CCG-1423 concentration, cytotoxicity increases and cell viability decreases. MSCs treated at these concentrations showed a reduction of fibroblastic morphology and increased death rate due to cytotoxicity. Therefore, further testing of CCG-1423 cytotoxicity was conducted using lower concentrations. The control groups, consisting of MSCs treated with DMSO and 50 ng/mL TGF $\beta$ 2, showed no visible morphological changes with respect to the treatment groups, which consisted of MSCs treated with 500 nM, 1  $\mu$ M, and 2  $\mu$ M. In terms of LOX enzyme production, LOX does not seem to be consistently impacted by CCG-1423 treatment. However, Western blot and densitometry analyses showed an increase in LOX production in the TGF $\beta$ 2 treatment groups, which is consistent with our lab's previous findings. Thus, densitometry analyses showed inconclusive impact in LOX production by MRTF-SRF inhibition.

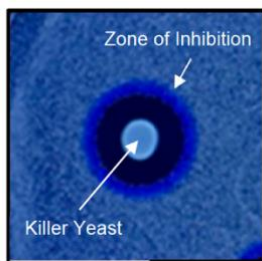


**Conclusions:** The use of the first-generation inhibitor CCG-1423 allowed cell viability but presented no visible morphological changes at concentrations lower than 2  $\mu$ M during tenogenic growth of MSCs. Therefore, it is concluded that the use of CCG-1423 must be further assessed for its effectiveness in inhibiting MRTF-SRF activity. Additionally, the second-generation inhibitor CCG-203971, known to be less cytotoxic, will be assessed due to its potential for enhanced efficiency. Furthermore, Western blotting and densitometry analyses showed no conclusive evidence of changes in LOX production due to MRTF-SRF inhibition. Thus, an additional experimental process to better understand the impacts of activating MRTF-SRF pathway must be conducted, as well as exploration of whether LOX is more related to cellular morphology change or other potential TGF $\beta$ -induced signaling pathways.

**Lily Givens (College of Science)**

**Mentor: Paul Rowley (Biological Sciences)**

**Abstract:** Fungal infections, particularly those caused by *Candida* species, pose a significant threat to global health. This threat is exacerbated by limited, and often ineffective treatment options that rely on chemically synthesized medications. A potential alternative to traditional antifungal drugs lies in the application of “killer toxins” produced by certain yeast strains. Yeast exhibiting the “killer” phenotype are capable of secreting toxins that are harmful to neighboring susceptible yeasts while maintaining immunity themselves. This project will investigate the novel killer toxin K21L found in *S. kudriavzevii*, a homolog of the K21 toxin found in *S. paradoxus*. Preliminary data shows a high level of sequence similarity between K21 and K21L, indicating the newly discovered K21L will likely possess the killer phenotype. This project aims to confirm the presence of the K21L gene and killer toxin expression by *S. kudriavzevii*. Subsequent cloning of K21L and expression by *S. cerevisiae* will confirm that K21L is a killer toxin. This work is novel because there is no known strain of *S. kudriavzevii* in the literature that possesses the killer phenotype. The validation of the K21L toxin would establish K21L as the first known killer toxin in this species.



**Figure 1:** Killer yeast inhibiting the growth of a susceptible yeast. Dead, susceptible yeast cells become stained by methylene blue, while the living yeast are able to reduce it and remain brightly colored.

**Results:** The presence of the killer phenotype was indicated by a zone of growth inhibition or staining of susceptible lawn yeasts by methylene blue. Multiple known toxins (K2 & K28) were used as positive controls. Both toxins were tested against 29 lawn strains. K21 inhibited the growth of 9 strains. K21L inhibited the growth of 17 strains. 8 susceptible strains were shared between the two toxins. Strains susceptible to both toxins showed a larger zone of growth inhibition against K21. The novel toxin K21L found in *S. kudriavzevii* Y27342 possess the killer phenotype.

**Conclusions:** The killer phenotype of K21L is due to the presence of a cytoplasmic persisting dsRNA virus. K21L exhibits similar killing activity to its homolog K21L. Further experimentation must be done to confirm the sequence of the M21L sequence in *S. kudriavzevii* due to inconclusive preliminary results. Future work will include continued work on confirming the sequence of the M21L sequence, cloning and expression of K21 and K21L in *S. cerevisiae*, experiments investigating spectrum of activity of K21 and K21L at varying pH and temperature and designing of chimeras of M21 and M21L.

K21	K21L	Strain
Blue	Blue	<i>N. dair</i> NCYC_777
Blue	Blue	<i>C. glab</i> ATCC 2001
Blue	Blue	<i>C. glab</i> Y-1417
Blue	Blue	<i>C. glab</i> Y-17256
Blue	Blue	<i>C. glab</i> CBS 138
Blue	Blue	<i>S. cer</i> BY4741
Blue	Blue	<i>S. cer</i> CYC_1113
Blue	Blue	<i>S. cer</i> DSM_70459
Blue	Blue	<i>S. cer</i> MS300C (K28)
Blue	Blue	<i>S. cer</i> NCYC_1001
Blue	Blue	<i>S. cer</i> Y-2429
Blue	Blue	<i>C. glab</i> YB-181
Blue	Blue	<i>C. glab</i> ATCC 66032
Blue	Blue	<i>C. glab</i> ATCC 90030
Blue	Blue	<i>S. par</i> OS 294 (K74)
Blue	Blue	<i>K. afr</i> NCYC 2729
Blue	Blue	<i>N. cast</i> NCYC 2898
Blue	Blue	<i>S. cer</i> K12
Blue	Blue	<i>S. par</i> CBS 432
Blue	Blue	<i>S. par</i> A12C
Blue	Blue	<i>S. mik</i> NBRC 1815
Blue	Blue	<i>S. mik</i> SSS 211
Blue	Blue	<i>S. mik</i> NBRC 10993
Blue	Blue	<i>S. kud</i> NBRC 1802
Blue	Blue	<i>S. kud</i> NBRC 10991
Blue	Blue	<i>S. kud</i> SSS 411
Blue	Blue	<i>S. bay</i> CBS 7001
White	White	No killing ability found
Light Blue	Light Blue	Blue halo present
Dark Blue	Dark Blue	Clear zone present
Light Blue	Dark Blue	Both blue halo and clear zone

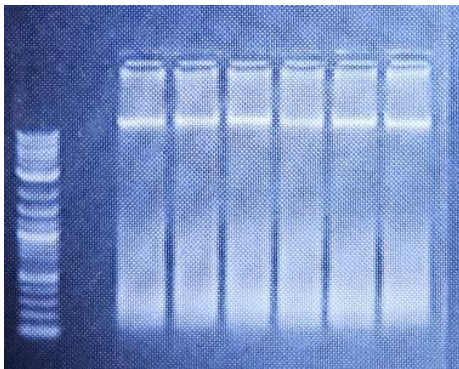
Understanding the cell forms that underlie the chlamydial developmental cycle

**Megan Ward (College of Science)**

**Mentor: Scott Grieshaber (Biological Sciences)**

**Abstract:** *Chlamydia trachomatis* is a bacteria that relies upon a developmental cycle consisting of three distinct cell forms: reticulate bodies (RBs), intermediate bodies (IBs), and elementary bodies (EBs). RBs replicate within host cells but are not infectious. EBs are infectious but cannot replicate. IBs are transitional forms from RB to EB. Developmental cycle completion is central to chlamydial pathogenesis in that *C. trachomatis* are obligate intracellular parasites of eukaryotic cells. Infection of this specific genus of *Chlamydia* can cause blinding trachoma as well as STIs with the potential to cause pelvic inflammatory disease and infertility. The regulation and mechanisms of these cell forms are currently poorly understood. Preliminary and published data indicate four stages of the cycle, but understanding cellular contributions to the developmental cycle and pathogenesis can be difficult due to mixed cell environments of chlamydial inclusions. Therefore, this project will focus on understanding the regulation of gene expression in these early populations, and the impact of regulation on the infectious cycle. We will develop a CRISPRi knockdown screen to assess the role of essential genes on cell type regulation, and then investigate the role of cell type-specific expression.

**Results:** Over the course of this summer, I designed plasmids using Benchling, an online software for the visualization and construction of theoretical plasmids.



The software allowed me to use sequences from preliminary studies to piece together theoretical plasmids that I would then be making in the lab. My advising professor helped me to create the basic template that is used for CRISPR constructs, adding on the bits and pieces to target specific sequencing in this knockdown project. Making the backbone of the plasmid was successful after two tries, with bright bands of DNA showing up on the electrophoresis gel. The bands of DNA were cut out and purified.

*Figure 3. This image shows results from an electrophoresis gel, including a 10KB ladder on the far left and 6 samples of DNA backbone to the right. A dye allows UV to cause the bands to glow brightly just above the top "rung" of the 10Kb ladder, indicating that it is at our projected 16Kb size. The other gradients that appear in the sample columns are fragments and debris. The DNA bands were cut out using sterile razorblades, and then purified using centrifugation.*

**Conclusions and Future Directions:** I'm now re-doing the PCR for the backbone again to have more available, using two different guide RNA templates. I will then repeat the ligation with a 5:1 ratio and a flush of insert for each one. Every colony that results will be streaked out for isolation, grown in *E. coli* within liquid LB media, purified using a miniprep, and sent out for sequencing. I'm also working with my professor to reassess the design of the plasmid on Benchling to look for any errors.

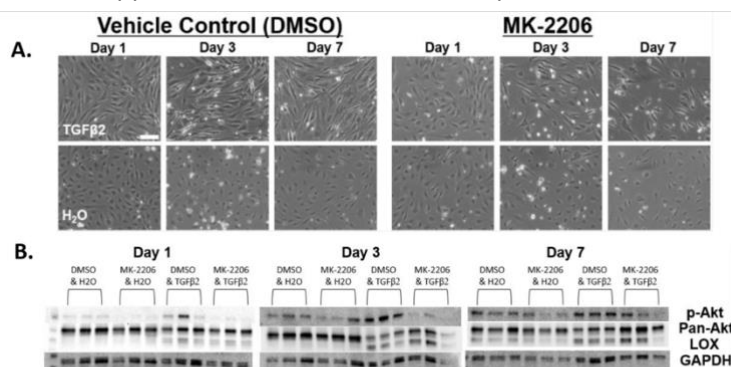
Without a proper cloning of the constructs with sequencing verification, I cannot move forward with a chlamydial transformation, as well as other tests and assays that would follow. If I can finally get this plasmid to ligate and give me colonies that come back with the correct sequencing, I can then transform it into *Chlamydia trachomatis* using host epithelial kidney cells from the African greenback monkey. From there, I can continue with entry and growth assays, as outlined above, as well as the testing for the phosphorylation of TARP.



**Abstract:** Tendon injuries are common and result in altered mechanical properties, affecting quality of life. In developing tendons, collagen molecules within collagen fibrils are crosslinked by the enzyme lysyl oxidase (LOX), establishing a strong collagen network and impacting the mechanical properties of tendon (Marturano et al 2013). A challenge for developing therapies to control LOX and tendon function is the limited information on the mechanisms that regulate LOX production by cells. To address this, our recent work found that LOX production may be increased by mesenchymal stem cells (MSCs) when treated with transforming growth factor (TGF) $\beta$ 1 or (TGF) $\beta$ 2 (Pancheri et al 2024), but the cell signaling pathways involved in this regulation are unknown. TGF $\beta$  cell signaling may include the Akt pathway, and our prior work suggests Akt may regulate stem cell differentiation toward the tendon lineage (tenogenesis) (Theodossiou et al 2021). Akt is a kinase that, once activated (phosphorylated), can influence various cellular processes including cell growth, protein synthesis, and apoptosis (Gopallawa et al 2021). Though previous studies suggest Akt signaling and TGF $\beta$  impact tendon, the cell signaling cascade that results in the regulation of LOX by MSCs remains unknown. Therefore, the objective of this study was to determine how TGF $\beta$ -induced LOX production by MSCs is regulated by Akt signaling. To assess this, we treated MSCs with TGF $\beta$ 1 or TGF $\beta$ 2 and a chemical inhibitor of Akt (MK-2206) or chemical activator of Akt (SC-79) and evaluated LOX protein production.

**Results:** TGF $\beta$ 2 treatment resulted in a fibroblastic cell morphology at all timepoints. MK-2206 treatment appeared to impact the MSCs resulting in less fibroblastic morphology and lower cell density, beginning at day 1 (Fig 1A). TGF $\beta$ 2-induced p-Akt was also found to trend down ( $p = 0.09$ ) with MK-2206 treatment at day 1, and p-Akt remained reduced at days 3 and 7. LOX levels were significantly increased with MK-2206 at day 1 ( $p < 0.05$ ) and continue to trend upward at days 3 and 7, compared to all controls groups (Fig 1B). To determine if TGF $\beta$ 1 impacts LOX production through Akt, we explored how LOX levels are impacted by MK-2206 and TGF $\beta$ 1. Our initial findings suggest that MK-2206 altered TGF $\beta$ 1-induced cell morphology and Akt activation, similar to our prior findings with TGF $\beta$ 2. However, at day 3, MK-2206 treatment resulted in a trending ( $p = 0.09$ ) decrease in TGF $\beta$ 1-induced LOX production. This is an interesting finding and suggests that Akt may play a unique role in LOX production depending on the TGF $\beta$  isoform. This is particularly intriguing as TGF $\beta$ 1 is typically associated with fibrosis, while TGF $\beta$ 2 is typically associated with tenogenesis. Further studies are ongoing to better understand the role of Akt activation in LOX production by C3H10T1/2 MSCs. For example, our preliminary findings showed that SC-79 resulted in a transient Akt activation after 1 hr, and LOX appeared to be decreased, compared to vehicle controls. However, this will need to be

studied further. In summary, activation of Akt in MSCs may have a regulatory role in TGF $\beta$ -induced LOX production. These findings enhance our understanding of how the Akt pathway is involved in LOX-mediated collagen crosslinking, which will improve tendon tissue engineering and treatments to restore tendon function.



**Fig 1: A.** Phase contrast images of MSCs on days 1, 3, and 7, treated with DMSO (left) and 500 nM with MK-2206 (right). Cells were also treated with TGF $\beta$ 2 at 50 ng/mL (top row), or sterile water (bottom row). Scale bar=250  $\mu$ m. **B.** Western blots show protein levels of p-Akt, Pan-Akt, LOX and GAPDH (loading control) at day 1, 3, and 7. Each lane corresponds to a biological replicate (n=3).

## Transcriptional investigations into Neonatal Gut Development related to Early Feeding

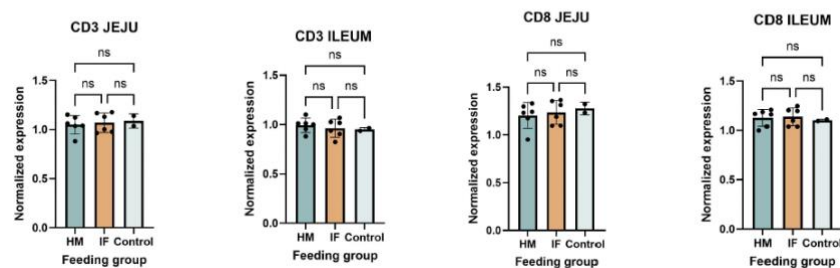
**Sierra Keele (Biology)**

***Mentor: Bethany Fehrenkamp (WWAMI)***

**Abstract:** While numerous correlational studies suggest that human milk (HM) optimizes infant gut development<sup>1</sup>, little is known about the physiological process. To investigate HM's protective mechanisms for intestinal development, we used the neonatal piglet model. The recommended time to exclusively breastfeed an infant is six months<sup>2</sup>, which is equivalent to one month in piglets<sup>3</sup>. We hypothesized that HM-fed piglets would show increased paracellular junctions and reduced inflammatory markers in the intestines compared to infant formula (IF)-fed piglets.

**Methods:** We reared littermate Yorkshire-duroc piglets for 28 days, assigning them to HM-fed (n=6) and IF-fed (n=6) groups, alongside controls reared on sow's milk (n=2) at the farm. Following euthanasia and tissue collection, we extracted RNA from intestinal tissues, purified them of DNA contaminants, synthesized complementary DNA (cDNA), and performed quantitative-PCR (qPCR). We examined paracellular junction proteins (Claudin 1, Tight Junction Protein 1, Tight Junction Protein 2, Occludin, and Cadherin 1), immunomodulatory cytokines (Interleukin (IL)-2, IL-4, IL-8, IL-10, IL-1B, and TNF $\alpha$ ), and lymphocyte markers (CD3e, CD8a, CD20, CD79b). Results were normalized to the reference gene beta actin within individuals and averaged across feeding groups

### Lymphocyte Markers



**Results:** We used ANOVA, analysis of variance, with multiple comparisons to determine differences between feeding groups. The results from this project were included in two publications under review currently. Also, there is extreme variation in expression of IL-2 in the ileum of IF-fed group compared to the HM-fed and control group. While there were little differences in transcript abundance of these select genes, it is still apparent that HM feedings play a role in optimizing gut development. As part of a larger project, our lab has determined that histomorphology is significantly different across feeding groups. I learned wet lab skills (RNA extraction, cDNA synthesis, qPCR) and statistical analysis techniques. The experiences this summer expanded my professional network, improved my presentation skills, lab skills, and overall professional development.

**Discussion:** Contrary to our expectations, there were no significant differences in the expression of inflammatory markers or paracellular junctions. However, as part of a larger project, it is still clear HM plays a role in optimizing gut development. Future research will involve a global transcriptomic analysis of the ileum using next-generation sequencing data.

## BUDGET and EXPENSES

Last Name	First Name	Supply Budget	Supply Budget Spent	Stipend	
Johnson	Emile	\$ 1,000.00	\$ 955.87	\$ 5,000.00	
Abendroth	Barrett	\$ 1,000.00	\$ 1,056.73	\$ 5,000.00	
Macon	Emma	\$ 1,000.00	\$ 998.81	\$ 5,000.00	
Rodman	Loretta	\$ 1,000.00	\$ 999.00	\$ 5,000.00	
Wing	Kevin	\$ 1,000.00	\$ 925.00	\$ 5,000.00	
Vaage	Annie	\$ 1,000.00	\$ 983.20	\$ 5,000.00	
Setters	James	\$ 1,000.00	\$ 1,010.10	\$ 5,000.00	
Cernuda			\$ 1,000.00	\$ 5,000.00	
Herraiz	Andrea	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00	
Ward	Megan	\$ 1,000.00	\$ 1,000.00	\$ 5,000.00	
<b>SURF INBRE</b>					
Palmer	Julia			\$ 5,000.00	
Sierra	Keele			\$ 5,000.00	
<b>Totals</b>		<b>\$ 9,000.00</b>	<b>\$ 8,928.71</b>	<b>\$ 55,000.00</b>	
Spent in FY25 on Posters			\$ 466.23		
			<b>\$ 9,394.94</b>	<b>\$ 55,000.00</b>	<b>\$ 64,394.94</b>
				<b>Carry-forward</b>	<b>\$ 605.06</b>

### BUDGET JUSTIFICATION

#### Student Stipends: \$55,000

Each student received a stipend salary of \$5,000 for 10-weeks of 40h/week faculty-mentored work in the Summer between May 28 and Aug 2 knowing that they had to present at the Idaho Conference for Undergraduate Research (ICUR 2024). The students all presented posters and wrote final reports. Those reports are summarized above.

#### Student Supply Funds: \$10,000

Each OUR SURF student received a supply budget of \$1,000 for their project and \$1,000 was available for incidental expenses (i.e., poster printing following the end of FY24 on June 30, 2024). Not all students spent out their funds, some overspent. The SURF-INBRE students did not receive supply funds from the OUR as they received those from Idaho INBRE.

**TOTAL: \$65,000**

**SPENT: \$64,394.94**

**Overall** - The project carried forward **\$605.06** to FY25 and we hope to use those funds to further support our students.