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Inquiry Editors

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Editor's Note

Welcome to the new issue [volume 21 (2)] of the Inquiry Journal. This issue contains several interesting features. This issue highlights two outstanding faculty members (Drs. Tim Muldoon & Michelle Gray) who have a wonderful track record of working with undergraduate students. I salute these faculty members for their commitment to support high quality undergraduate research on this campus.

This issue also features a research paper published by an undergraduate student, Salem Jackson, and her faculty mentor, Dr. Fiona Goggin. Their paper is focused on Plant elicitor peptides (Peps), that are produced in plants in response to many stresses and can activate defense responses (i.e., plant "immunity") against pests and pathogens. Their research is likely the first step towards risk assessment using an exciting new approach to pest management. The Office of Undergraduate Research congratulates Dr. Goggin and Ms. Jackson for their high-quality research. We are grateful that these researchers have decided to publish their top notch research in the Inquiry Journal. We urge the other research-active faculty to choose the Inquiry Journal as an avenue to communicate their high impact research.

The publication of this issue of the Inquiry Journal would not have been possible without the help of our devoted faculty who dedicated their time to peer-review manuscripts submitted for publication. Credit is also due to Sophia Nourani who has worked hard with us to prepare this issue of Inquiry. Our special thanks also go to Dr. Suzanne McCray, vice provost for enrollment services and Director of the Office of Nationally Competitive Awards (ONCA), and Dr. Chelsea Hodge, Director of Grants and Research Innovation, Honors College, who contributed the material, published as the Honors Corner and ONCA Notice at very short notice. It will be our endeavor to permanently feature both Honors Corner and ONCA Notice in the future issues of the Inquiry Journal.

Lastly, we greatly acknowledge the help provided by Ms. Melody Herr and Ms. Cedar Middleton for working closely with us to get this Issue of Inquiry published in Scholarly Works in a timely manner. There has been a significant turnover of administrators on this campus. In this context, Dr. John English, Vice Chancellor, Division of Research and Innovation, has decided to return to the Industrial Engineering faculty beginning January 1, 2023. Dr. English will be definitely missed at the DRI. He has been a great leader and a strong proponent of promoting high quality of undergraduate research on this campus. We, at the OUR, will dearly miss Dr. English for his compassion and encouragement. We wish him all the best in all his future endeavors. OUR looks forward to the leadership of Margaret Sova McCabe and welcomes her into the interim VCRI role.

Suresh K. Thallapuranam

Director, Office of Undergraduate Research

Division of Research & Innovation

Faculty Highlights

Michelle Gray

Dr.Michelle Gray, PhD, is the former director of the University of Arkansas College of Education and Health Professions (COEHP) honors program. She has taught several courses in the exercise science field on campus for over 12 years. Alongside her teaching and research work, Dr. Gray has recently transitioned into the role of interim head of the department of health, human performance, and recreation.

Dr. Gray's recent research involves investigation of ailments relating to aging and their effects on the human body. A large part of Dr. Gray's project focuses on measuring lower-body muscular power and physical function in older adults, which has not been studied as much as it has been in younger individuals.

Dr. Gray utilized a specific kind of exercise equipment, the TENDO weightlifting analyzer, to calculate the power and speed of an older adult moving from a sitting to a standing position. Dr. Gray then validated TENDO to predict a person's lower body muscular power. Muscular power is important because it provides valuable information to health professionals about how to improve physical independence among older adults without causing injury.

"The things I knew were the things we were using for athletes, but I'm not going to put my grandmother through a 40-yard dash or a vertical jump," Dr. Gray remarked.

Dr. Gray is also currently investigating the relationship between the deterioration of physical and cognitive function in individuals at risk for Alzheimer's and dementia. Alongside a California-based startup group called NeuroTrack Technologies, Dr. Gray and her students are working to develop an app which regularly tests for early signs of Alzheimer's and dementia.

"My parents are in their mid 60s. I'm starting to see some of those negative changes, both in physical and cognitive function," Dr. Gray shared. "With this app, you can test yourself every day, every week, every

month. It's more accurate and realistic compared to the traditional cognitive test setting at a doctor's office."

Dr. Gray, who has mentored over 100 students at the UofA, said undergraduate research is a win-win situation for both the student and the professor. Dr. Gray has four undergraduate students in her lab who have been on her
research team since they were freshman, and Dr. Gray implied getting involved early can also be very beneficial for a student's future plans.

She emphasized that any student involved in research gains added value on top of their educational experience at the university. Research students gain skills which Dr. Gray claims cannot be taught in the classroom at the undergraduate level, such as conflict resolution among classmates and the use of professional-grade equipment in a standard lab environment. Most importantly, Dr. Gray added, students get an opportunity to interact with human participants.

"I want folks to join my team, I don't want people to work for me," Dr. Gray said about her lab. "That may sound like it's the same, but I feel like it's completely different."

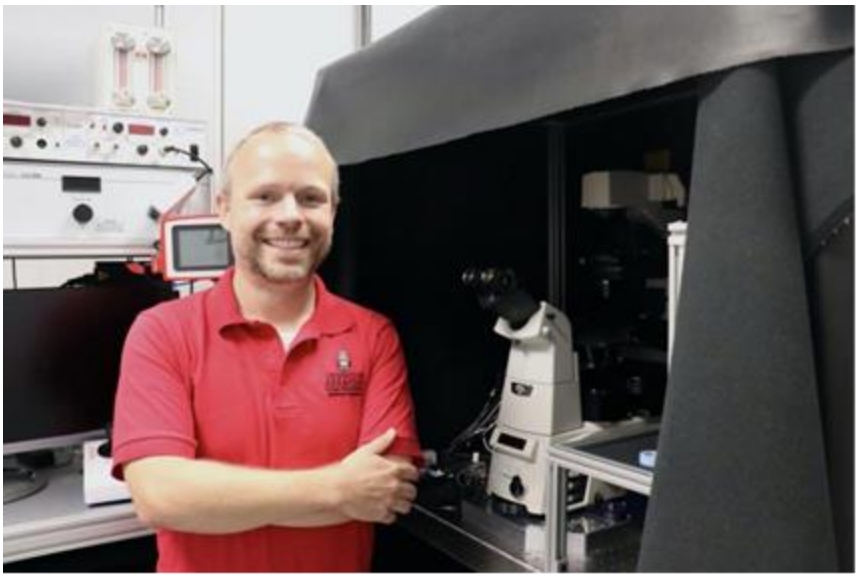
Dr. Gray is from a small farming community outside of Chattanooga, Tennessee, and received her PhD at UARK after completing her master's degree at Ball State University in Indiana. When Dr. Gray isn't teaching or in the lab, she enjoys biking in the NWA area.

Timothy Muldoon

Dr.Timothy Muldoon teaches biomedical instrumentation and clinical observations and needs finding courses, which are core requirements for the biomedical engineering major at the University of Arkansas. Dr.Muldoon also teaches biomedical microscopy, which is a senior-level elective course that focuses on the usage and design of microscopes in laboratory environments.

Dr.Muldoon is originally from Michigan, but completed his PhD and MD work in Houston, Texas. He continued to serve as a postdoctoral research scientist with Dr. Elizabeth Hillman at Columbia University in New York, NY, before joining the University of Arkansas as a faculty in 2012.

Dr.Muldoon's research primarily focuses on the use of optical tools to probe and understand disease processes and their response to therapy on a cellular level. Dr.Muldoon discussed how his lab uses these imaging tools to study the role of macrophages in cancer, and how they respond to different therapies and immunotherapies.



“Cancer immunotherapy is one of the major pillars of cancer therapy,” Dr.Muldoon articulated, ”but I think that understanding macrophage biology is going to be key to being able to extrapolate where we are currently with immunotherapy to a broader groups of patients.”

Dr.Muldoon’s work has been in developing miniaturized endoscopic imaging and spectroscopy systems. Using what he calls ‘optical biomarkers’, Dr.Muldoon and his students are able to view and interpret certain biochemical reactions under a microscope. This research could lead to the creation of drugs and treatment strategies that can directly target a population of cells for beneficial means.

Dr.Muldoon shared that while most of his current lab students may not continue in this specific field, basic research experience is vital to understanding any scientific process and can help a student go in many different directions. Dr.Muldoon also emphasized the importance of collaboration while working in a research environment.

“No one just sits in a vacuum and can come up with a brilliant idea that is unassailable, so I think you have to get used to having constructive criticism,” Dr.Muldoon stated. “That's what I try to spend a lot of my efforts on my work with the undergraduate student researchers.”

In Dr.Muldoon’s free time, he enjoys spending time with his family, friends and colleagues.

Root Phenotyping of Peptide-Treated *Glycine max*

Salem Jackson
***Faculty Advisor* – Dr. Fiona Goggin**

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Abstract

Plant elicitor peptides (Peps) – endogenous chains of amino acids involved in natural plant defense – have been shown to decrease damage from herbivores and pathogens by inducing an immune response, increasing the emission of volatile organic compounds (VOCS), transcripts, and metabolites. Exogenous treatment of soybean seeds with plant elicitor peptide GmPep3 has been shown to induce these broad-spectrum defenses and offers a new method for increasing crop yield. However, the effects of GmPep3 on indicators of soybean health – root characteristics, growth stages, etc. – have not been fully realized.

Using the root-phenotyping platform RhizoVision Explorer, several root traits of soybean plants treated with GmPep3 were analyzed to determine whether there was a statistically significant difference between the roots of plants treated with peptide and without peptide. These root traits included total number of root tips, total root length (mm), and surface area (mm^2).

Results indicate that there did not appear to be a statistically significant difference in the number of root tips between plants treated with GmPep3 and those not treated with GmPep3. There were, however, observed differences in total root length and surface area between treated and untreated seeds during one repetition of the experiment. However, these differences were no longer statistically significant by the end of the experimental period, indicating that although plant growth was initially impacted by the addition of the peptide treatment, these effects were no longer present by the end of the growing period.

Profiles of the Authors

Salem Jackson graduated with a B.S. in Biology with Honors in May, 2022. Her career goal is to be a physician, and she is currently enrolled in medical school at the University of Arkansas Medical School in Little Rock. She has work experience as a COVID screener and medical scribe, and has volunteered as an academic mentor for the EMPOWER program. She is the recipient of a Governors Distinguished Scholarship, an Honors College Fellowship, and an Honors College research grant.

Dr. Fiona L. Goggin is a professor in the Department of Entomology and Plant Pathology, where she has worked since 2001. She holds a Ph.D. in Entomology from the University of California, Davis, and a B.S. in Plant Science from Cornell University. Dr. Goggin's research program focuses on plant immunity against insects and nematodes, and seeks to identify the molecular and physiological mechanisms that contribute to host plant resistance against these herbivores. The Goggin laboratory also investigates the influence of these defenses on plant growth and development.

Introduction

The soybean plant, or *Glycine max*, is a fundamental crop worldwide, increasing in demand each year. According to the USDA, 86 million acres of soybean were harvested in the United States in 2021 alone, representing a 57-billion-dollar industry (USDA, 2021). Due to its high nutritional value and versatility, many experts believe it may be the key to alleviating world hunger. However, several biotic and abiotic factors threaten the staple crop each year, including temperature, access to nutrients, and diseases. One of the greatest threats are pests, leading to drastically decreased yields in the top three soybean-producing countries – USA, Argentina, and Brazil (Hartman, 2011). The soybean cyst nematode (SCN), for instance, accounts for approximately 30% of this annual yield loss, devastating roughly 20,000,000 bushels between 2010 and 2014 in Arkansas alone (Allen, 2017). Furthermore, SCNs can survive underground for extended periods of time, undermining the success of crop rotation once fully established (Jones, 2013). Root knot nematodes (RKN) are also of particular concern in the southern United States. In 2016, studies indicated that 82% of Arkansas soybean cultivars were susceptible to RKNs while only 18% had moderate to total resistance (Ross, 2016).

A combination of several approaches is typically used to counter pest-related yield losses. Pesticides are one of the most common management tools, increasing in use from the 1960s to the 1980s, and leading to increased yields worldwide. However, this approach has raised concerns regarding human and environmental health (Coupe, 2015). Integrated pest management (IPM) is another common approach, combining pesticide use with more sustainable practices to decrease negative impacts on human and environmental health. IPM allows for a certain level of plant damage so long as overall yields remain unaffected (Bueno, 2013). However, small-scale farms in rural areas often lack the appropriate technical support and knowledge to implement these changes to the necessary degree (Grasswitz, 2019). In the 1990s, genetically modified (GM) crops came to the forefront of pest management, leading to the production of cultivars that are herbicide-resistant or internally protected against herbivory (Coupe, 2015). Concerns regarding this method include nutrient deficiencies in GM crops, although these concerns are not supported by scientific study. Clearly, the issue of pest control in crops has yet to be resolved and new technologies must be implemented to avoid decreased yields.

Induced plant defenses may be an additional tool in reducing yield loss. This term refers to the ways in which plants naturally defend them themselves against herbivory, without the use of pesticide. These defenses may include the accumulation of toxins, antidigestive proteins, and antifeedants on the surface of the plant after tissue has been damaged by feeding (Skibbe, 2008). For instance, the potato species *Solanum tuberosum* expresses cystine proteinase once feeding begins, which deters its thrip predator *F. occidentalis (*Steenbergen, 2018). This form of protection may also involve countering the negative effects of herbivory, including increased growth, photosynthetic rates, and nutrient uptake (Moreira, 2015). Finally, induced defenses may attract the predator of the specific herbivore, thereby indirectly reducing plant tissue damage (Skibbe, 2008). For example, the infestation of the tomato plant with spider mites leads to a volatile production that attracts the predatory mite, *Phytoseiulus persimilis* (Kant, 2004). Research has shown that the jasmonate (JA)-dependent signaling cascade is responsible for the execution of these broad-spectrum defenses (Skibbe, 2008).

Effectors released by the specific herbivore into the wound site activate these changes through transcriptional modification, phytohormone signaling, and posttranslational protein

changes. Transcription factors and secondary metabolites are a common type of effector, and a number have been identified. The parsnip, for example, produces a toxic secondary metabolite that reduces predatory webworm performance (Pappas, 2017).

Plant elicitor peptides (Peps) – endogenous chains of amino – are a type of signal involved in induced plant defense. Initially discovered in *Arabidopsis*, plant elicitor peptides correlated to an induced immune response, increasing the emission of volatile organic compounds (VOCS), transcripts, and metabolites – all involved in plant defense against pathogens and herbivory (Huffaker, 2015). Three soybean Peps (GmPep1, GmPep2, GmPep3) have since been isolated and developed into an exogenous seed treatment. When expressed, these genes have been shown to decrease nematode reproduction by approximately 40% to 70% (Lee, 2018).

Although previous research indicates the ability of soybean Peps to induce nematode resistance, the tradeoffs are not entirely understood. Although the biomass of soybean roots and shoots treated with GmPep have been studied, other indicators of soybean health – root characteristics, growth stages, etc. – have not been fully realized (Lee, 2018). There is a possibility that peptide treatments may have a negative impact on soybean root growth. A study in 2020 showed decreased *Arabidopsis* root growth due to interaction with receptor kinases PEPR; similar interactions may occur in soybean and reduce root growth (Shen, 2019).

Image-based phenotyping is a burgeoning field that attempts to standardize plant traits in an efficient and quantitative manner. In this method, several plant images are taken and run through a program that extracts the desired data. Image-based phenotyping is particularly useful because it allows for the possibility of non-destructive sampling and thus longitudinal data collection, as well as the ability to extract a large amount of data and increase statistical power. A study in 2013 used image-based phenotyping to study the relationship between phosphate deficiency in soil and *Brassica* root architecture using the program ImageJ, showing a strong correlation between the two variables (Shi, 2013).

Rhizovision Explorer is a new software designed for image-based phenotyping of roots. It allows researchers to extract several root characteristics – length, diameter, volume, etc. – from images taken from a scanner. Rhizovision Explorer is unique due to the implementation of several techniques that allow for more accurate data extraction, including the ability to choose a precise region of interest (ROI), filter out non-root objects, and fill in holes in roots. The overall goal of the program is to standardize root data across fields of study and allow for increased data extraction from root images (Seethepali, 2021).

This study aimed to determine whether the addition of plant elicitor peptide GmPep3 to *Glycine max* seeds would result in a statistically significant difference in root growth using Rhizovision Explorer as the medium for root data extraction, focusing specifically on the total number of root tips, total root length (mm), and surface area (mm^2) as indicators of root growth. Decreased root growth in plants treated with GmPep3 would indicate the possibility that Peps involve trade-offs in plant health while protecting against herbivory and pathogen invasion.

Materials and Methods

Imbibition

General procedures regarding imbibing soybean seeds with GmPep3 were obtained from a previous study ("Plant elicitor peptides promote plant defense against nematodes in soybean," in

Molecular Pathology, 2018*). In vitro* synthesis of the 23 amino-acid peptide GmPep3 (PSHGSVGGKRGSPISQGKGGQHN) was performed by Biomatik Corporation (Cambridge, ON, Canada), and purity was verified by C18 high-performance liquid chromatography (HPLC) and mass spectrometry. Sixty soybean seeds (*Glycine max,* cv Lee), twenty per treatment group, were imbibed in Petri dishes at room temperature (24° C) for eight hours in a solution of 0.1% Tween 20 and 1 µM or 4 µM of GmPep3. Control seeds were imbibed in water and Tween 20 only. Petri dishes were covered with aluminum foil during imbibition to simulate natural the germination process.

Plant Growth

To ensure the experimental results would be compatible with future nematode assays, procedures regarding plant growth were also obtained from the same study ("Plant elicitor peptides promote plant defense against nematodes in soybean," in *Molecular Pathology,* 2018). After imbibition, seeds were transferred to the greenhouse and grown under standard greenhouse conditions (16-h light/8-h dark photoperiod, 21–27 °C) in Sunshine Mix for approximately 72 hours until germination was complete. Seedlings were then transferred to autoclaved sandy loam in 8 oz Styrofoam pots with eight small punctures at the base to ensure proper drainage. Plants were watered daily by hand.

Root Scanning

Three days after transferring to sandy loam, 1/3 of the plants from each treatment group were removed from the Styrofoam cups and their roots were washed thoroughly to remove soil and debris. Plants were then placed on Epson scanner tray and their roots were manually spread to ensure adequate visualization could be achieved. The number of roots visualized at once varied based on the size of the root; it was ensured that no overlap occurred between different plant roots. JPEG images at 300 dpi resolution of roots were produced and roots were discarded after visualization. This process was repeated six days after germination and nine days after germination until all plant roots had been scanned.

Root Phenotyping

Guidance regarding root-phenotyping was obtained from a previous study ("RhizoVision Explorer: open-source software for root image analysis and measurement standardization" in *AoB Plants,* 2021). Root images were analyzed using open-source software RhizoVision Explorer. A Region of Interest (ROI) was drawn around each root, beginning at the soil line and ending at the root cap. Image pre-processing consisted of the following standardized parameters: whole-root analysis mode, converting pixels to physical units, image-thresholding level of 200, 'filter non-root objects' and 'fill holes in root objects' both set to 5. Color was inverted to ensure adequate visualization of the root system. Skeletonized versions of each root were then produced by the program. Forty quantitative traits were extracted from the skeletonized images. The three root traits of interest in this study were number of root tips, total length (mm), and surface area (mm^2).

Statistical Analysis and Graphing

All experiments were analyzed using JMP Genomics Pro 16 (SAS Institute, Cary, NC, USA). Data sets were first tested for equal variance and then one-way ANOVAs were performed to identify differences in the treatment groups between the three root traits of interest. Box plots

were also created in JMP to display the total data collected. If statistically different at $\alpha = 0.05$, means separations were performed with a Tukey HSD test and displayed on the box plots.

Repetition

The procedures previously described were repeated three times, designated as Experiments 1-3 in the remainder of this study. For each repetition, root images were labeled as Day 3, Day 6, or Day 9 (days since germination) to indicate the time point the root image was taken.

Results

Images

Using RhizoVision Explorer, skeletonized images of each root were produced. A visual comparison of the skeletonized images from Experiment 1 are shown in **Figure 1** using the first root scanned in each treatment group on Day 3, Day 6, or Day 9.

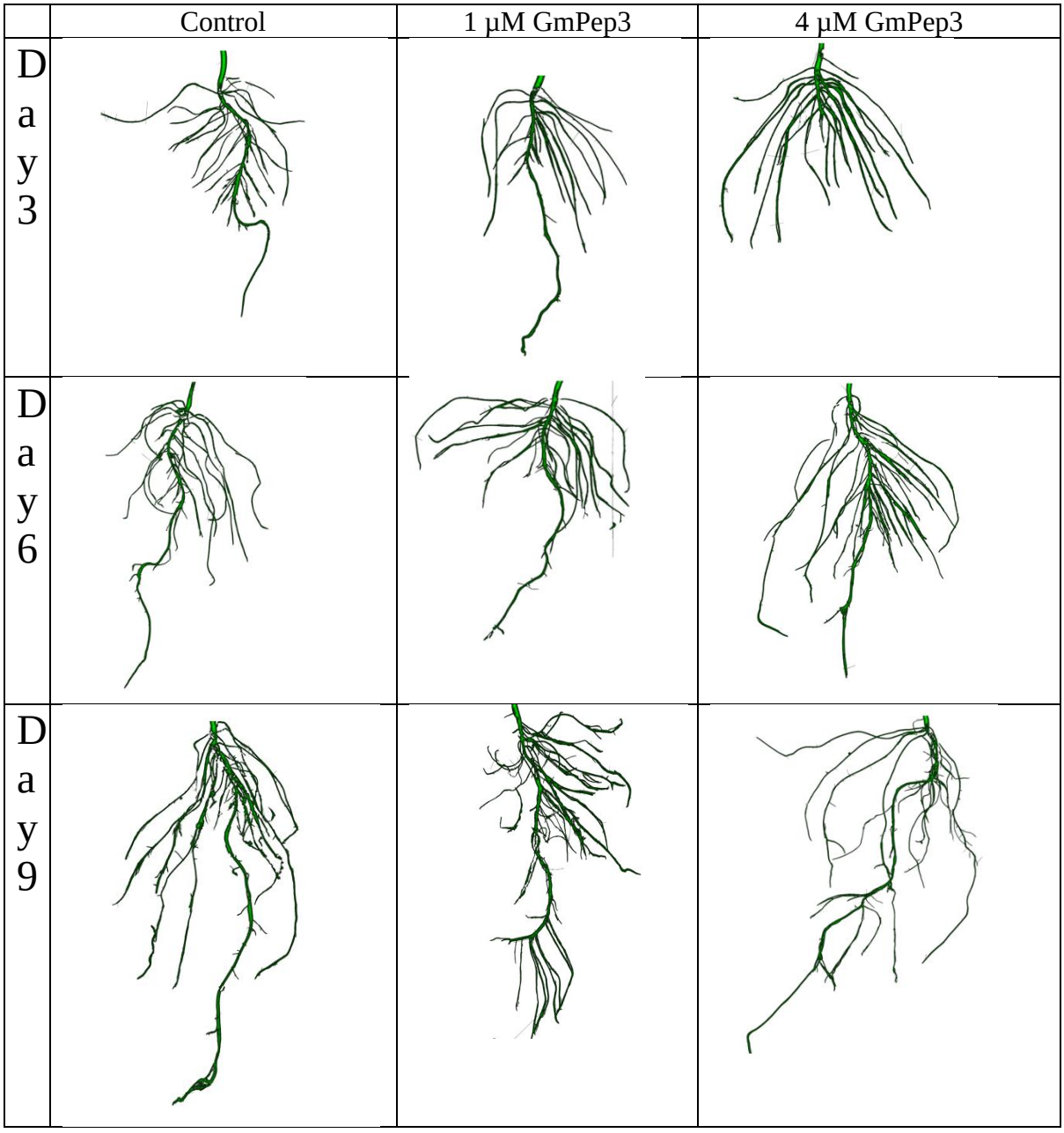
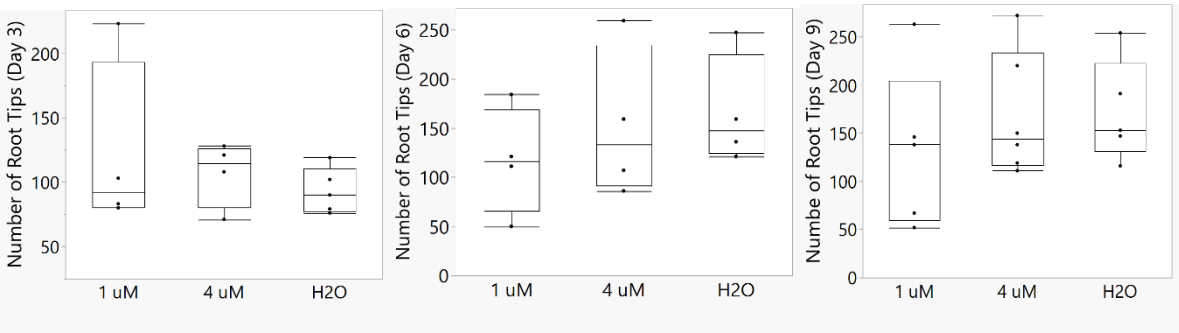


Figure 1. Output images from Rhizovision Explorer of plants treated with 1 µM GmPep3, 4 µM GmPep3, and no GmPep3 over the course of Experiment 1.

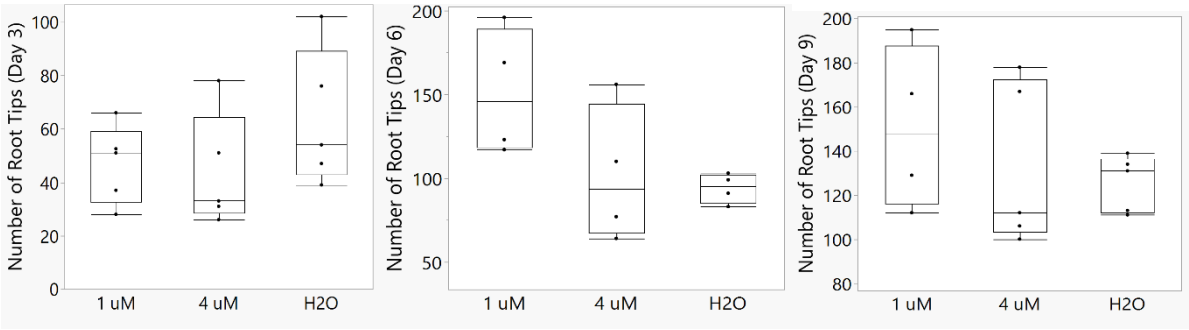
Root Tips

After three repetitions of the described experimental design, the number of root tips were not observed to significantly differ across the three treatment groups. One-way ANOVA testing demonstrated that there was not a statistically significant difference in the number of root tips on plants treated with water, 1 µM GmPep3, or 4 µM GmPep3 (df = 2, p > 0.05). Box plots were created to display the data (**Figure 2**).

Experiment 1



Experiment 2



Experiment 3

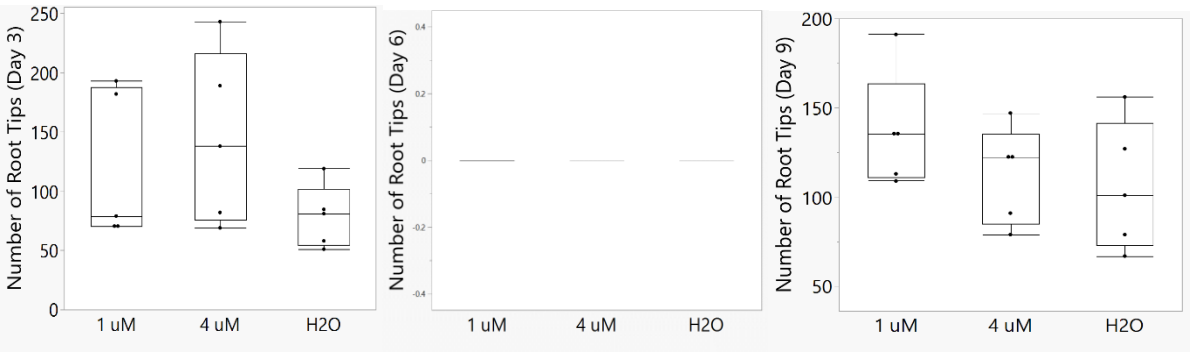


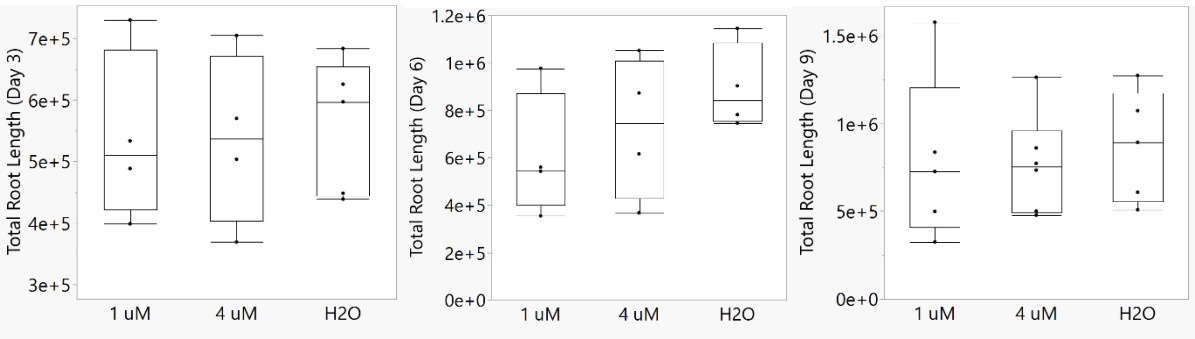
Figure 2. Effects of peptide treatment on number of root tips for Experiments 1-3

Root Length

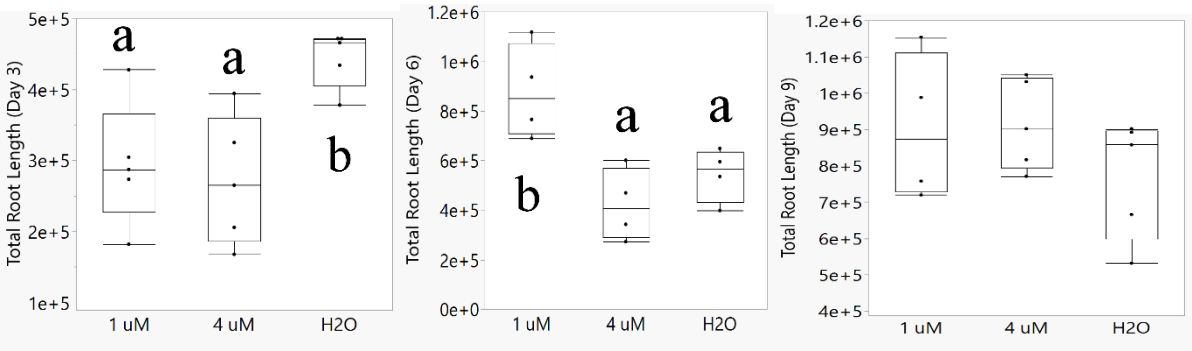
For experiments 1 and 3, one-way ANOVA testing demonstrated that there was not a statistically significant difference in the total root length between the treatment groups (df = 2, p > 0.05). For experiment 2, ANOVA testing indicated a significant difference in root length on Day 3 (df = 2, F = 7.4393; p > 0.0079) and Day 6 (df = 2, F = 9.6703, p > 0.0057). If statistically

different at $\alpha = 0.05$, means separations were performed with a Tukey HSD test. By Day 9, no statistically significant difference was detected ($df = 2$, $p > 0.05$). Box plots were created the display the data (**Figure 3**). On the graphical display, **a** and **b** are used to indicate significant difference between treatment groups. If no letters are present, no significant difference is assumed.

Experiment 1



Experiment 2



Experiment 3

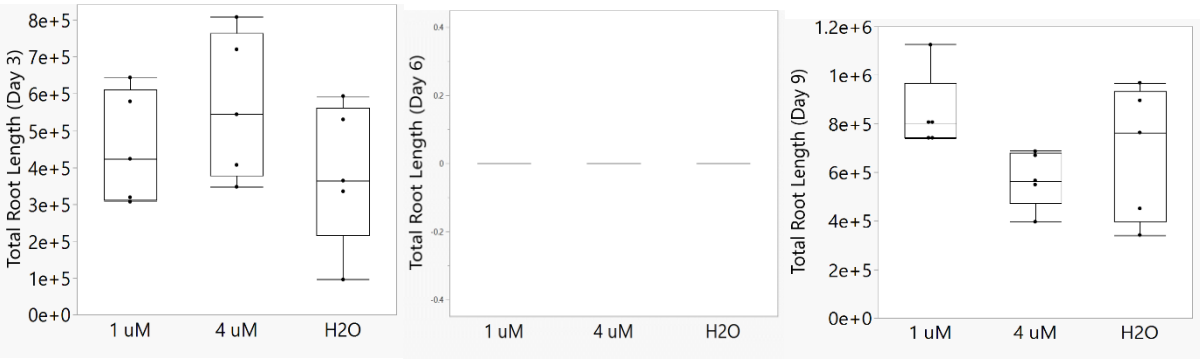
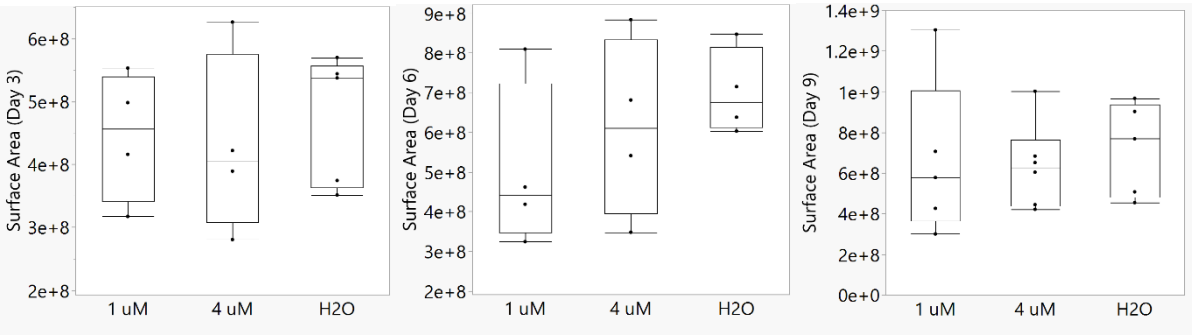


Figure 3. Effects of peptide treatment on total root length (mm) for Experiments 1-3.

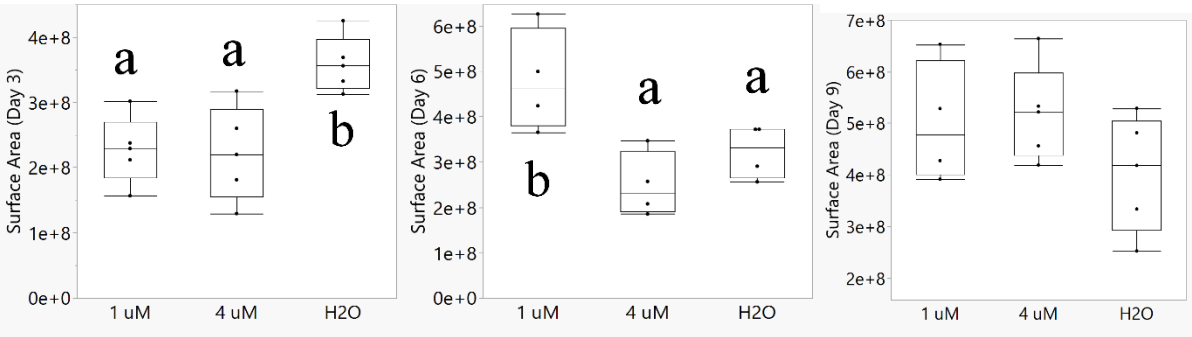
Surface Area

For experiments 1 and 3, one-way ANOVA testing demonstrated that there was not a statistically significant difference in the total surface area (mm^2) between the treatment groups ($df = 2$, $p > 0.05$). For experiment 2, ANOVA testing indicated a significant difference in surface area on Day 3 ($df = 2$; $F = 9.3066$; $p > 0.0036$) and Day 6 ($df = 2$, $F = 7.7622$, $p > 0.0110$). If statistically different at $\alpha = 0.05$, means separations were performed with a Tukey HSD test. By Day 9, no statistically significant difference was detected ($df = 2$, $p > 0.05$). Box plots were created the display the data (**Figure 4).** On the graphical display, **a** and **b** are used to indicate significant difference between treatment groups. If no letters are present, assume no significant difference.

Experiment 1



Experiment 2



Experiment 3

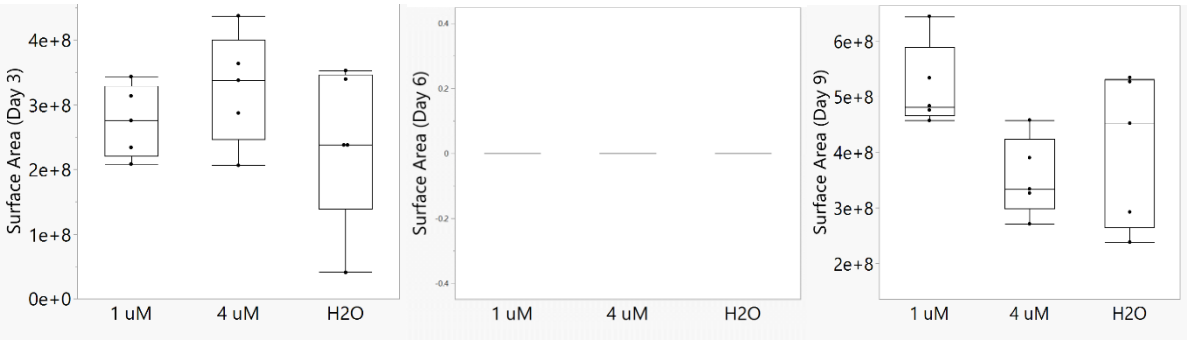


Figure 4. Effects of peptide treatment on surface area (mm^2) for Experiments 1-3.

Areas to Note

Data from Experiment 3, Day 6 was unable to be obtained due to scanner error and thus statistical analysis and graphical display are not present. It was also noted that small scratches were present on the scanner tray that were unable to be removed during image processing. These scratches can be seen in **Figure 1** as unnaturally straight lines that do not correspond to the actual root.

Discussion

The aim of this research project was to determine whether soybean seeds treated with GmPep3 would display differences in root growth - quantified by the number of roots tips, total root length (mm), and surface area (mm^2) - compared to plants that were not treated with GmPep3. An additional question raised was whether increasing the concentration of GmPep3 would correlate to differences in root growth.

Based on the statistical tests done, there does not appear to be a significant difference in the number of root tips between treatment groups. This indicates that GmPep3 does not increase or decrease the number of root tips in soybean up to nine days after germination. This finding is consistent with **Figure 1**, which does not show a visually apparent difference in the number of root tips between the treatment groups.

Looking at total length (mm) and surface area (mm^2), two out of the three experiments indicate no statistically significant difference at any time point, although Experiment 2 indicated statistical difference at the first two time points. However, by the third time point no significant difference was observed in either total root length or surface area. This may indicate that although plant growth was initially impacted by the addition of the peptide treatment, these effects were no longer present by the end of the growing period. This is not an unexpected result, as the addition of bio activators such as peptide treatments are known to involve a metabolic cost due to the energy needed to defend against herbivory, (Gatehouse, 2002). This metabolic cost has the potential to vary expected growth in a variety of ways and could explain the leveling-out that was observed in Experiment 2. **Figure 1** does not appear to display a clear difference in total root length or surface area between treatment groups, supporting the general indication by Experiments 1 and 3 that treating soybean seeds with GmPep3 does not significantly alter these root traits over the course of nine days.

Increasing the concentration of GmPep3 from 1 µM to 4 µM did not appear to display differences in the chosen root characteristics. Only in Experiment 2, Day 6 was there a statistically significant difference between total length and surface area between seeds treated with 1 µM peptide and 4 µM peptide. By Day 9, this difference was no longer observed. These findings are somewhat consistent with **Figure 1**, although visual comparison between 1 µM and 4 µM treated seeds on Day 9 shows a marked difference in root tips and general root fullness. This visual difference, however, does not appear to represent the data according to statistical analysis.

Unfortunately, data was unable to be obtained from Experiment 3, Day 6 due to scanner error. Due to the nature of root scanning which involved destructive sampling, these plants had to be discarded and could not be visualized. However, data from Day 3 and Day 9 of this experiment can still be compared to the other repetitions.

An area to note are the small scratches that were present on the scanner tray and could not be removed from the processed images. Although these scratches likely affected the extracted data to some degree, they appeared to be relatively uniform across the tray rather than being concentrated in specific areas. A base-level of error was thus assumed, and images were still compared to one another with the expectation that they would all be affected by the scratches to a similar degree. A new scanner tray or research into digital removal of these scratches would be beneficial in future repetitions of this experiment.

Although this study suggests that GmPep3 does not significantly alter root growth in soybean, there were several limitations. The sample size was relatively small and signals more experimentation is necessary to determine whether the data can be generalized to a larger population of soybeans treated with GmPep3. Due to time constraints and scanner size, the ability to study root growth over a long period of time was also not feasible and therefore the data cannot be used to make assumptions regarding root growth after a certain period. Furthermore, only three root parameters were chosen to represent root growth. Other key parameters – convex area to quantify the spread of the roots, average root orientation to determine the direction of growth – would also be meaningful factors to consider when studying root growth. Because total root length and surface area data appeared to display a strong positive correlation, choosing another parameter like convex area or root orientation may have provided a more wholistic view of how root growth was affected by the GmPep3 treatment.

There are several avenues this area of study could take in the future. For example, studying how roots of plants other than *Glycine max* are affected by peptide treatments would broaden the scope of the study and allow for comparison between plant species. Furthermore, it would be beneficial to better understand how concentrations of GmPep3 correlate to root growth by creating a peptide concentration gradient rather than choosing only two concentrations. Additionally, indicators of induced plant defenses could be studied in more detail. The presence of reactive oxygen species (ROS) can signify induced plant defenses and could be an avenue for determining more exact differences between plants treated with peptide and those not treated with peptide (Chen, 2020).

In conclusion, findings indicate that imbibing soybean seeds with GmPep3 does not significantly alter the total number of root tips, root length, or surface area during the initial growth stage. This further supports the use of peptide treatments in agriculture as a tool to increase natural plant defenses and thus increase crop yield.

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Honors Corner

Just before publication this semester, we learned of the Fall 2022 SURF results! The Student Undergraduate Research Fellowship (SURF) is awarded by the state of Arkansas, and our students compete against others from universities across the state. 32 students won SURF grants this year, including 31 honors students. Winners represent all six colleges and 22 departments. Their research spans a diverse array of topics, including the gentrification of secondary cities in the US, southern stereotypes in young adult literature, and harmful algal blooms. In addition to the 32 SURF awards, the Honors College awarded the Honors College Research Grant to 95 honors students.

Julianna Kantner, a senior studying International Studies, was awarded a SURF grant for her project on expanding volunteer effectiveness in refugee resettlement. Julianna also received an Honors College Research Grant last year for her research.

Julianna Kantner, front, helping furnish an apartment for a refugee family who will soon arrive in Northwest Arkansas. Julianna's research focuses on Canopy NWA, a local refugee resettlement nonprofit.

Stephen Pierson, a senior in Mechanical Engineering, received an Honors College Research Team Grant last year for his work on alternative solar-powered 3D printing for space

mission use. Stephen just received a SURF for his honors research project, "Characterizing the Effects of Geometry and Manufacturing Technique on the Cooling Efficiency of Microchannel Heat Sinks."

Stephen Pierson working in Dr. Han Hu's mechanical engineering lab. Here Stephen is testing the light source collimator prototype for the solar simulator.

Honors research is one of the most important academic experiences students have at the university. Research prepares students for what comes after college, whether that's a graduate or professional school or a career. By pursuing such a unique experience, students build important skills for their resumes that are transferable to any post-graduation goal. Research provides additional opportunities for students, including conference presentations, grants, and nationally competitive awards. Through their research endeavors, students are able to form meaningful relationships with faculty, an invaluable boost to their academic pursuits.

Interested in starting your honors research?

- Find out what is required for research by your college. Go to the honors website for your academic college and read the information there regarding the honors thesis. These links are also available at honorshub.uark.edu, under the Research tab.

- Collect information and examples of research in your major. Visit honorsstories.uark.edu to read dozens of blogs written by students about their research. Talk to your professors or graduate assistants about what research typically looks like in your discipline.

- Consider what topics in your field interest you. Remember, you don't need a specific research question at this point! Just start narrowing down your interests.

- Look into what faculty are researching. You will ask a faculty member to be your mentor whose research expertise aligns with your interests. Visit the departmental website for your major and/or closely related fields. Google the name of your department and "UARK" to find the departmental website. Then go to the faculty directory and click on their names to see their profiles.

- Seek out additional help! The Research tab on honorshub.uark.edu has more information on finding a research topic and a mentor. Keep an eye out for workshops on these topics and more! You can also schedule a 1:1 meeting with the Director of Grants and Research Innovation, Chelsea Hodge, on UASuccess for additional guidance.

Office of Nationally Competitive Awards
2021-2022 Student Profiles

The Goldwater Scholarship *(established by Congress in 1986) works to provide a continuing source of highly qualified scientists, mathematicians, and engineers by awarding scholarships to college sophomores and juniors who intend to pursue careers in these fields. Scholars receive up to $7,500, and the award can be renewed for an additional year. To be competitive students should have some experience with research at the time of application.*

- **Mary Jia**, a Stuttgart native and an honors biomedical engineering major, was named a 2022 Goldwater Scholar. Jia's primary research focuses on developing a prime editing solution for Duchenne Muscular Dystrophy, and she is supported by a State of Arkansas Student Undergraduate Research Fellowship. She is first author in an article submitted to the J*ournal of Magnesium and Alloys* for her research into the assessment of a novel boron nitride magnesium nanocomposite for orthopedic implants. Jia has been active on campus in the Biomedical Engineering Advisory Board and the First-Year Engineering Program Research Mentor Program. She is a Bodenhamer Fellow and an Arkansas Distinguished Governor's Scholar. She will pursue a PhD in biomedical engineering.

- **Joseph Roll**, from Joplin, Missouri, and an honors physics and mathematics major, was also named a 2022 Goldwater Scholar. Roll's primary research examines second harmonic generation of SnS monolayers, work that was supported by a State of Arkansas Student Undergraduate Research Fellowship. His contribution to an experimental research team to analyze a thin slab of SmSbTe has been published in *Advanced Quantum Technologies*. Outside of the lab, Roll is a Student Ambassador, serving as a tour guide to prospective students and their families. He has received the Davis P. Richardson Scholarship and the New Arkansan Non-Resident Tuition Award. Roll will pursue a PhD in theoretical physics.

The Fulbright U.S. Student Program *awards fellowships for U.S. graduating college seniors, graduate students, young professionals and artists to study, conduct research, and/or teach English abroad. Stipends and the length of stay in the selected country vary depending on the individual program. Recipients of the Fulbright U.S. Student fellowships are referred to as Finalists.*

- **Hannah Allred** graduated in May 2022 with a BA in Spanish, minoring in anthropology. She applied as an undergraduate and received the award to teach English in Galicia, Spain. On campus, Allred was heavily involved with the Volunteer Action Center, including serving as both a volunteer and chair of the VAC's Passionate About Literacy Program. Off campus, Allred was a Latino recruitment specialist intern for the Girl Scouts Diamonds in Rogers and a substitute teacher in Fayetteville Public Schools. She plans a career teaching in a bilingual school.

- **Duru Erkan** graduated *summa cum laude* with a BA in French and a BS in biology in May 2022. She was an Honors College Fellow and Arkansas Governor's Distinguished Scholar. Erkan was selected as a Finalist to teach English in Belgium. On campus, Erkan was inducted into Phi Beta Kappa in 2021, and she was involved in the International Culture Team, Inspirational Chorale and Honors College Advisory Board. She also volunteered for the Canopy NWA After School Buddy Program, as well as at Washington Regional Medical Center in the Emergency Department. She plans a career as a pediatrician.

- **Sol Halle** graduated *summa cum laude* with a BA in international and global studies and political science, minoring in French, in May 2022. She is a Finalist for an English teaching assistantship in Madrid, Spain. She was involved with National Model United Nations, being named Outstanding Delegate in 2019. In 2021, she was named an En Voz Alta Mentee with the Women's Action for New Directions organization. Recently, Halle completed a virtual internship with the U.S. Department of State. Halle plans a career in the Foreign Service.

- **Charlie Rodgers** graduated *summa cum laude* in December 2021 with a BS in exercise science, minoring in psychology. He is a Finalist for an English teaching assistantship in the Czech Republic. He served as a research assistant of the Exercise is Medicine Research Group and was awarded a 2021 Student Undergraduate Research Fellowship to support his undergraduate research. He has also served as distribution leader for Razorback Food Recovery, vice chair of Honors College of Education and Health Professions, and vice president of the Pre-Physical Therapy Club. Off campus he interned with Big Brothers Big Sisters NWA and worked as a camp counselor in North Carolina. He plans to pursue a PhD in epidemiology.

- **Lexi Scott** graduated in May 2022 with a BAT in Spanish education, minoring in history. She is a Finalist for an English teaching assistantship in Madrid, Spain. Scott has a longstanding interest in teaching and tutoring, volunteering to teach adult ESL classes at El Buen Samaritano in Austin, Texas, as well as at a bilingual private school in Honduras. She also worked as a resident facility director and served as a SOAR volunteer, helping Spanish-speakers improve their literacy skills. She plans a career as a Spanish educator, and she wants to help establish more bilingual schools in Arkansas.

***The National GEM Consortium** has a mission to increase the participation of underrepresented groups at all levels of graduate study in engineering and science. The GEM Fellowship provides practical engineering summer work experience through an employer sponsor and an academic fellowship (covering tuition and fees) as well as a stipend which may be used at any participating GEM member university.*

- Chloe Benton, originally from Fort Worth, Texas, graduated in May 2022 *cum laude* with a BS in physics and minors in astronomy, mathematics and philosophy. Benton has received several academic awards, including a Sturgis Study Abroad Fellowship and an Arkansas Louis Stokes Alliance for Minority Participation Research

Grant. Her undergraduate research with guidance from Bret Lehmer, associate professor of physics, focused on analyzing how X-ray binary populations vary in galaxies over a range of physics conditions through rich data sets taken from the Chandra X-Ray Observatory. After completing her PhD program, she plans to complete a post-doctoral appointment and ultimately become a U.S. Science Ambassador to make connections between the United States and the National Astronomical Research Institute of Thailand in Chiang Mai, Thailand.

The Rhodes Scholarship, *one of the world's most prestigious awards, covers all expenses associated with graduate study for two to three years at Oxford University. Every year, 32 American Rhodes scholars are selected, while award numbers vary for other countries. Students of all disciplines are encouraged to apply.*

- **Coleman Warren**, who recently graduated as an honors industrial engineering and political science major, was named a 2022 Rhodes Scholar for graduate study at Oxford University in the United Kingdom. Warren, a native of Farmington, is also a 2021 Truman Scholar. In addition, he is the recipient of the Chancellor's Scholarship and the Governor's Distinguished Scholarship as well the Industrial Engineering Sophomore Scholar Award, an Arkansas Academy of Industrial Engineers Scholarship, and the Gold President's Volunteer Service Award. In the summer before his sophomore year, Warren served as an AmeriCorps VISTA Summer Associate for the Food Bank for the Heartland in Omaha, Nebraska, which later led to his creating Simple + Sweet, an artisanal ice cream business that has so far donated over 12,500 meals to local food banks and was recently recognized by Good Morning America.

The Truman Scholarship *(created by Congress in 1975 as a living memorial) awards $30,000 for post-graduate study to students pursuing careers in public service. Students apply during their junior year. They are selected first as finalists, then after a rigorous interview process, may be selected as Scholars. Funds are awarded when a student enters graduate school. Coleman Warren was a 2021 Truman Scholar. Julianne Kantner and Grace Stoops were 2022 Truman Finalists.*

- **Julianna Kantner**, a 2022 Truman Finalist (and a Marshall Finalist), is on a pre-law track. She is deeply involved in refugee resettlement efforts in Northwest Arkansas, has served as president and vice president of Students with Refugees, and volunteers with non-profits working towards food security and youth mentorship. She is also vice president of Rotaract where she trains students on strategies for social change. For her honors thesis, she is researching volunteer program development in refugee resettlement and launching an advocacy training program for college students to assist the local resettlement agency. Kantner intends to pursue a law degree to gain the legal knowledge necessary to represent clients and provide legal aid to marginalized communities.

- **Grace Stoops**, also a 2022 Truman Finalist, studies public health with a minor in medical humanities, with a long-term focus on student health education at both secondary and college levels. On campus, she founded Sexual Health Organization and Outreach (SHOO). SHOO provides sex education to U of A students through events,

seminars, and guest speakers. She has also volunteered at The Little Light House, a nonprofit school for disabled children, and is currently a hospitality and management intern at the YMCA of the Rockies. Stoops plans to obtain a Master's in Public Health with an emphasis in health education and initially work for the Centers for Disease Control and Prevention. In the future, she hopes to use her extensive research to expand SHOO nationally as a non-profit and create outreach programs for college students.

Udall Scholarship Foundation *(created in honor of Morris K. and Stewart L. Udall) awards 55 merit-based scholarships of up to $7,000 and 55 honorable mentions to college sophomores and juniors each year. Students apply in the categories of the environment or in Native American healthcare or tribal policy (students in this latter category must be Native American).*

- **Taylen Day**, an honors junior from Arlington, Texas, was named a 2022 Morris K. and Stewart L. Udall Scholar. Majoring in psychology, Day has actively engaged in the Native American Student Association, assisted in research in the DREAM lab and worked as the Volunteer Action Center president. Off campus, she has also worked as an ophthalmic work up technician at Retina Partners of NWA and a summer administrative intern at the Methodist Mansfield Medical Center. Day's professional aspirations are to serve as a medical doctor to the Native American population. More specifically, she wants to meet a great need within the community by working with Native American women as an OBGYN and plans to use her work to raise awareness about the medical and mental health issues that Native American women have historically faced.

Students wishing to applying for any of these or other competitive scholarships or post-graduate opportunities should contact the Office of Nationally Competitive Awards.