WASHINGTON STATE UNIVERSITY

SUMMER UNDERGRADUATE RESEARCH
ABSTRACT BOOK 2021

Office of
Undergraduate Research
WASHINGTON STATE UNIVERSITY

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Letter from Our Associate Director

Welcome to WSU Summer Undergraduate Research!

For almost a decade, Washington State University has welcomed inquisitive and enterprising students from across the nation to join us for summer undergraduate research. Owing to ongoing disruptions from COVID-19, students faced difficult challenges to conducting on-site research for the 9-week appointments that faculty usually offer through federal grants. Research Experience for Undergraduates (REU) grants, funded by the National Science Foundation (NSF), and USDA grants that include Extension in agricultural communities, were the principal sources of funding for most of the programs represented in this abstract book. Others operated independently.

WSU's summer research programs started at the end of May, when campus reopening efforts were still in a nascent phase. Nevertheless, all visiting students made efforts to achieve full vaccination status before arriving in Pullman, and these precautions ensured a safe working environment for everyone who made a commitment to proceed with in-person work.

Of the nearly 60 undergraduate researchers presenting research at the Summer Symposium, 22 students conducted their research on campus, while the others found ways to work remotely or in a hybrid capacity. Hailing from over 30 different colleges and universities in all, this remarkable group of student researchers showed ingenuity in overcoming obstacles to make these opportunities possible. The Office of Undergraduate Research is proud to showcase the results from their extraordinary efforts.

Over three days—July 30, August 3, and August 6—the students listed below will deliver virtual presentations on Zoom. They each have 5 minutes to present their work, allowing 5 minutes for questions at the end. The research topics range from interdisciplinary studies in STEM education, waves in physics, wearable computing, plant cell biology, deep learning, phenomics, atmospheric modeling of climate change, and the nexus of food, energy, and water (FEW).

We are thrilled to provide a platform to showcase the incredible work that has transpired this summer, and we truly appreciate your interest and support.

Sincerely,

Colin Mannex

Associate Director,

Office of Undergraduate Research

Summer Research 2021 News Story

July 26, 2021

MEDIA CONTACT: Colin Mannex, Associate Director of the Office of Undergraduate Research, colin.mannex@wsu.edu

WSU summer undergraduate research featured at virtual symposia

Subhead: The mentored research of nearly 60 undergraduates will be featured at three virtual symposia taking place on Friday, July 30, Aug. 3, and Aug. 6.

PULLMAN, Wash.—Washington State University will feature the mentored research of nearly 60 undergraduates from 36 universities at three virtual symposia on Friday, July 30, Aug. 3, and Aug. 6. Each event runs from 10:30-noon each day. The public is invited to the no-cost presentations.

"The Office of Undergraduate Research has had the opportunity to assist research programs from a number of STEM disciplines this summer as they hosted students on campus and virtually for around 10 weeks," said Colin Mannex, associate director.

"The students may come from institutions across the nation plus WSU, but they shared a common experience by working with WSU's outstanding faculty researchers and their teams on a variety of important projects.

"We look forward to hearing individual students explain the work they did and the results they found during their time at WSU."

Supported by grants from organizations such as the National Science Foundation as well as professors' grants, the research projects and their principal investigators this year are:

- "Multidisciplinary Undergraduate Research Training in Wearable Computing," led by Hassan Ghasemzadeh
- "Stakeholder Informed Modeling of Innovations in the FEW," led by Julie Padowski
- "Research Experiences for Undergraduates on HPC and Deep Learning," led by Dingwen Tao
- "Research in Interdisciplinary STEM Education (RISE)," led by Erika Offerdahl
- "Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest," led by Shelley Pressley
- "Northwest Advanced Renewables Alliance (NARA)," led by Shelley Pressley
- "Plant Cell Biology and Biochemistry," led by Andrei Smertenko
- "Phenomics Big Data Management," led by Sindhuja Sankaran
- "Waves in the Universe and Technology," led by Brian Collins
- "Transcriptional Regulators of Plant Cell Wall Biosynthesis," led by Laura Bartley

- "Nuclear, Optical, Magnetic, and Electronic (NOME) Materials Laboratory," led by John McCloy

Student projects this Friday will be from the Sankaran, Padowski, and Offerdahl labs. On Aug. 3, they will be from the Collins, Tao, Ghasemzadeh, and Bartley labs. On Aug. 6, presenters will be from the Pressley, McCloy, and Smertenko labs. A schedule posted on the summer undergraduate research website details the names of student researchers and their presentation times.

The Office of Undergraduate Research is part of the Division of Academic Engagement and Student Achievement in the Office of the Provost and Executive Vice President

Summer Research Symposia Presentation Schedules

All Presenters will have 10 minutes to present and answer questions.

July 30: 10:30am – 12pm

Phenomics Big Data Management

Research in Interdisciplinary STEM Education

Stakeholder Informed Modeling of Innovations in the FEW

Aug 3: 10:30am – 12pm

Multidisciplinary Undergraduate Research Training in Wearable Computing

Laboratory of Laura Bartley

Waves in the Universe and Technology

Aug 6: 10:30am – 12pm

Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Northwest Advanced Renewables Alliance

(NOME lab) and in the HYdrogen Properties for Energy Research (HYPER)

Plant Cell Biology and Biochemistry

List of Abstracts

Presenter	Research Program	Project Name
Antonio Franco	Phenomics Big Data Management	Correlation Between RGB and Gene Expression Data to Identify Lentils Having a high Resistance Expression to Aphanomyces
Lindsey Stachofsky	Phenomics Big Data Management	Applications of Unmanned Aerial Vehicles for Detecting Drought Tolerance in Spring Wheat Varieties
Maicynn Hansen	Phenomics Big Data Management	Evaluation of Changes in Vegetation Indices Due to In-field Sensor Angles
Pia Spychalla	Phenomics Big Data Management	Using Unmanned Aerial Vehicles (UAV) to Identify Metribuzin-tolerant Winter Wheat
Robin Javid	Phenomics Big Data Management	Evaluation of Blueberry Fruit Quality using Standard and Modified Catcher Plates
Angela Hong	Research in Interdisciplinary STEM Education	Setting Students up for Success in General Chemistry With a Novel Prep Chem Class
Archer Harrold	Research in Interdisciplinary STEM Education	How do Student Roles in Small Groups Differ Across Data Interpretation Tasks?
Elizabeth Elliott	Research in Interdisciplinary STEM Education	Examining the Impacts of a CURE in an Undergraduate Introductory Biology Course for URMs
Emilee Bernath	Research in Interdisciplinary STEM Education	How do CUREs Affect Content Learning: A Comparison of In-Person and On-Line Presentation of an Upper-Level Developmental Biology Research Experience
Esperanza Artiles	Research in Interdisciplinary STEM Education	Understanding Scientific Argumentation in Large-lecture Biology: Characterizing the Effect of Task Framing on Students' Use of Resources
Jazmyn Juarez	Research in Interdisciplinary STEM Education	Setting Students up for Success in General Chemistry With a Novel Prep Chem Class
Maria Mozo Cardona	Research in Interdisciplinary STEM Education	Health Education Through Arts-based Learning (Heal): From Stem to Steam

Presenter	Research Program	Project Name
Nyckolaus Ledezma	Research in Interdisciplinary STEM Education	Understanding How Different Leaderships Inhibits or Enables Students from Expressing Alternative Ideas In Large Introductory Biology Courses
Nyckolaus Ledezma	Research in Interdisciplinary STEM Education	Understanding Scientific Argumentation in Large-Lecture Biology: Characterizing What Resources Students Use in an Argumen
Puja Shah	Research in Interdisciplinary STEM Education	How Do Cures Affect Scientific Literacy: In-person and Online Implementation of an Upper-level Developmental Biology Course-based Research Experience
Asmita Acharya	Stakeholder Informed Modeling of Innovations in the FEW	Planning and Analysis Tool for Resilient Power Grid with Hydro Generation
Dehlia Wolftail	Stakeholder Informed Modeling of Innovations in the FEW	Quantification of The Colville and Spokane Tribe Water Right Adjudication and Potential Impacts to Current Junior Water Right Holders.
Gustavo Mendez Soto	Stakeholder Informed Modeling of Innovations in the FEW	Examining the Impact of Groundwater on the Sustainability and Resilience of the Yakima River Basin During Drought Years
Hailey Smith	Stakeholder Informed Modeling of Innovations in the FEW	Analyzing the Impact of Social Capital on the Adoption of Efficient Irrigation in Washington State Orchards
Jade Mokry	Stakeholder Informed Modeling of Innovations in the FEW	Coeur d'Alene Lake Model
Jiyoung Park	Stakeholder Informed Modeling of Innovations in the FEW	Municipal Water Supply and Demand Management Through Wastewater Reuse and Increasing Block Pricing in the City of Pasco
Kendahl Heckstall	Stakeholder Informed Modeling of Innovations in the FEW	Can Apples Beat the Climate Change Heat with a Lower Water Footprint?
Lauren Lansford	Stakeholder Informed Modeling of Innovations in the FEW	System Dynamics Model of Changing Groundwater Storage and Behavior in the Walla Walla Valley Due to Climate Change

Presenter	Research Program	Project Name
Liam Reynolds	Stakeholder Informed Modeling of Innovations in the FEW	Refining the Definition of Urban Agriculture to Streamline Public Policy Development and Implementation
Jonathan Vivian	Laboratory of Laura Bartley	Regulation of Acylransferase Gene in Cell Wall Biosynthesis
Ahmed Abdelgalil	Multidisciplinary Undergraduate Research Training in Wearable Computing	Predicting Your Emotions? Long-short Term Memory (Rnns) Vs. Decision Tree's Algorithm
Grace Stewart	Multidisciplinary Undergraduate Research Training in Wearable Computing	Development of User-Friendly Object Detection Method for Video Labelling In Matlab to Be Used with Eye Tracking Video Data
Ryan Holder	Multidisciplinary Undergraduate Research Training in Wearable Computing	Comparing The Predictability of Sensor Modalities to Detect Stress from Wearable Sensor Data
Annie Wang	Waves in the Universe and Technology	Measuring the Velocity of Aluminum Foil Accelerated by Laser Ablation Using VISAR
Emily Kehoe	Waves in the Universe and Technology	Searching for Active Galactic Nuclei in Dwarf Galaxies NSA 91579 and NSA 112250
Fiona McLary	Waves in the Universe and Technology	Infrared Spectroscopy of 4:1 Methanol-Ethanol for Diamond Anvil Cell Pressure Calibration
Helena Belzer	Waves in the Universe and Technology	Analyzing the Effects of Interfacial Mixing on Bilayer Organic Photovoltaic Cells
James Serna	Waves in the Universe and Technology	An Intuitive Picture of Radioactive Decay: Fermi's Golden Rule, Landau-Zener Transitions, and Entanglemen
Jonathan Loera	Waves in the Universe and Technology	Investigating Efficiency Optimizing Parameters for Blade-Coated PBDB-T:PC71BM System

Presenter	Research Program	Project Name
Noora Ghadiri	Waves in the Universe and Technology	Creating a More Realistic Profile for Differentially Rotating Neutron Stars
John Bussey	(NOME lab) and in the HYdrogen Properties for Energy Research (HYPER)	Nano and Micro Phase Identification in Natural and Synthesized Glass
Clara Ehinger	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Deploying Mobile and Remote Air Quality Sensing Technologies for Urban and Rural Sustainability
Dalynn Kenerson	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Volatile Organic Compounds Emitted from Asotin Complex and Snake River Complex Fire
Dylan Fernholz-Hartman	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Urban Tree Cover Distributions for Biogenic Emission Modeling
Eleanor Curtright	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Reflective Ash: Determining Hyperspectral Signatures of Wildfire Ash Under Different Moisture Contents
Isabelle Jernigan	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Using the Particle-Into-Liquid Sampler (PILS) to Better Understand Water Soluble Organic Carbon (WSOC) in the Atmosphere
Jacob Lindblom	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	The Role of Oxygen in Aerobic Decomposition at Washington State University's Compost Facility, Carbon Trading Opportunities, and Improvements to EPA's Waste Reduction Model
Joseph Rotondo	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Three-Year Analysis of Eddy Covariance Data to Understand Benefits and Weaknesses of Differing Crop Rotations in the Palouse
Kaitlyn Lindholm	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Evaluating Microbial Sources of Greenhouse Gas Emissions in Compost
Katherine McCown	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Analyses of Water-Soluble Volatile Organic Compounds from Compost Emissions at Washington State University

Presenter	Research Program	Project Name
Kylie Wilson	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Gaseous Volatile Organic Compounds Emitted from Washington State University Compost Facility
Samuel Jurado	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	Quantifying the Influence of a Heat Wave Event on the Surface Energy Balance over Sagebrush in Washington Using Eddy Covariance Flux Data
Zachary Watson	Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest	The Effects of Relative Humidity and Ammonia on the Measurement and Detection of Volatile Organic Compounds from Compost
Jessica Zhang	Northwest Advanced Renewables Alliance	Development of a UV-curable Bio-Based Resin for 3D Printing
Joanne Low	Northwest Advanced Renewables Alliance	The Influence of the Drawing Process on Chemical Recycling of Cotton Waste for Regenerated Fibers
Katherine Rasmussen	Northwest Advanced Renewables Alliance	Development of Medium Density Fiberboard (Mdf) Composites from Combination of Wood Chips and Waste Low-density Polyethylene (Ldpe) Packaging Film
Alejandro Barragan-Morales	Plant Cell Biology and Biochemistry	MACET4 Smertenko Lab
BreeLynn Robinson	Plant Cell Biology and Biochemistry	Characterizing the Functional Domains of MACET4
Jenalle Pana	Plant Cell Biology and Biochemistry	MACET4 Role in Phragmoplast Microtubule Nucleation.
Nhu-Y Do	Plant Cell Biology and Biochemistry	Characterizing Functional Domains of MACET4: A Plant Specific Microtubule Nucleating Protein
Peter Coggan	Plant Cell Biology and Biochemistry	Macet Expression and Function Across Plant lineages

Abstracts

Correlation Between RGB and Gene Expression Data to Identify Lentils Having a high Resistance Expression to Aphanomyces

Presented by: Antonio Franco

Program: Phenomics Big Data Management

Co-authors: Stephen Ficklin

Home Institution, Major, Class Standing: Heritage University, Environmental Science/Biology, Senior

Lentils have a high nutritional value and can be grown within marginal lands, but they have been affected by global warming and a pathogen called Aphanomyces. Aphanomyces also known as root rot, effects the roots of the lentil in which symptoms are seen within 7 to 14 days of exposure, once exposed it is fatal to the plant and will slowly rot the roots. Many acres can be affected without a farmer knowing costing them land and revenue. Early identification can mitigate the problem by culling those effected and those that are around them, up to 18 cm. Currently farmers and breeders cannot identify lentils that have root rot unless they pull out the lentils checking the roots or until it is too late with many being affected. In order to identify Aphanomyces, will be investigating two different sets of data, RGB (visual data) and gene expression data. The data that has been collected was from a data set with nine lentils accessions with all having various levels of resistance, replicated three times with two different time points, and two treatments (controlled and inoculated). Using python and supervised machine learning, the purpose is to identify lentils that have a high resistance expression to Aphanomyces. Once identified, we will then use RGB data to investigate and identify those expressing high level of resistance to those with low levels of resistance and point out key visual differences between high and low level of resistance. My hypothesis is if we find genes that are associated with levels of resistance using RGB data and the genetic data, we could then go into further testing and breeding can occur to see if the gene resistant lentils are inherited to create a lentil more resistant then the previous generation.

Evaluation of Changes in Vegetation Indices Due to In-field Sensor Angles

Presented by: Maicynn Hansen

Program: Phenomics Big Data Management

Co-authors: Aaron H. Carter, Rebecca J. McGee, Milton Valencia Ortiz, Worasit Sangjan, and Sindhuja Sankaran

Home Institution, Major, Class Standing: University of Illinois Urbana-Champaign, Crop Sciences, Senior

RGB and multispectral sensors in crop phenotyping provide opportunities to increase efficiency in crop breeding efforts. Reflectance measurements from RGB and multispectral sensors can be used to calculate vegetation indices (VIs), functional in understanding crop responses and generating crop traits predictions. The integration of Internet of Things (IoT) with sensors allows for real-time crop monitoring and data collection. In-field placement of IoT sensor systems at nadir angle is constrained by intended field of view and overhead shadowing. An alternative solution is the sensor field placement adjacent to the region of interest from an angled position, which results in oblique images. This study evaluates the effect of different sensor (RGB and multispectral) angles on the calculated crop vegetation indices. The RGB and multispectral data were collected at three angles (30°, 45°, and 60° from nadir) from plots of three different crops (winter wheat, spring pea, and chickpea). Ground reference data were collected with an unmanned aerial vehicle (UAV) equipped with similar RGB and multispectral cameras. Image data from both in-field IoT sensor systems and UAV were processed using Matlab and FIELDimageR for the vegetation indices (normalized difference vegetation index, green normalized difference vegetation index, normalized green red difference index, and green leaf index) extraction. Analysis of variance (ANOVA), post-hoc, and Pearson correlation will be performed on the data sets. It is anticipated that there will be significant differences between VIs extracted from images acquired at different angles and ground reference data. The results of this study will inform the IoT sensor setup and the use of image distortion correction in the extraction of VIs for crop monitoring applications.

Evaluation of Blueberry Fruit Quality using Standard and Modified Catcher Plates

Presented by: Robin Javid

Program: Phenomics Big Data Management

Co-authors: Lisa Wasko DeVetter and Yixin Cai

Home Institution, Major, Class Standing: Washington State University, Organic and Sustainable Agriculture, Junior

New machine harvesters with soft-surface catch plates may allow growers to more economically and efficiently pick their fresh market blueberries without sustaining bruise damage. Machine harvesting for fresh market is appealing because it relies on less labor, which reduces the problems associated with high labor costs and shortages. However, fruit quality needs to be comparable to handpicked fruit and that means reduced bruising. Therefore, there is great interest in advancing machine harvesting for fresh market blueberry growers as a way to cut labor costs and maintain profitability. The current methods of evaluating bruising on blueberry are highly subjective, time consuming and reliant on the human eye to distinguish subtle variations in bruising across different cultivars. The purpose of my project is to focus on a more objective approach to evaluate bruising on blueberry by utilizing image processing to distinguish variations in bruising for three commonly grown blueberry cultivars in Washington state when dropped on standard and modified catching plates. The overall goal of my project is to advance the objectivity of how bruising is viewed when subject to catcher plates impacts for three commonly grown blueberry cultivars, which in the long run will facilitate bruise assessment and assessing machine harvest technologies that help growers harvest their blueberry crop. In order to reach the goal through this project, I will do image analysis using an improved method and collect additional data by dropping hand harvested blueberries from three different cultivars (‘Reka’, ‘Duke’, and ‘Draper’ or ‘Liberty’) from the heights of 30, 60, and 90 cm onto traditional and modified catcher plates. The blueberries will then be evaluated for firmness and then cut open to evaluate visible bruising. The program MatLab will be used for image processing that will assist in establishing a more objective system for evaluating blueberry bruising.

Using Unmanned Aerial Vehicles (UAV) to Identify Metribuzin-tolerant Winter Wheat

Presented by: Pia Spychalla

Program: Phenomics Big Data Management
Co-authors: Arron Carter and Andrew Herr
Home Institution, Major, Class Standing: University of Wisconsin - Madison, Molecular Biology, Senior

Metribuzin-tolerant winter wheat (Triticum aestivum L.) varieties would allow growers to apply maximum rates of the herbicide in order to have better weed control but without the concern of causing injury to their crop. The use of unmanned aerial vehicles (UAV) and spectral reflectance indices (SRI's) would improve the selection process by eliminating bias from visual ratings. The objective of this study was to determine if the use of UAVs would be an accurate and effective alternative to visual ratings for the detection of metribuzin-tolerant lines. The study was conducted at Washington State University Spillman Research Farm in Pullman, Washington in 2020 and 2021. Soft white winter wheat varieties were evaluated in a paired row system with a high rate of metribuzin row and a non-sprayed control row. The plots were imaged using a multispectral camera 21 days after herbicide application and visual injury ratings were recorded within the same week. SRI's looking at chlorophyll content, water content, and canopy cover were calculated from the calibrated images. Correlation analysis was done to determine if there is a significant relationship between the index differences of the treatments and the injury notes. SRI's looking at chlorophyll content and canopy cover did not have any correlation to the visual ratings in either of the years. However, it was found that NWI-2 has a +0.66 correlation to the visual ratings in 2021. The positive correlation indicates the treated rows had a lower water content compared to the control rows. The results show a possibility of UAVs replacing visual ratings with SRI's looking at water content. The use of objective data rather than subjective observations would help improve metribuzin tolerance detection and breeding program selection.

Applications of Unmanned Aerial Vehicles for Detecting Drought Tolerance in Spring Wheat Varieties

Presented by: Lindsey Stachofsky

Program: Phenomics Big Data Management
Co-authors: Michael Pumphrey and Peter Schmuker
Home Institution, Major, Class Standing: University of Idaho, Biological Engineering, Junior

Unmanned aerial vehicles (UAVs) are an important part of precision agriculture and the automation of data collection. They are more precise than manual observation, save time, and allow for information to be collected without human error. UAVs will be used to study the importance of drought tolerance and long-term crop productivity. By determining whether there is significant genetic variation for drought related signatures in modern variety spring wheat trials, it evaluates how UAVs and remote sensing can be used to measure stress response. Images from the UAV will be captured using the spring wheat breeding variety trails where routine phenotypic measurements are already being collected. This includes plant height, yield, test weight, heading date, and protein content. The images and the information collected will go through statistical analysis of both field measurements and data using R coding and multiple indices such as normalized difference vegetation index (NDVI) and normalized water index (NWI). The statistical analysis will be comparing the 2021 wheat variety trials to previous years. It is predicted that there will be decreases in NDVI compared to previous years with some varieties having greater percent reductions. The data collected will benefit both the spring wheat breeding program at Washington State University and the advancement of using UAVs as an application of precision agriculture.

Understanding Scientific Argumentation in Large-lecture Biology: Characterizing the Effect of Task Framing on Students' Use of Resources

Presented by: Esperanza Artiles

Program: Research in Interdisciplinary STEM Education
Co-authors: Jessie Arneson, Brett Baerlocher, Nyck Ledezma and Erika Offerdahl
Home Institution, Major, Class Standing: Central Washington University, Mathematics and Science, Senior

Scientific argumentation is a skill that is important for science majors and future citizens alike. Our Research in Interdisciplinary STEM Education (RISE) project is to determine if argumentation-based instructional practices are feasible in large-lecture environments. This research was conducted over two semesters in a large-lecture (n >450 students) introductory biology course. During the argumentation-based instruction, students were provided three data sets to analyze with peers and use to make a scientific argument. As part of this instruction, students submitted a written summary response using the data to explain a scientific phenomenon. We were curious about the degree to which students used the data sets and classroom information in their summary responses. First, we developed and iteratively refined a codebook that ultimately consisted of five resource codes. After establishing inter-rater reliability, two researchers began coding de-identified summary responses (n>750). Preliminary data shows that most students did leverage at least two resources within their summary responses, though the depth of their integration is still unknown. Once coding is completed, we can observe what resources students use as leverage in their summary writing, how the resources leveraged changed, to what degree do students integrate multiple resources, and how integration relates to how the task was framed.

How do CUREs Affect Content Learning: A Comparison of In-Person and On-Line Presentation of an Upper-Level Developmental Biology Research Experience

Presented by: Emilee Bernath

Program: Research in Interdisciplinary STEM Education
Co-authors: Puja H Shah and Erica Crespi
Home Institution, Major, Class Standing: Heritage University, Biology, Junior

In addition to giving research experiences to a broader base of students, it is hypothesized that course-based undergraduate research experiences (CUREs) increase disciplinary content knowledge, increase motivation in science, and enhance understanding of the nature of science. It is unknown, however, how learning outcomes and the quality of CUREs experience vary between scientific disciplines or whether it is taught in-person or on-line formats. We evaluated 4 years of Student Assessment of Learning Gains surveys (2016-2017, 2020-2021) administered after a laboratory-based CURE in an upper-level developmental biology course at Washington State University. Students designed, conducted, and analyzed experiments that examined effects of environmental chemicals on animal development. The first two years were taught in the laboratory, 2020 was taught half in the laboratory then transitioned online due to the onset of the COVID pandemic, and 2021 was taught fully online. We found across years, 60-73% of the students reported that the CURE helped learning course content, and more than 89% reported positive ways the CURE helped their learning. These included hands-on activity, real-life application of concepts and clarified concepts taught in lecture, and students commented that they missed hands-on activities when it was taught on-line. In addition, 35.85% to 55.56% more students reported that they learned “a lot” or “a great deal” in environmental developmental biology (focus of CURE) than that reported for any other content area. Students valued experiencing the CURE, as % students listed the laboratory experience was their favorite part of the course; however, many students commented that the CURE was time consuming, did not align with lecture content, and was too narrow in focus. These data support the idea that CUREs enhance disciplinary content learning, and there was no evidence indicating that the on-line delivery negatively affected this learning outcome of the CURE.

Examining the Impacts of a CURE in an Undergraduate Introductory Biology Course for URMs

Presented by: Elizabeth Elliott

Program: Research in Interdisciplinary STEM Education
Co-authors: Gretchen Rollwagen-Bollens
Home Institution, Major, Class Standing: Pacific Lutheran University, Biology, Senior

Course-Based Undergraduate Research Experiences (CUREs) engage undergraduates in research as part of their STEM courses. In a CUREs students conduct a discovery-based research project to gain experience with the research in the way scientists do it. At Washington State University (WSU) Vancouver, an institution that has a large non-traditional student population, a CURE was implemented in an introductory biology course (Bio 106) to support their unique student body over four years (2017-2020). To understand how the CURE may have benefited students, a common assessment tool, Test of Scientific Literacy Skills (TOSLS) was given at the beginning and end of the semester. The overarching question was: Were there differences in learning gains and success in a science course depending on the identities and demographics (Gender, Race/Ethnicity, Socioeconomic status, etc.) of the students? Our goal was to determine whether the CURE had a differential impact based on their identities. To address this overarching question we had two additional questions:

1. What is the relationship between academic success measures (grades, etc.) and TOSLS gains/losses?
2. How does academic success and TOSLS gains/losses compare between Underrepresented Minorities (URM) and non-URM groups?

TOSLS had been administered to Bio 106 students and we wanted to understand how it could be used to understand how the CURE impacted important scientific skills and if it could be used with course grades to evaluate students. Our results show that academic success measures and TOSLS in Bio 106 are not comparable. We are continuing to explore how Bio 106 URM and non-URM students compare with TOSLS.

How do Student Roles in Small Groups Differ Across Data Interpretation Tasks?

Presented by: Archer Harrold

Program: Research in Interdisciplinary STEM Education

Co-authors: Brandon Call, Andy Cavagnetto, Lauren Duffy, Anna Ferroggiaro, Nyck Ledezma and Dana Roach

Home Institution, Major, Class Standing: University of Nebraska-Lincoln, Chemistry, Senior

Argumentation can enhance student learning outcomes such as domain-specific knowledge, argumentative reasoning, and critical thinking skills. Though research has been done investigating many learning outcomes associated with argumentation-based tasks, less research has investigated the social dynamics of small groups in such settings. In this study we investigated what student roles develop in groups and if they change over time. The study took place in a large-lecture introductory biology course, students were separated into 11 groups consisting of two to three students, and their interactions were recorded for analysis. Over the course of two lecture days, students were prompted with three content-oriented data figures from the primary literature and given approximately 15-20 minutes to collectively answer questions pertaining to each data figure. Group recordings were separated into episodes, which consisted of a group's discussion over one figure. Each episode was analyzed qualitatively (e.g open coding, analytic memo writing). Codes were created and assigned by three researchers who collectively discussed their thoughts after listening to and watching the videos and reading the transcript. Five roles emerged from coding. Leaders, which include four subtypes: Dominant, Confused, Shared-Leadership, and Teaching, and four secondary roles: Task-Oriented, Follower, Critic, and Bystander. This codebook was used to assign roles to every student in each episode, and student roles were compared across the three data interpretation tasks. Mixed results were found, some groups show little change in roles over the three tasks while others have all students change (e.g a Leader in task one may be a bystander in task two). These results may imply the critical function of resources (e.g background knowledge), and subsequent analysis needs to be done to further explore such resources and their influence on roles.

Setting Students up for Success in General Chemistry With a Novel Prep Chem Class

Presented by: Angela Hong

Program: Research in Interdisciplinary STEM Education
Co-authors: Paul T. Buckley and Jazmyn Juarez
Home Institution, Major, Class Standing: Pacific Lutheran University, Chemistry, Senior

A preparatory chemistry class (Chem 103) was developed at Washington State University that features a novel curricular design, a flipped-classroom approach, and weekly tutorial sessions led by an undergraduate TA. We compared grades (end-of-semester and mid-semester assessments) for seven semesters of Chem 103 cohorts in relation to Chem 105 students who did not take Chem 103. The students who took Chem 103 had at least as much success in general chemistry than students who did not, confirming that Chem 103 is working as preparation for Chem 105. We also examined equity gaps for underrepresented groups in STEM (women, first generation, underrepresented minorities), and these results will be presented.

Setting Students up for Success in General Chemistry With a Novel Prep Chem Class

Presented by: Jazmyn Juarez

Program: Research in Interdisciplinary STEM Education
Co-authors: Angela Hong and Paul Buckley
Home Institution, Major, Class Standing: Claremont McKenna College, Molecular Biology and Religious Studies, Senior

A preparatory chemistry class (Chem 103) was developed at Washington State University that features a novel curricular design, a flipped-classroom approach, and weekly tutorial sessions led by an undergraduate TA. We compared grades (end-of-semester and mid-semester assessments) for seven semesters of Chem 103 cohorts in relation to Chem 105 students who did not take Chem 103. The students who took Chem 103 had at least as much success in general chemistry than students who did not, confirming that Chem 103 is working as preparation for Chem 105. We also examined equity gaps for underrepresented groups in STEM (women, first generation, underrepresented minorities), and these results will be presented.

Understanding Scientific Argumentation in Large-Lecture Biology: Characterizing What Resources Students Use in an Argumen

Presented by: Nyckolaus Ledezma

Program: Research in Interdisciplinary STEM Education
Co-authors: Jessie Arneson, Espi Artiles, Jacob Woodbury and Erika Offerdahl
Home Institution, Major, Class Standing: California State Polytechnic University, Pomona, Biology, Senior

Scientific argumentation is a skill that is important for science majors and future citizens alike. Our Research in Interdisciplinary STEM Education (RISE) project is to determine if argumentation-based instructional practices are feasible in large-lecture environments. This research was conducted over two semesters in a large-lecture (n>450 students) introductory biology course. During the argumentation-based instruction, students were provided three data sets to analyze with peers and use to make a scientific argument. As part of this instruction, students submitted a written summary response using the data to explain a scientific phenomenon. We were curious about the degree to which students used the data sets and classroom information in their summary responses. First, we developed and iteratively refined a codebook that ultimately consisted of five resource codes. After establishing inter-rater reliability, two researchers began coding de-identified summary responses (n>750). Preliminary data shows that most students did leverage at least two resources within their summary responses, though the depth of their integration is still unknown. Once coding is completed, we can observe what resources students use as leverage in their summary writing, how the resources leveraged changed, to what degree do students integrate multiple resources, and how integration relates to how the task was framed.

Health Education Through Arts-based Learning (Heal): From Stem to Steam

Presented by: Maria Mozo Cardona

Program: Research in Interdisciplinary STEM Education
Co-authors: Robert Danielson, Molly Kelton and Vianette Peña
Home Institution, Major, Class Standing: MiraCosta College, Biomanufacturing, Junior

Health Education through Arts-based Learning (HEAL) is an NIH-funded health sciences education project at Washington State University. Buzzing for Blood, a ~20-hour HEAL curriculum implemented in afterschool settings, served 3rd-5th graders in predominantly Latinx communities in rural Washington. Buzzing for Blood used arts-based methods, including photography, scientific illustration, and infographics, to teach children about mosquito morphology and ecology.

A central learning goal of Buzzing for Blood was to support children's systems thinking about zoonotic diseases like West Nile Virus. Multiple assessment measures were used to gauge whether and how children developed systems thinking. In an "image selection" task, children were provided thirty-six diverse images such as irrigated landscapes, livestock, or doctors' offices and asked to select which of those images they thought had some form of relationship with getting sick from a mosquito. The image selection task was administered both prior to and following the program. The program was administered twice, and results are reported in the aggregate.

Twenty-three students participated in the program. Fifteen students completed the preliminary image selection task and ten students completed the post task. Five students completed both pre and post task. While analyses are ongoing, preliminary findings suggest that, overall, children selected more images on the post assessment than on the pre.

Future analysis will include triangulating the image selection data with other forms of assessment data gathered for this program, including student drawings and open-ended questionnaire responses, to provide a more complete picture of students' systems thinking about mosquito-borne illness.

Findings suggest that Buzzing for Blood may have supported students' systems thinking, allowing them to critically analyze how West Nile Virus and mosquito morphology and ecology connect to their lives. Ultimately, this might permit them to identify risks in their own agricultural communities and aid in the prevention of zoonotic diseases.

How Do Cures Affect Scientific Literacy: In-person and Online Implementation of an Upper-level Developmental Biology Course-based Research Experience

Presented by: Puja Shah

Program: Research in Interdisciplinary STEM Education
Co-authors: Emilee J. Bernath and Erica J. Crespi
Home Institution, Major, Class Standing: Raritan Valley Community College, Biology, Junior

Course-based undergraduate research experiences (CUREs) are hypothesized to increase scientific literacy and broaden the base of undergraduate participation in research. How the quality of the CURE experience or the learning of scientific literacy skills varies among scientific disciplines and between in-person and online formats is poorly understood. In this study we examined assessments of scientific literacy from similarly structured CUREs implemented over seven years in an upper-level developmental biology course at Washington State University. In this CURE, students read primary literature, formed hypotheses, and designed, conducted and analyzed experiments to explore the effects of environmental chemicals on animal development. The CUREs were taught in-person in the laboratory from 2015 to 2018, in a hybrid format in 2020, and fully online during 2021. We analyzed Test of Scientific Literacy Skills (TOSLS) pre- and post-course data, and Student Assessment of Learning Gains (SALG) data from a subset of years. We found that compared to introductory courses, the TOSLS items were less difficult for upper-level students, and while students with lower pre-course scores showed significant learning gains, students with higher initial scores reached the limits of the test and thus showed minimal gains. We saw stable performance and learning gains across years despite differences in format. SALG data showed more nuanced differences in learning between formats, including the increased learning of graphing and statistical skills during the fully online 2021 semester, but lower gains of skills involving working with others or ability to articulate a testable hypothesis. We propose that a modified TOSLS with items of increased difficulty to help discriminate learning gains of students with greater initial scientific literacy would be better for use in upper-level courses, and the gains in scientific literacy skills after experiencing CUREs focused on biological research is robust to differences between in-person and online formats.

Planning and Analysis Tool for Resilient Power Grid with Hydro Generation

Presented by: Asmita Acharya

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Sanjita Ramyasai Bhavirisetty, Sanjeev Pannala and Anurag K. Srivastava
Home Institution, Major, Class Standing: Washington State University Tri-Cities, Computer Science, Junior

High-impact low-probability (HILP) events such as a hurricane, heavy snow, heat waves, and floods cause widespread power outages and blackouts. With the increasing challenges concerning the threats to the power systems and the growing need to mitigate the impacts of the HILP events, resilience has become a crucial desirable characteristic for the power grid infrastructures. The operator of the distribution grid needs to analyze previous threats as well as predict other possible threats so that pre-planning can be done to mitigate its impact on the overall power system. This paper explains the development of the planning and analysis tool for the resilient power grid with hydro generation. Hydro resources need to be coordinated with distributed energy resources to meet the grid resilience requirements while meeting water constraints.

The overall development of the tool is divided into the front end, back end, and database. The front end exhibits the presentation layer of the tool that is implemented using HyperText Markup Language (HTML), Cascading Style Sheets (CSS), and JavaScript (JS). The back end is the server of the tool implemented using Python flask. The database stores all the static and dynamic data streams, and imports/export structured data from external resources if needed. Here, we made use of PostgreSQL.

We discuss in detail the importance of the tool and its functionality. This tool facilitates the operator to identify the possible threats so that they can visualize and prepare strategies for assets safety, maintain inventory, alert customers beforehand, and reduce its impact on system resilience. Finally, the qualitative assessment of the tool's ability is presented to explain its contribution and effectiveness. It includes details about how investing in smart grid technologies such as remote-controlled switches, Distributed Energy Resources (DERs) and increased distribution automation can be beneficial for resilience enhancement.

Can Apples Beat the Climate Change Heat with a Lower Water Footprint?

Presented by: Kendahl Heckstall

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Matthew Pruett, Yvonne Manning and Kirti Rajagopalan
Home Institution, Major, Class Standing: Georgia State University, Nutrition Science, Senior

The Washington State part of the Columbia River Basin (CRB) has consistently been the leading producer of apples in the United States, accounting for about 90% of the US apple production. Climate change threatens apple production in multiple ways, e.g. through changes in crop yields, quality, transpiration requirements. One poorly understood climate-change implication which involves the food-water nexus, is the implication for sunburn risk management. This risk is typically managed by applying additional overhead irrigation for cooling with implications for areas that are already water stressed. The objective of this work is to (a) understand how sunburn risk in the CRB is evolving under climate change and (b) evaluate the ability of management innovations such as adoption of over-tree netting to alleviate this risk while minimizing water demands for evaporative cooling. Honey Crisp is considered as an example apple variety for analysis given its known susceptibility to sunburn risk. Historical climate data and future climate projections under two different representative concentration pathways (RCPs) - RCP 4.5 and 8.5 that correspond to relatively lower and higher temperature increases - are used to drive a fruit surface temperature model. Hourly fruit surface temperature estimates are compared with sunburn threshold temperatures to quantify risk. Three different types of netting that filter varying levels of incoming shortwave radiation are considered as management options. Results demonstrate that overall, sunburn risk increases significantly with climate change. Over-tree netting has the ability to reduce sunburn risk, however the type of netting used is important given competing responses of reductions in windspeed and incoming radiation on fruit surface temperatures. Moreover, netting in and of itself does not seem sufficient to manage increasing sunburn risk in the CRB and additional water demands for evaporative cooling are necessary with potential to increase water scarcity.

System Dynamics Model of Changing Groundwater Storage and Behavior in the Walla Walla Valley Due to Climate Change

Presented by: Lauren Lansford

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Jan Boll
Home Institution, Major, Class Standing: Washington State University, Civil Engineering, Senior

Water availability above and below the land surface is experiencing shortages with increasing frequency of extreme events due to climate change, creating greater challenges for fair and just water resource management in the western United States. Within the Walla Walla Valley in Washington and Oregon State, water resource management policy and operations are changing in response to the need for more sustainable practices to satisfy stakeholders' current and future needs. In this study, a system dynamics model analysis of the Walla Walla Valley's future water availability centers around the groundwater storage capacity within the valley and aims to model the dynamic recharge/discharge relationship of the Walla Walla River and the valley's aquifer. The model considers the most significant inflows and outflows of Walla Walla Valley's aquifer consisting of surface streamflow and irrigation pumping, respectively. Climate change impact on hydrological processes was accounted for directly in the data used for streamflow, from seventeen General Circulation Models running Representative Concentration Pathway 4.5 (RCP4.5) and RCP8.5 scenarios. Experiencing changing and variable streamflow recharge, the model will evaluate how the groundwater stock experiences cyclical withdrawal for irrigation use, defined by hypothetical irrigation schedules for the three largest irrigated crops in the valley, by cumulative area. With successful behavior, the model can stand as a base model. In the future, other water management (e.g., managed aquifer recharge) and hydrological processes can be added to enhance the usefulness of the model in informing Walla Walla Valley stakeholders on climate-impacted groundwater storage and behavior.

Examining the Impact of Groundwater on the Sustainability and Resilience of the Yakima River Basin During Drought Years

Presented by: Gustavo Mendez Soto

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Collins Asante-Sasu, Sasha McLarty and Fabio Scarpare
Home Institution, Major, Class Standing: Heritage University, Environmental Science, Sophomore

This study analyzes the impact of groundwater on the Sustainability and Resilience of the Yakima River Basin during three recent drought years (2001, 2005, 2015). We gathered multiple metrics to focus our attention on the effects of the drought years using a newly developed SusTainability and Resilience (STAR) calculator. These metrics consisted of three main sectors, food, energy, and water to evaluate the findings within the Food-Energy-Water (FEW) nexus. For the food metrics, we used the proration percent by water year, crop yield divided by evapotranspiration and economic damages. For the energy metrics, we used hydropower generation, sales per customer, and CO_2 emissions. Lastly, for water we focused on average annual discharge, water level anomaly post-drought, and emergency groundwater authorizations. These metrics were primarily collected using the Yakima River Basin boundaries, though many times this was not the case due to data limits. Some data were acquired at the county scale, state scale, or for specific areas within the basin. Acquiring the specific data for the drought years proved to be the most difficult task but once collected, helped us form a general idea and comparison as to how much damage the drought years were causing to the Yakima River Basin and the potential role of groundwater in mitigating those damages. This study provides an example of how to evaluate the FEW nexus in drought conditions.

Coeur d'Alene Lake Model

Presented by: Jade Mokry

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Allyson Beall King
Home Institution, Major, Class Standing: University of Idaho, Fishery Resources, Sophomore

The development and expansion of hydroelectric power in the Inland Northwest impacted the Coeur d' Alene Lake ecosystem and the indigenous community that exists within that ecosystem. The expansion of Post Falls Dam between 1903 and 1906 changed the natural cycle of seasonal and hydrologic flux in the Coeur d' Alene Basin. These issues have been exacerbated by heavy metal pollution from historic mining practices in the Coeur d' Alene River Basin. This change has resulted in significant increases to water temperature and biogeochemical nutrient cycling, which in turn has created conditions for metal chelation, eutrophication, and anoxia. Anthropogenic modifications to Coeur d' Alene Lake have created unnatural water flows that promote the movement of heavy metals which impacts present cultural foods, public health, and ecosystem function in the region. Sqigwts, (Sagittaria latifolia), commonly known as water potato, is a staple subsistence food of the schitsu'umsh people, the indigenous community that is centered in the Coeur d'Alene Lake ecosystem. Sqigwts requires seasonal water inundation for optimal growth; however, unnatural lake fluctuations impact its habitat along with rising rates of lake recreation which promote erosion. Artificial lake fluctuations make traditional harvest methods difficult, and elevated metal concentrations from legacy mining has resulted in contamination that limits human consumption. Changes in management at Post Falls Dam such as replacing the energy produced with wind power and lowering the lake level to restore wetlands in the southern end of the lake alongside vegetative restoration to remediate heavy metal contamination would have the potential to restore abundance of traditional foods and accessibility to historical harvesting sites while reducing the amount of sediment lost due to erosion and metals present. A previously built system dynamics model now includes acres of inundation based on a bathymetric map for both the dammed and natural run of the river flows. Exploration of policies that impact lakebed inundation will serve to support restoration of sqigwts habitat. Next steps should explore the impact of potential policies on other traditional foods such as camas, tule, both resident and adfluvial populations of westslope cutthroat trout and bull trout. Restoring habitat impacted by unsustainable resource use is key to supporting sustainable and equitable resource use within the food energy water nexus.

Municipal Water Supply and Demand Management Through Wastewater Reuse and Increasing Block Pricing in the City of Pasco

Presented by: Jiyoung Park

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Juile Padowski
Home Institution, Major, Class Standing: Wheaton College, Environmental Science, Senior

The global human population is growing exponentially, but clean water resources are limited. As climate change brings more frequent and severe droughts to the western United States, the practice of water conservation becomes more important. This study focuses on water supply and demand management in the City of Pasco, located in the state of Washington. Pasco has been rapidly growing, and the statistics indicate that the city might face water shortages in the near future. As a solution to this problem, the City has been focused on acquiring additional surface water rights through the Quad City Water Rights (QCWR) Agreement. However, these QCWR rights do not fully cover the volume of water needed for City of Pasco, meaning the City needs to find alternatives to its water shortage problem. This project uses systems thinking and systems dynamic modeling to explore how different types of innovations might alleviate the pressure on Pasco to find new water rights. Two innovations explored here are wastewater reuse and increasing block pricing. The model results demonstrate that applying innovations reduces the amount of water pulled from McNary Pool, the main source of surface water supply for the city of Pasco. However, the cost of infrastructure for wastewater reuse is expensive and time-consuming. Increasing block pricing, on the other hand, could be practiced comparatively easily and has been shown to be effective at conserving water. While there are other innovations that could be practiced, this study highlights two potential innovations for water conservation for Pasco and provides a modeling framework that could be modified for other cities that are experiencing water shortage similar to the city of Pasco.

Refining the Definition of Urban Agriculture to Streamline Public Policy Development and Implementation

Presented by: Liam Reynolds

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Michael Brady
Home Institution, Major, Class Standing: The University of Illinois at Urbana-Champaign, Agricultural and Biological Engineering, Junior

Urban Agriculture (UA) has the potential to play a significant role in increasing the sustainability of cities worldwide. However, at the local level, there are difficulties implementing Urban Agriculture policy, due to the numerous diffuse definitions of Urban Agriculture. This was seen through a case study of the Five Boroughs Farm in New York City. It was found that to be successful, policy making needs to specifically address the diversity and multifunctionality of Urban Agriculture. I propose using the concept of isoquants to refine existing definitions of Urban Agriculture to help public officials develop successful Urban Agriculture policies. This is done based on the difference in inputs, factors of production, and outputs, direct and indirect impacts. Urban Horticulture (UH) requires little land and capital, but a large amount of labor, with the outputs emphasizing community development and invigoration over profits. On the other hand Urban Food Manufacturing (UFM), requires little land and labor, but a very large amount of capital, with the outputs emphasizing economic development and profits over community development. To promote Urban Horticulture, policymakers should utilize agricultural easements to enable food production activities to ignore the high land values of urban environments. To promote Urban Food Manufacturing, policymakers should provide large start-up stipends to cover the high capital requirement and open the door for the creation of industrial clusters. These policy levers are tested in a Stella Architect simulation to visualize their dynamic impacts. The simulation adjusts the allocation of factors of production and measures the amount of UA jobs created and land used for UA operations. This simulation can be used as a tool to help policymakers develop laws that create the desired environmental and economic impacts. This will contribute to making cities more productive and sustainable places.

Analyzing the Impact of Social Capital on the Adoption of Efficient Irrigation in Washington State Orchards

Presented by: Hailey Smith

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Michael Goldsby and Daniel Mueller
Home Institution, Major, Class Standing: Washington State University, Environmental and Ecosystem Sciences, Senior

Occurrences of water scarcity and drought, intensified by climate change, are becoming more frequent around the globe. Because irrigation accounts for nearly 70% of global water use (Food and Agriculture Organization of the United Nations, 2016), the adoption of higher efficiency irrigation technologies is an important step toward meeting the goals of food and water security in a changing climate. Many theories suggest that the adoption of new technologies is the direct result of economic decisions. However, other factors such as social capital have been shown to influence the adoption decision and could help us explain why some orchard-growing regions in Washington State adopt more efficient technologies quicker than others. We performed a preliminary analysis of data from irrigation methods surveys in Washington orchards and data developed to estimate social capital. Our analysis suggests that on average, orchards in counties with above average social capital adopt more efficient irrigation technologies faster than orchards in counties with below average social capital. This study uses a Stella Architect systems dynamics model to help describe these trends between rates of adoption and social capital, and to project potential consequences of those trends on food-energy-water security. Using the systems dynamics model, we aim to develop projections based on possible interventions to targeted parameters that will improve water conservation in the Columbia River Basin.

Food and Agriculture Organization of the United Nations. (2016). *Water withdrawal by sector*

(Aquastat). https://www.globalagriculture.org/fileadmin/files/weltagrarbericht/

Weltagrarbericht/13Wasser/2016WorldData-Withdrawal_eng.pdf

Quantification of The Colville and Spokane Tribe Water Right Adjudication and Potential Impacts to Current Junior Water Right Holders.

Presented by: Dehlia Wolftail

Program: Stakeholder Informed Modeling of Innovations in the FEW
Co-authors: Jennifer Adam
Home Institution, Major, Class Standing: Heritage University, Environmental Studies, Senior

This project aims to explore potential outcomes from the pending water rights adjudication for two Washington State Tribes first the Twelve Bands that compose the Confederated Tribes of the Colville Reservation and second the Spokane Tribe of Indians using a dynamic modeling software Stella Architect. The tribes have developed instream and out of stream water use plans that include: Increasing and maintaining Salmon population, agriculture, livestock, domestic, industrial, and municipal future use. The tribes out of stream water uses were quantified at one million cubic acre feet between April and October when the majority of water used for irrigation will come from the Lake Roosevelt Basin (LRB) that sits above the Grand Coulee Dam. The Upper Columbia River Basin's minimum Instream flow rule established in1980 to maintain the health and quality of rivers will change based on the tribe's decision. Four different scenarios were established to explore different minimum instream flow rules as: before 1943, 1944-1950, 1951-1979, after 1980. In this project, we use historical data from United States Bureau of Reclamation for instream flow into LRB and reservoir storage for the four different scenarios. With the minimum instream flow rules adjusting for the four different scenarios, predicted results are non-tribal water right users water user may have their water supply cut off during dry years between Banks Lake to Bonneville Dam, so minimum instream flows can still be met according to the tribes' water use plan.

Predicting Your Emotions? Long-short Term Memory (Rnns) Vs. Decision Tree's Algorithm

Presented by: Ahmed Abdelgalil

Program: Multidisciplinary Undergraduate Research Training in Wearable Computing
Co-authors: Marcus Blaisdell
Home Institution, Major, Class Standing: Villanova University, Computer Engineering, Sophomore

Studies have shown and proven that both neural networks and tree algorithms are great methods of predicting target variables and/or outcomes. Trees are composed of simple Boolean-like algorithms that tend to work similar to if/else statements. On the other hand, neural networks are composed of multiple layers with large amounts of neurons making them a complex structure. Although there isn't a direct correlation on which machine learning method is better for emotion predictions, previous research has shown neural networks tend to outperform tree's algorithms when it comes to inputs of numerical data. In return, for this research experiment, it is anticipated that the Long-Short Term Memory (RNNs) will outperform the Decision Tree's Algorithm. This is because the data that will be used to predict the emotions and train both of these methods is numerical data representing the following factors: blood volume pulse, body temperature, and electrothermal activity.

Comparing The Predictability of Sensor Modalities to Detect Stress from Wearable Sensor Data

Presented by: Ryan Holder

Program: Multidisciplinary Undergraduate Research Training in Wearable Computing
Co-authors: Monica Chen, Ramesh Sah and Hassan Ghasemzadeh
Home Institution, Major, Class Standing: Pullman High School, , High school

Pervasive computing and machine learning can offer valuable assistance in detecting and intervening stress as it occurs. We hypothesize that stress can be detected from wearable sensor data using machine learning methods, and that detection can be improved by prioritizing modalities that are most indicative of stress. Here, we investigate how different wearable sensor modalities perform on the stress detection problem. We compared accelerometer, electrodermal activity, blood volume pulse, and temperature data. Three learning algorithms were used to compare these modalities: nearest neighbors, decision tree, and a convolutional neural network. Our data came from the WESAD dataset (based on n=15 subjects), from which we created stressed and non-stressed labels by combining meditation and baseline labels for non-stress, and removing all other labels but the stressed label. We ran experiments with both a random sample of the data as a testing group, and with leave-one-out validation with one subject's data as the testing group. Additionally, we split the data into raw data and statistical descriptors of the data. With the random sample test group, we found acceleration to be most predictive using nearest neighbors and decision tree, and electrodermal activity to be most predictive using the convolutional network based on accuracy and f score as evaluation metrics. In the leave-one-out validation, we found electrodermal activity to perform highest for all classifiers evaluated on the same metrics. Since leave-one-out validation is less likely be affected by overfitting, we conclude that the results of the leave-one-out validation are more reliable. This leads us to conclude that electrodermal activity is the most indicative wearable sensor modality of stress. In future testing on our own ADARP data, we hope to support these same findings when we analyze data gathered outside of a lab.

Development of User-Friendly Object Detection Method for Video Labelling In Matlab to Be Used with Eye Tracking Video Data

Presented by: Grace Stewart

Program: Multidisciplinary Undergraduate Research Training in Wearable Computing
Co-authors: Robert D. Catena, Abdullah Mamun and Uma Vangapaty
Home Institution, Major, Class Standing: University of Maryland - College Park, Computer Science, Junior

The current manual process for labelling objects of interest in video recorded by the Tobii Pro Glasses 2 is incredibly inefficient, so as a result we compared three object detection algorithms to determine which provides the ideal balance between accuracy and speed when used to automate the labelling process in MatLab. Between the three algorithms in question - YOLO V2, YOLO V3, and SSD - we hypothesized that the YOLO V2 algorithm would provide the most ideal results. The significance of automating this process in MatLab is the creation of a user-friendly automated labelling method for biomechanics and clinicians, and the eventual creation of a real-time detection and alert system to bring attention to objects in a walker's path. With similar methods already in existence, the novelty in this code is threefold. The first two novel aspects of this code include its adaptability to different data, as well as the simplicity of use and familiarity of MatLab. The third aspect is our goal of not using a GPU, which will allow for broader use by labs and clinicians who may not have GPU access. In order to create this automated method, we tailored publicly available code1 to simplify and condense the code in order to increase user friendliness. Hyperparameters were also changed in order to allow for reasonable detector training times without the use of a GPU. At the moment, the average precision is <0.24, and average miss rate is between 0.85 and 0.90. These suboptimal results suggest either the need for GPU access, or the need to reject our hypothesis in favor of either YOLO V3 or SSD. Overall, we concluded that further investigation into the comparison between the three object detection algorithms is needed, as well as further comparison of results both with and without GPU access.

Analyzing the Effects of Interfacial Mixing on Bilayer Organic Photovoltaic Cells

Presented by: Helena Belzer

Program: Waves in the Universe and Technology
Co-authors: Fred Woodall and Brian Collins
Home Institution, Major, Class Standing: Wellesley College, Physics and French, Junior

Bilayer organic photovoltaics are an attractive technology due to their use of carbon-based polymers, and the potential for applications in wearable and biomedical technologies. However, OPVs need to reach much higher efficiencies to be commercially viable. In this study, I analyzed the effects of interfacial mixing between the electron donor and acceptor molecules within the active layer of a bilayer cell on total output efficiency. Using zinc phthalocyanine as the electron donor layer and Carbon-60 as the acceptor, all molecular layers were deposited onto an indium tin-oxide substrate using a physical vapor deposition chamber. This study began with a standard bi-layer device, where ZnPc and C60 were deposited in sequence, achieving a power conversion efficiency or PCE of 3.1%. In transitioning to a mixed interface, where the donor and acceptor layer were deposited at the same time, PCE dropped dramatically. In order to optimize molecular orientation and improve PCE, we changed the deposition ratio, added a single layer of ZnPc before the mixed layer to take advantage of strong intermolecular pi-pi interactions, and increased the thickness of the C60 layer to distance the active layer from the electrode. the future, we plan to study the effects of temperature dependent deposition, and possibly introduce the polymer PEDOT: PSS to aid in hole transport. These results show that interfacial mixing may be able to achieve similar PCE to traditional bi-layer cells, and that bi-layer cells still need pure molecular layers between the substrate and electrode layers in order to combat resistance.

Creating a More Realistic Profile for Differentially Rotating Neutron Stars

Presented by: Noora Ghadiri

Program: Waves in the Universe and Technology
Co-authors: Matthew Duez
Home Institution, Major, Class Standing: California State University, Fullerton, Physics, Senior

Hypermassive neutron stars are produced upon binary neutron star mergers. These are rotating neutron star equilibria whose masses are allowed to exceed the rest mass of non-rotating neutron stars because of their differential rotation. The goal is to construct hydrostatic equilibria that resembles these configurations.

The code written by Cook, Shapiro and Teukolsky (1992, 1994) calculates profiles of differentially rotating equilibria. However, it requires rotation laws for which angular velocity is monotonic in radius which is not realistic for binary neutron star mergers. In this project, the code is modified to allow more realistic and general post-merger profiles; it allows the location of the maximum angular velocity to be offset from the axis. Calculations for this modified code are done in full general relativity and they allow an arbitrary barometric equation of state. This code can be used to make sequences of neutron stars, or to create initial data for an evolution of a neutron star.

Searching for Active Galactic Nuclei in Dwarf Galaxies NSA 91579 and NSA 112250

Presented by: Emily Kehoe

Program: Waves in the Universe and Technology
Co-authors: Vivienne Baldassare and Erik Wasleske
Home Institution, Major, Class Standing: Clarkson University, Physics, Senior

We present follow-up spectroscopic measurements of two dwarf galaxies, NSA 91579 and NSA 112250, that show signs of active galactic nuclei (AGN). It is important to study such phenomena since little is known about black holes (BH) in dwarf galaxies. Since these galaxies undergo relatively fewer mergers, their original BH masses are similar to their current masses. Therefore, studying these BHs can help us understand how they formed and grew in the early universe. To find low-mass BH in our study, we search for AGN using spectroscopy taken between 2004-2005 from the Sloan Digital Sky Survey (SDSS) and follow up our observations with data from the Double Spectrograph (DBSP), which was taken in 2019. We look for signs of broad Hα by fitting Gaussian curves to various spectroscopic lines in each galaxy's spectrum. Signatures of broad Hα may be observed from other stellar processes, such as Type II supernovae (SN). Broad Hα from an SN will disappear over time, but will remain persistent from an AGN. Therefore, we must follow up observations on AGN candidates to distinguish if the broad Hα is from an accreting black hole, or a stellar process such as an SN. In our research, we find that both candidates have persistent broad Hα over a 20 year span, which suggests that they are classified as AGN. We then measure the masses of the BHs from NSA 91579 and NSA 112250 using virial techniques, and find their masses to be ~ 2.34×10^5 $M_\odot$ and ~ 1.26×10^5 $M_\odot$ respectfully. Knowing the masses of these BHs can help us understand how BHs form in galaxies.

Investigating Efficiency Optimizing Parameters for Blade-Coated PBDB-T:PC71BM Systems

Presented by: Jonathan Loera

Program: Waves in the Universe and Technology
Co-authors: Awwad Alotaibi and Brian Collins
Home Institution, Major, Class Standing: University of California Merced, Physics and Chemistry, Senior

The rapid development of organic photovoltaic (OPV) devices shows promise for their commercial use in the near future. OPV's are preferred to silicon devices due to their cost effectiveness, ease of production, and polymer composition which grants the possibility of making flexible devices. Currently, OPV devices are spin-coated with solution to apply a photoactive layer onto a substrate. Spin-coating, however, cannot be scaled up for commercial use as it is an inefficient use of material. Blade-coating is a much more efficient method of casting solution and is scalable for commercial use. In our work, we studied the polymer:fullerene system, PBDB-T:$PC_{71}BM$. Literature reports a power conversion efficiency (PCE) as high as 5.93(7)% for spin-coated PBDB-T:$PC_{71}BM$ systems. We varied the blade coating speed to determine the optimal thickness of the photoactive layer and characterized the thickness by UV/Vis absorbance measurements. Using a blade coater, we were able to produce a PBDB-T:$PC_{71}BM$ device with a PCE of 7.15%. Our work demonstrates that blade coating is a casting method capable of producing high performance systems while reducing material waste. We have shown that the blade-coated is a valid casting method to scaling the production of OPV devices for commercial use.

Infrared Spectroscopy of 4:1 Methanol-Ethanol for Diamond Anvil Cell Pressure Calibration

Presented by: Fiona McLary

Program: Waves in the Universe and Technology
Co-authors: Lauren Barmore and Matthew McCluskey
Home Institution, Major, Class Standing: Agnes Scott College, Physics, Junior

High-pressure studies of materials using diamond anvil cells (DACs) require the presence of a calibration substance to determine the pressure inside the DAC. Ruby fluorescence is the most common calibration method. However, the use of ruby is difficult when conducting spectroscopic studies of materials that display similar fluorescence lines. 4:1 methanol-ethanol (ME) is already a widely used pressure transmitting medium in DAC experiments and is hydrostatic up to ~10 GPa, but it has not been previously studied as a potential calibration material. To develop a model for the pressure dependence of ME's spectral peaks, a Fourier transform infrared spectrometer (FTIR) was used to obtain the infrared absorption spectrum of ME under pressure in a piston-cylinder DAC. Ruby microspheres were used to calculate the DAC pressure based on the R_1 and R_2 fluorescence lines in the visible spectrum. A primary peak was consistently present in the ME spectrum in the range of approximately 4400 to 4525 cm^{-1}. A secondary peak was also observable at lower wavenumbers in about half the scans. Plotting the pressure P against the wavenumber f of the primary peak, a linear relationship emerged. The best fit equation for the primary peak was $f = 13.38P + 4405.1$, where f is in cm^{-1} and P is in GPa, with $R^2 = 0.9836$. For the secondary peak, the equation was $f = 13.918P + 4004$ with $R^2 = 0.976$. The excellent fits indicate that ME calibration is reliable up to 9 GPa. The quantification of this relationship should enable spectroscopic DAC studies that have previously been challenging or impossible due to certain materials' incompatibility with ruby.

An Intuitive Picture of Radioactive Decay: Fermi's Golden Rule, Landau-Zener Transitions, and Entanglement

Presented by: James Serna

Program: Waves in the Universe and Technology
Co-authors: Jared Brennan, Fred Gittes and Michal McNeil Forbes
Home Institution, Major, Class Standing: Wright State University, Physics and Mathematics, Senior

Quantum tunneling occurs where a particle is able to penetrate a barrier that has a higher potential than the particle's kinetic energy. Classically, this behavior is not allowed. Radioactive decay occurs when an unstable atomic nucleus loses energy by radiation and creates decay products and this process sometimes leads to the emission of particles. The interest is the role tunneling has in radioactive decay and this is evaluated with different intuitions. Fermi's Golden Rule leads to an exponentially decaying tunneling rate, while a two-state model is more intuitive with simple oscillatory behavior shown for the tunneling rate. In this paper, we resolve the apparent conflict between oscillation and exponential decay by simulating a double-well system and creating the appropriate parameters to interpret this exponential decay behavior in terms of interference between the eigenstates of the wavefunction for a given particle. We also explore the effects of internal degrees of freedom on the symmetry of tunneling and the formation of entangled states.

Measuring the Velocity of Aluminum Foil Accelerated by Laser Ablation Using VISAR

Presented by: Annie Wang

Program: Waves in the Universe and Technology
Co-authors: James Hawreliak
Home Institution, Major, Class Standing: University of Rochester, Physics and Applied Mathematics, Senior

Some of the most extreme thermodynamic conditions in the laboratory are created using shock waves, generated by lasers or large gas guns. This project explores the acceleration of 25 micron-thick Aluminum foils to high velocities using laser ablation. There is a direct correlation between laser beam intensity and foil acceleration. In this project, we set out to characterize this process. Our samples consist of Al foil glued to a 25 micron-thick Kapton foil mounted on a glass plate. In a single event experiment, lasting only a fraction of a microsecond, the laser rapidly heats the interface between the window and the thin foil. A hot, high-pressure plasma is generated which launches the foil sample. The results demonstrated that a 25 micron-thick Al foil can be accelerated up to a velocity of ~ 2.60 km/sec. The velocity of the foil was measured with the Velocity Interferometer System from Any Reflector (VISAR). We found that the more laser energy applied, the higher the foil velocity. The velocity increases logarithmically before it maximizes at 2.60 km/sec at around 2.80 J and remains relatively constant for energies up to 4.78 J. These results demonstrate that higher intensity lasers produce higher acceleration, but the velocity does not continuously increase with laser energy, which offers further insight into how materials respond under high-pressure plasma.

Reflective Ash: Determining Hyperspectral Signatures of Wildfire Ash Under Different Moisture Contents

Presented by: Eleanor Curtright

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Bob Brown, Sarah Lewis and Pete Robichaud

Home Institution, Major, Class Standing: Washington State University, Civil Engineering, Sophomore

With the wildland fire season intensifying in recent years due to climate change, it is important to understand how remotely sensed images of wildfire ash cover changes with moisture. Currently, it is possible to map post-wildfire ash cover with the use of satellite imaging; however, it would be useful to know the moisture content of the ash to better understand its increased risk for erosion. The purpose of this experiment is to determine, in the laboratory, if the hyperspectral signatures of wildfire ash change under different moisture regimes and if these changes are replicable with different varieties of ash. We took reflectance measurements of ash samples from three separate wildfires using a spectroradiometer. The baseline reading is from oven-dried ash, and subsequent readings are collected after adding moisture to the samples in a range from zero to 300%. The samples are then oven-dried for fifteen-minute increments, re-measuring the reflectance after each interval, until the samples have returned to their original dry state. Our preliminary results show that there is a difference in the hyperspectral signatures of wet and dry wildfire ash samples, and that incremental differences in moisture content are apparent. We found dry ash to be significantly more reflective than wet ash and this was consistent amongst all three ash types. We also observed notable reflectance features at certain wavelengths that could be potentially meaningful when determining the moisture content of wildfire ash cover in the field. Our findings indicate that there is a relationship between moisture and reflectance, and we conclude that this information can likely be scaled up to a field experiment. It is expected that we will be able to use remote sensing to predict the moisture content of ash imaged after a wildfire.

Deploying Mobile and Remote Air Quality Sensing Technologies for Urban and Rural Sustainability

Presented by: Clara Ehinger

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Kristian Gubsch, Yoni Rodriguez and Von Walden

Home Institution, Major, Class Standing: Washington State University, Chemical Eningeering, Sophomore

As air pollution continues to be a problem as seen around the world, many communities will face increased exposure to hazardous air quality. While the air quality in many locations will not be improved soon, there may be ways in which to avoid the most hazardous areas by tracking and modeling the air pollution. Many current air quality models document air quality on a macro scale which can be useful. However, it can be helpful to know the air quality of specific locations in greater detail. The goal of this project is to fill this gap in technology by developing and deploying mobile air quality sensors in a greater density than used for other models. In this project, a raspberry pi, a small computer, was configured with sensors for temperature, pressure, humidity, and particulate matter. This sensor would allow an inexpensive network of sensors to be assembled and deployed nearly anywhere. Having only one working sensor after recently finishing the design phase of this project limits the range of questions to test. Therefore, the particulate matter measurements from the AirNow sensor in Pullman will be used to compare the indoor particulate matter readings of the raspberry pi sensor to analyze the patterns between outdoor and indoor particulate matter in bad air quality events such as smoke. After the raspberry pi sensor has been calibrated to the AirNow sensor, it will collect data in different buildings around Pullman. The data collected indoors will be compared to the outdoor air quality collected by the AirNow sensor. The analysis may give insight into the effectiveness of different air purification methods that could lead to future research into which methods are the most effective and sustainable as bad air quality from wildland fires becomes increasingly common.

Urban Tree Cover Distributions for Biogenic Emission Modeling

Presented by: Dylan Fernholz-Hartman

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest
Co-authors: Alex Gunther
Home Institution, Major, Class Standing: University of Redlands, Environmental Science, Senior

LA county has long struggled with air quality due to its unique geography and very high levels of development. Organized efforts to improve air quality have reduced anthropogenic sources of pollutants, but biogenic sources of VOC's play a significant role in ozone formation and formation of secondary organic aerosols (SOA's)[1]. This key factor has been largely overlooked in the past and the objective of this study is to quantify the contribution of Biogenic VOC emissions in the region.

Using satellite imagery, surface cover data was collected on iTree, a software tool for sampling random points within defined boundaries. Data was first collected for individual cities, then for the entire county. Data from cities was used to examine what factors control tree cover variability at a local level. Data from the entire county was compared with existing estimates of pinene and isoprene emissions.

The tree cover fraction for the entire county was 15%, with individual cities ranging from 4.5-22.5%. The variable with the strongest correlation to tree cover was median house value with an R^2 of 0.785, closely followed by percent of non-white population vs tree cover with an R^2 of 0.747. With respect to emissions the sum of isoprene was found to be 32,508 tons/year, and the total pinene was calculated to be 7,441 tons/year.

The variability in city average tree cover tended to fall along economic and racial lines, which may be due to time and resources requirements for tree growth. While the average tree cover was 15%, accurately estimating the BVOC emissions presents some challenges. The second highest land cover was shrubs, additional green, photosynthesizing plants which are also a source of VOC's. Grass and shrubs accounted for 26.3% of the county's total land cover and were not factored into BVOC emissions.

These measurements provide a valuable first step in assessing BVOC emissions and contain useful information about the distribution of trees among communities. As urban greening continues, this information can help make informed decisions about not only what species to plant but what communities could benefit most from the variety of ecosystem services trees provide.

[1]Gu, S.; Guenther, A.; Faiola, S., Effects of anthropogenic and biogenic volatile organic compounds on Los Angeles air quality. UC Irvine: 2020**,** 18-21.

Using the Particle-Into-Liquid Sampler (PILS) to Better Understand Water Soluble Organic Carbon (WSOC) in the Atmosphere

Presented by: Isabelle Jernigan

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Celia Faiola

Home Institution, Major, Class Standing: The Pennsylvania State University, Meteorology, Junior

Particulate matter is a component of the atmosphere that can have large, negative impacts on both the climate and human health. Water soluble organic carbon (WSOC) makes up a significant fraction of particulate matter but is frequently uncharacterized in many online aerosol measurement techniques. Due to its potential impacts on human health when absorbed in lung fluids, it is important to include WSOC in particulate matter measurements and analysis. One method to do this is to use a particle into liquid sampler (PILS), in which small ambient air particles are passed through an environment supersaturated chamber with water vapor where they rapidly grow to the size of microdroplets. From there, they are impacted on a surface, easily collected using a lithium fluoride wash, and analyzed using techniques such as electrospray ionization high resolution mass spectrometry (ESI-HRMS). This study focuses on setting up, running, and collecting samples using the PILS. A detailed description of the PILS will be provided with a literature summary of how this instrument has been used to characterize WSOC. Preliminary data from samples collected by the PILS in Pullman, Washington will also be shown to depict how the PILS is used to better understand aerosols.

Quantifying the Influence of a Heat Wave Event on the Surface Energy Balance over Sagebrush in Washington Using Eddy Covariance Flux Data

Presented by: Samuel Jurado

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Zhongming Gao, Heping Liu and Patrick O'Keeffe

Home Institution, Major, Class Standing: Cornell University, Earth and Atmospheric Science, Sophomore

The sagebrush ecosystem covers approximately 120 million acres across 14 western states and three Canadian provinces and is one of the largest interconnected habitat types in North America. However, this ecosystem has experienced degradation largely due to climate change induced stress. It remains unclear as to how the sagebrush ecosystem will respond to climate change with more frequent and severe heat waves and droughts. In this study, we utilize an eddy covariance (EC) flux system to directly measure the impacts of the 2021 Pacific Northwest heat dome on land-surface fluxes over a sagebrush ecosystem in Hanford, Washington. Comparisons between the field's recordings and the data collected by the tower one year prior and the 30-year averages for the region will allow us to quantify how the heat dome influences partitioning of available energy into sensible and latent heat fluxes and thus Bowen ratios. We aim to demonstrate that heat dome induced changes on an environment's biogeochemical structures can have significant impacts on its the surface energy balance and their feedbacks to atmospheric forcings. It is hypothesized that the heat wave event induces a positive feedback by providing higher sensible heat flux and lower latent heat flux, which promotes more heating and drying of the overlying atmosphere. As a consequence, it is likely that heat dome induced atmospheric-forcings would increase the aridity of sagebrush environments in the future.

Volatile Organic Compounds Emitted from Asotin Complex and Snake River Complex Fire

Presented by: Dalynn Kenerson

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Gabby Dickinson

Home Institution, Major, Class Standing: Lewis Clark State College, Chemistry, Junior

Wildfires emit large amounts of pollutants into the atmosphere. As global warming is increasing, the pollutants that wildfires emit are becoming a bigger threat to communities impacted by forest fires. Analyzing wildfire smoke is important to study in order to understand the impact wildfires have on the environment. Wildfire smoke studies are often limited to the study of particulate matter, carbon monoxide, and carbon dioxide. This research is focused on volatile organic compounds (VOCs). This study examined smoke from the Asotin Complex and Snake River Complex fires and their impact on air quality in the Lewiston and Clarkston Valley (LCV). In addition, samples from the Hells Canyon National Recreation area were examined and the impacts of wildfires on remote and protected areas were compared with the LC Valley observations. The air samples were collected using dual bed air sorbent tubes and analyzed via thermal desorption-gas chromatography-mass spectrometry. Benzene, terpenes, and other VOCs were analyzed in forest fires which may have a significant impact on populations with respiratory and cardiovascular disorders. The risk factors due to VOCs will be discussed in further detail.

The Role of Oxygen in Aerobic Decomposition at Washington State University's Compost Facility, Carbon Trading Opportunities, and Improvements to EPA's Waste Reduction Model

Presented by: Jacob Lindblom

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Tom Jobson

Home Institution, Major, Class Standing: South Dakota School of Mines and Technology, Atmospheric and Environmental Sciences, Junior

A new Washington State law to reduce food waste includes diverting material from landfills to compost sites, where both aerobic and anaerobic decomposition can occur. In aerobic decomposition, microorganisms must have sufficient oxygen to convert organic waste into water, heat, and carbon dioxide; in anaerobic decomposition, microorganisms convert organic waste into simple molecules while releasing methane, a potent greenhouse gas (GHG). Diverting food waste from landfills to composting facilities has the potential to reduce urban emissions of methane, reducing the carbon footprint of city infrastructure. The purpose of this study is to determine methane emission rates from composting and how this may be impacted by oxygen levels in the compost pile. We will use methane emissions data collected from the Washington State University Compost Facility (WSU Compost) from July 2020 to determine methane emission rates from negative aeration composting. Pile oxygen measurements will be conducted in July 2021. The emission rate of methane per ton of waste will be compared to methane released from landfilling the same ton of waste to better quantify GHG reduction benefits. After calculating the carbon offset, we hope to learn how WSU Compost can sell their credits, if possible. Furthermore, we plan to suggest improvements for the Environmental Protection Agency's (EPA's) Waste Reduction Model. We suggest the EPA adds an "animal waste" material type, as animal waste, bedding, byproducts can account for a significant fraction of compost or landfill compositions. We also suggest that emission factors for organic material types are better quantified and their process for doing so is well-documented. These improvements will help governments from the state to local level better plan their waste removal strategies.

Evaluating Microbial Sources of Greenhouse Gas Emissions in Compost

Presented by: Kaitlyn Lindholm

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Sandra Paola Un Jan Contreras and Courtney M. Gardner

Home Institution, Major, Class Standing: University of Idaho, Biological Engineering, Senior

Composting is a promising solution to many environmental issues such as reducing global waste and replenishing degraded soil. Vermicompost is a worm-based compost that is an emerging field due to its many benefits such as increased nutrient levels, water retention, and microbial activity. However, worms and microbes used to produce vermicompost are known to produce greenhouse gases such as nitrous oxide, there are concerns about the greenhouse gas emissions produced during composting and the sustainability of this emerging waste treatment process. To date, there is little research on the microbes in compost and how they contribute to this process. This study investigated the abundance and metabolism of key microbes and their role in reducing/producing greenhouse gases in compost. Samples were obtained from a vermicomposting system at a dairy farm in Royal City, Washington at multiple stages of the treatment process including liquid influent and effluent, solid worm castings, and worm beds. This study utilized DNeasy DNA isolation kits, polymerase chain reaction (PCR), and gel electrophoresis to analyze compost samples for six different greenhouse gas related genes including *mcrA, pmoA, nirK, nirS, norB, and nosZ.* Quantitative polymerase chain reaction will be used to find the abundance of these genes. The liquid influent sample was found to contain the *pmoA* gene. Our results indicate the possibility of aerobic methanotrophs being present at this compost site which could contribute to methane reduction and a more environmentally friendly compost site.

Analyses of Water-Soluble Volatile Organic Compounds from Compost Emissions at Washington State University

Presented by: Katherine McCown

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Kylie Wilson, Tom Jobston and Nancy A. Johnston

Home Institution, Major, Class Standing: Lewis Clark State College, Biology and Chemistry, Senior

The aerobic digestion systems used by compost facilities are the main complicating factor for VOC analysis of compost emissions. These digestion systems involve ducts that pull air through the compost pile. The ducts are susceptible to high humidity, temperature, and concentration of VOCs making them incompatible with common methods, involving stainless steel equipment, due to the corrosive nature of the VOCs emitted from composting. To better understand the effects of local composting facilities on air quality, a method was adapted to analyze VOCs collected in the air duct. A small impinger was connected to a dual air sorbent tube and a pump to pull the concentrated air from the duct. The water-soluble VOCs are allowed to condense into the impinger while the nonpolar gases are collected by the dual air sorbent tube. The water sample was analyzed using Thermal-Desorption Gas Chromatography Mass Spectrometry (TD-GC-MS) and Headspace GC Instrument. To evaluate the effectiveness of the method, pilot trials were run in the laboratory using compost collected from Washington State University (WSU) Composting Facility. Several compounds were examined with VOC standards of known concentration, including ketones, aldehydes, alcohols, sulfides and acids. The results of the pilot trials will show what fraction of water-soluble compounds are being condensed into the impinger compared to insoluble compounds collected by the dual sorbent tube. Further experimentation will be needed to prove the effectiveness of this method to be used at local composting sites to analyze the VOCs emitted in hot and humid environments.

Three-Year Analysis of Eddy Covariance Data to Understand Benefits and Weaknesses of Differing Crop Rotations in the Palouse

Presented by: Joseph Rotondo

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Erin Brooks, Zhongming Gao, Kendall Kahl, Eric Russel and Shelley Pressley

Home Institution, Major, Class Standing: University of Oklahoma, Meteorology and Mathematics, Junior

Producers in the dryland cereal production systems of the Palouse are looking to alternative crop rotations to increase crop biomass production, and improve soil health. Biomass production is closely linked to seasonal precipitation in this non-irrigated, semi-arid environment. The purpose of this project is to study the impacts of crop rotations on net carbon storage, which helps educate growers how they may earn carbon credits and payments based on their cropping system. In the project we examine the effects of precipitation on seasonal carbon exchange in three crop rotations. The three rotation styles are "aspirational" (spring wheat, cover crop, winter wheat), "incremental" (spring wheat, winter pea, winter wheat), and "business as usual" (spring wheat, fallow, winter wheat). Eddy covariance data is taken from three flux towers in Saint John, Washington and three flux towers in Genesee, Idaho to compare these carbon budgets. Carbon and water fluxes from the 2018, 2019, and 2020 growing seasons are compared with precipitation and additional meteorological data to analyze benefits and drawbacks of each crop rotation style.

The 2020 growing season at Saint John accumulated more carbon (referred to as gross primary production or GPP) than 2018 or 2019. There was less cumulative GPP in the "aspirational" crop rotation style (910 g C m^{-2}) in comparison to that of the "incremental" and "business as usual" rotations (1078 g C m^{-2} and 1056 g C m^{-2}, respectively). The cumulative ecosystem respiration (REco) was similar in the "aspirational" and "business as usual" crop rotations, with only a 4% difference. In conclusion, the "aspirational" and "incremental" crop rotations may provide a more sustainable and higher yielding alternative to the "business as usual" crop rotation. Additionally, cover crops can be utilized as a forage crop for haying and winter legumes provide a cash-crop, both options more lucrative than fallow.

The Effects of Relative Humidity and Ammonia on the Measurement and Detection of Volatile Organic Compounds from Compost

Presented by: Zachary Watson

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Tom Jobson

Home Institution, Major, Class Standing: Florida Institute of Technology, Meteorology, Junior

Composting is becoming much more prevalent in the Pacific Northwest. While composting looks promising and appears cleaner than landfilling, there has not been much research on the volatile organic compounds (VOCs) emitted from compost sites. For the beginning of the project, samples collected from the Washington State University compost facility in 2020 were analyzed, and the compounds were identified using the gas chromatography-mass spectrometer (GC-MS). Each peak was integrated and a relative percentage for each compound was calculated. The three most abundant compounds were acetone, alpha-pinene, and 2-butanone. The next part of the project is focused on environmental effects of measuring VOCs from compost. Some VOCs are water soluble, so the impact of relative humidity on the consistency of results obtained from the GC-MS were tested. A known gas mixture with compounds found in compost was used and diluted with varying relative humidity levels. The area and height of each peak were found for each compound, as well as their averages and standard deviations. It appears that the relative standard deviation increases with increasing relative humidity. Additionally, the results within each trial varied significantly, even though the setup remained constant. After this step, we plan on introducing ammonia to the gas mixture. The hypothesis is ammonia causes problems with the air preconcentration system using Tenax adsorbents, so they are not trapped and detected by the GC-MS. Since ammonia is a significant emission from composting, the presence of ammonia may cause an underestimation of VOC emissions. Doing research in detecting VOCs being emitted from compost has important implications for determining if composting is beneficial regarding toxic air pollutants and its impact on climate. VOCs assist in the formation of ozone in the lower levels of the atmosphere, which is a health hazard for humans and a negative impact on the climate.

Gaseous Volatile Organic Compounds Emitted from Washington State University Compost Facility

Presented by: Kylie Wilson

Program: Atmospheric Chemistry and Climate Change: Measurements and Modeling in the Pacific Northwest

Co-authors: Tom Jobson, Nancy A. C. Johnston and Katie McCown

Home Institution, Major, Class Standing: Lewis-Clark State College, Earth Science, Sophomore

Composting is a process used to help break down organic waste in a more natural aerobic way but tends to have a stench that is not inviting. To explore these smells and their potential effects, samples taken will observe Volatile Organic Compounds (VOCs) emitted from Washington State University Compost Facility. A method was developed to collect a variety of compounds in the hot and humid environment of the compost vent. An impinger placed in an ice bath with DI water was connected to the duct, that helps aerate the compost, and was slowly bubbled using an air pump. An air sorbent tube was connected to the pump to collect gaseous VOCs emitted and was subsequently analyzed via a Thermal Desorption- Gas Chromatography- Mass Spectrometer (TD-GC-MS). The water bubbled was analyzed by another student researching water soluble VOCs. Various VOCs were identified including terpenes and alcohols such as pinene and isopropyl alcohol. The research done is valuable to gain insights on VOCs emitted from the compost and potential health hazards.

The Influence of the Drawing Process on Chemical Recycling of Cotton Waste for Regenerated Fibers

Presented by: Joanne Low

Program: Northwest Advanced Renewables Alliance
Co-authors: Dan Liang, Hang Liu and Wangcheng Liu
Home Institution, Major, Class Standing: UC San Diego, Environmental Engineering, Sophomore

Cotton is an important natural material that requires a large amount of energy, water, and other resources to produce. In order to conserve resources in the production of cotton, there is a need for effective and efficient cotton waste recycling methods. Chemically recycling cotton waste is an attractive method because unlike mechanical recycling, chemical recycling is not restricted by the wear and tear conditions of post-consumer garments. Additionally, mechanical methods of recycling fibers decrease fiber length and strength during the fiber extraction process, and therefore degrade the quality of fibers. Chemical methods up-cycle waste by regenerating brand new fibers, so the quality is not lost. In this project, cotton waste is chemically recycled by dissolving and wet spinning for regenerated fibers. Cotton waste is hydrolyzed in a sulfuric acid solution to decrease the degree of polymerization. The hydrolyzed cotton is then dissolved in an alkali and urea solution for the wet spinning process. During wet spinning, the dissolved cotton solution is ejected from the spinneret of the extruder machine into a coagulation bath of sulfuric acid, creating the new fibers. The fibers pass through multiple water baths and rollers that move at various speeds in order to draw the regenerated fibers to different degrees. These regenerated cotton fibers are collected, rinsed, and dried. Fiber morphology, diameter, and mechanical properties are tested. Various properties of resultant fibers are evaluated in order to investigate the influence of the drawing process on fiber properties. We aim to create these regenerated fibers to have similar qualities as various textiles already used in the industry. If the regenerated cotton fibers are able to be woven into fabric comparable to commercial standards, then this method will be an economical and more environmentally sustainable way of recycling cotton.

Development of Medium Density Fiberboard (Mdf) Composites from Combination of Wood Chips and Waste Low-density Polyethylene (Ldpe) Packaging Film

Presented by: Katherine Rasmussen

Program: Northwest Advanced Renewables Alliance
Co-authors: Karl Englund and Hui Li
Home Institution, Major, Class Standing: The Pennsylvania State University, Environmental Systems Engineering, Junior

The global amount of plastic is projected to increase from 236 to 417 million tons per year by 2030. Yet only 14% of all plastic packaging is collected for recycling after use and the majority ends up in the environment (land and ocean). Recycling plastics is key to preventing an increase in the release of such materials into the environment. In this study, we develop a new method to incorporate hard-to-recycle waste plastic film materials (herein, low-density polyethylene (LDPE)) into wood chips and then generated a uniform fiber of wood and plastic mixture through the refining process. With the refined fibers, various fiberboards are created with varying amounts of waste LDPE film (0%, 10%, 30%, and 50%) and varying amounts of polymeric diphenylmethane diisocyanate (pMDI) adhesive (with and without). 30% and 50% fibers were made into two batches, one with and one without pMDI. The fiberboards are hot-press fabricated and their physical (density profile, water sorption) and mechanical (flexural and internal bonding) performance are evaluated. Furthermore, thermal behaviors of the wood and waste LDPE film are characterized using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) techniques.

Development of a UV-curable Bio-Based Resin for 3D Printing

Presented by: Jessica Zhang

Program: Northwest Advanced Renewables Alliance
Co-authors: Baoming Zhao and Jinwen Zhang
Home Institution, Major, Class Standing: University of Washington, Biochemistry, Sophomore

The rapid development of 3D printing has revolutionized manufacturing. Photocuring 3D printing has drawn attention due to its many advantages including speed and resolution. However, the UV resins currently used are petroleum-based as well as difficult to repair, and hard to decompose. To address these problems, we aim to produce a fully bio-based photocurable resin for 3D printing. For this project, the resin was synthesized from itaconic acid and glycerol in a one-pot process. This reduces waste and saves time by circumventing the purification that would take place between steps. Itaconic acid is produced from the fermentation of carbohydrates and glycerol is produced from plant oils and animal fats. After the reaction, the photoactive double carbon bond from the itaconic acid remains intact which allows the resin to be cured under UV light. Additionally, the -OH groups and ester linkages enable dynamic transesterification which allows the cured resin to be both recycled and repaired. Along with previously mentioned benefits, this reaction is also catalyst-free and solvent-free, reducing waste, hazardous materials such as VOCs, and pollution. The completion of the process will provide a UV-curable bio-based resin that is both recyclable and repairable.

Regulation of Acylransferase Gene in Cell Wall Biosynthesis

Presented by: Jonathan Vivian

Program: Laboratory of Laura Bartley
Co-authors: Hui Min Olivia Oung, Chengcheng Zhang and Laura Bartley
Home Institution, Major, Class Standing: Lewis-Clark State College, Bioinformatics, Senior

Fossil fuels are a resource that provides for the quality of life those in the first world enjoy. However, the impact on the environment is becoming more evident and incontrovertible. New sources of fuel are necessary to slow the effect of emissions and byproducts of the overarching complex of the oil industry. Switchgrass (*Panicum virgatum*) presents a resource of biomass that has potential to allow metabolism of cell wall sugars to ethanol fuels. Identifying cell wall biosynthesis promotor regions can lead to identifying organisms that provide a source that can be more efficiently converted into biofuel. In a recent study, four switchgrass genotypes were selected for RNA Seq analysis. Two phenotypes demonstrated a recalcitrance to digestion while two were more digestible indicating a better suitability to biofuel. Rice (Oryza sativa) is a model organism that presents a diploid phylogenic relative to the tetraploid switchgrass that could be posited to have parallel metabolic pathways to lignin production on a genomic level, specifically in proteomic transcription factors. Rice protoplasts were used to test various transcription factors interactions with the acyltransferase gene involved in cell wall biosynthesis. Using a dual luciferase assay yielded luminescent expression indicating transcription factors were interacting with the acyltransferase gene.

MACET4 Smertenko Lab

Presented by: Alejandro Barragan-Morales

Program: Plant Cell Biology and Biochemistry
Co-authors: Alyssa Maxine Parish, Sharol Anna Schmidt and Andrei Smertenko
Home Institution, Major, Class Standing: Washington State University, Biology/Pre-med, Senior

For plant cells to carry out cell division (cytokinesis), they must utilize a complex of interacting proteins and vesicles that lead to the formation of the cross wall between two daughter cells, called the cell plate. The cell plate forms when a microtubule array assembles the phragmoplast, a cytoskeleton structure, by trafficking cell plate material to the division zone of a dividing plant cell. Microtubules are inherently dynamic polymers made of α-tubulin and β-tubulin which can be regulated by interacting proteins. Many microtubule-interacting proteins that regulate phragmoplast dynamics are not fully yet understood. Previous research has suggested that the γ-tubulin ring complex (γ-TuRC) is involved with microtubule seeding, known as nucleation. This nucleation can assist with stabilization of microtubule minus ends as plus ends grow toward the division zone and transport cell plate fusion vesicles. However, γ-TuRC is not the only microtubule-nucleating protein that exists in plant cells. Other microtubule nucleating proteins can be γ-TuRC-dependent or γ-TuRC-non-dependent. Recent evidence suggests that γ-TuRC non-dependent nucleation is necessary to preserve microtubule polarity in dynamic microtubule arrays when there is no clear microtubule-organizing centre. MACET4 is a plant-specific microtubule nucleating protein in the phragmoplast that may work in concert with or independently of γ-TuRC. To investigate the interactions of *MACET4* on microtubules, recombinant N- and C- terminal fragments, Δ3 and Δ4 respectively, were produced through a prokaryotic expression system. Fluorescently-labeled tubulin was polymerized in the presence of MACET4 fragments and the resulting microtubules were imaged with the TIRF (Total Internal Reflection Fluorescence) microscope. Deciphering how MACET4 nucleates microtubules in the phragmoplast can help to model phragmoplast expansion and demonstrate how complex dynamic microtubule arrays maintain their shape and function during cell division.

Macet Expression and Function Across Plant lineages

Presented by: Peter Coggan

Program: Plant Cell Biology and Biochemistry
Co-authors: Sharol Schmidt, Tania Smertenko and Andrei Smertenko
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Microtubule structures are critical for cell growth and division. Understanding their function and formation will aid in developing crops with improved yields, growing times, and drought resistance. γ-tubulin complexes are required for the nucleation of microtubule polymers and are very conserved across all eukaryotes. However, plants are observed to have more microtubules than their γ-tubulin could produce. Macerator proteins (MACET) appear to be a *planta* specific microtubule nucleators. MACET proteins will aid in the understanding plant cell division which differs from animals with the formation of a cell plate. In this study, we utilized three assays to understand MACET. We used CRISPER CAS-9 to knock out all MACET proteins in *Physcomitrella patens,* a basal species of moss. This will allow us to compare MACET function across the plant kingdom by comparing *P. patens* to the more complex dicot-*Arabidopsis thaliana*. We also used a GUS reporter gene system to monitor the expression of MACET proteins 3,5, and 7 within developing embryos of *A. thaliana*. The last experiment performed was investigating a receptor protein expressed with MACET called IMK2 in a root growth assay. IMK2 mutants were exposed to multiple toxins to assess what target the Kinase bound to. The *P. patens* study has not yielded any results and mutant verification is ongoing. We observed GUS expression linked to MACET 5 in the developing embryo and, surprisingly, also in the endosperm of the seed. Finally, our root growth experiments showed no growth hinderances to IMK2 mutants. However, we observed more lateral roots in mutants that had callose synthesis prevented. Our results are the first to report MACET expression in the endosperm. This discovery could aid in the development of new techniques to produce yield. IMK2's roll in cell division is not understood but these results suggest a link to plant's hormonal system.

Characterizing Functional Domains of MACET4: A Plant Specific Microtubule Nucleating Protein

Presented by: Nhu-Y Do

Program: Plant Cell Biology and Biochemistry
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Due to the rigid cell wall, plant cells must utilize a unique cellular machine called the phragmoplast to form the cell plate that separates the daughter cells during cytokinesis. The phragmoplast is composed of two mirrored rings of microtubules which provide structural support for cell plate expansion. Microtubules are 25nm thick hollow tubes composed of α/βtubulin dimers and microtubule length changes by addition or removal of tubulin dimers. Along with providing structural support, microtubules facilitate intracellular transport of vesicles to build the cell plate. The phragmoplast forms in the center of the cell and expands centrifugally to bring the cell plate to the mother cell wall. Phragmoplast expansion is driven by the formation of new microtubules (nucleation) at the leading edge. However, microtubules require the aid of microtubule-associated proteins. The γtubulin ring complex (γTuRC) is a group of such proteins that binds to extant microtubules resulting in microtubule nucleation. However, not all microtubule nucleation is γTuRC-dependent. A plant-specific protein and microtubule-associated protein called MACERATOR4 (MACET4) has been observed *in vitro* and *in vivo* to promote nucleation and polymerization of microtubules1. There is the possibility that MACET4 interacts with γTuRC or may nucleate microtubules independent of γTuRC. Our work focuses on *MACET4* fragment behavior on microtubules in order to map the functional domains. We use *E. coli* cells to produce recombinant MACET4 fragments for microtubule assays *in vitro*. Recombinant protein fragments were added to purified tubulin dimers and allowed to polymerize. Tubulin behavior was quantified by SDS PAGE, spectrophotometry, and TIRF (Total Internal Reflection Fluorescence) microscopy. Comparing these assays results, we can infer which MACET4 fragments contain the functional domains involved in microtubule nucleation and polymerization, contributing to the understanding of phragmoplast microtubule dynamics.

MACET4 Role in Phragmoplast Microtubule Nucleation

Presented by: Jenalle Pana

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Microtubules are a key component of cell division and vesicle trafficking. In cell division, microtubules rearrange to form essential arrays for separating duplicated DNA and for splitting the cytoplasm in cytokinesis. The phragmoplast is a plant-specific microtubule array responsible for splitting the cytoplasm during cytokinesis by constructing a cell plate, that later matures into a cell wall, into separate daughter cells. Cell plate formation begins in the center of the cell and grows until it reaches the mother cell wall. New microtubules form on the outer edge of the phragmoplast, driving phragmoplast expansion and widening the zone for vesicle trafficking, thus spreading the cell plate. It is well-known that the gamma-tubulin ring complex (γTuRC) is responsible for microtubule nucleation. However, there is evidence of microtubule nucleation factors that are independent of γTuRC. To gain a better understanding of microtubule nucleation in phragmoplast expansion, we looked at functional domains of the plant-specific microtubule-nucleating protein MACERATOR 4 (MACET4). MACET4 is composed of 3 highly conserved regions and 2 non-conserved regions. We divided the protein into four fragments, Δ1, Δ2, Δ3, and Δ4, to determine whether the conserved regions corresponded with the microtubule-interacting functional domain. We observed each fragment and its function on microtubule behavior through multiple biochemical assays by polymerizing monomeric tubulin in the presence of recombinant MACET4 fragments. We found that the C-terminal conserved regions that make up Δ4 are responsible for a majority of MACET4 behavior. However, it is still unclear whether MACET4 works with or independently of the γTuRC nucleation, but with further research we will gain a better insight into MACET4 and its role in phragmoplast microtubule nucleation.

Characterizing the Functional Domains of MACET4

Presented by: BreeLynn Robinson

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The γ-tubulin ring complex (γTuRC) is responsible for the nucleation of microtubules in eukaryotic cells and is assisted by a variety of proteins to form microtubules. MACET4 is one protein that promotes the nucleation of microtubules. Whether MACET4 works in tandem with γTurC or is an independent nucleator is unknown. To understand how MACET4 nucleates microtubules, we set out to characterize the functional domains of MACET4. We split MACET4 into four different fragments, Δ1, Δ2, Δ3, and Δ4, based on the 3 conserved (Ci, Cii and Cii) and 2 non-conserved (Nci, Ncii) domains. Δ1 spans Ci, Δ2 spans Ncii-Ciii, Δ3 spans Ci-Nci, and Δ4 spans Cii-Ciii. We aim to uncover which functional domain is responsible for microtubule binding and nucleation.

To study MACET4 fragment behavior we have made a comprehensive work-flow to purify recombinant proteins for *in vitro* microtubule assays. Protein expression was carried out in the *E. coli* strain, Rozetta, and His-tag purified by Nickel column with an imidazole gradient wash. Fragments were then purified by FPLC on a size-exclusion column to remove contaminating proteins or degradation products. Buffer exchange was performed to refold recombinant proteins in microtubule-stable buffers.

Biochemical assays were performed by mixing MACET4 recombinant fragments with purified tubulin to assess microtubule behavior. Multiple microtubule assays were performed including imaging polymerized microtubules with the TIRF (Total Internal Reflection Fluorescence) microscope, bulk polymerization resolved by SDS PAGE, co-sedimentation with Taxol-stabilized microtubules resolved by SDS PAGE, and turbidimetric assays measured with a spectrophotometer. Each assay is designed to show whether the fragments bind microtubules, promote microtubule polymerization and how MACET4 impacts individual microtubule behavior. These biochemical assays will show which *MACET4* fragments contain functional domains that play a role in microtubule nucleation.

Nano and Micro Phase Identification in Natural and Synthesized Glass

Presented by: John Bussey

Program: (NOME lab) and in the HYdrogen Properties for Energy Research (HYPER)
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Glassy (amorphous) materials do not have a crystal structure. These materials are critical to many technologies and are at the forefront of materials research. Characterization is necessary to understand the fundamental science behind the properties of glassy materials and to harness these properties for specific applications. In order to understand the nature of glassy materials and specifically their structure-properties relationship, it is critical to know what phases make up each material. Glasses with multiple phases include those where there are multiple glass phases with different compositions (phase separation) and those where a crystal grows out of the glassy matrix (crystallite). This study analyzed a variety of different natural and man-made glasses, either containing phase separation or crystallites, particularly those between 200 nm and 10 μm. This characterization was supporting a project investigating the capabilities of 3D X-ray nano-Computed Tomography (nano-CT) for use in exploring nanoscale and microscale features in amorphous materials. For these types of phases (amorphous, small, and in low concentrations), typical phase identification tools used for crystalline materials are ineffective, therefore innovative, individualized, and varied methods are needed. Alternate tools for phase identification were utilized including X-Ray Diffraction, Energy Dispersive X-ray Spectroscopy, Vibrating Sample Magnetometry, Raman Spectroscopy, nano-CT, and analysis of scanning electron microscopy images. The phase of crystallites was identified in glass-crystalline aggregated volcanic ash from Mt. St. Helens, in a test nuclear waste melter from refractory corrosion, in colloidal metal particles, and in obsidian from Glass Butte, Oregon. Particularly notable was observed flow banding with magnetic nano/microlites in the obsidian. Separated phases were identified in barium borosilicate glass, gallium-lanthanum-sulfide optical glasses, and in silver-arsenic-sulfide chalcogenide glasses. Particularly notable was observed spinodal and hierarchical phase separations. These results allow for deeper understanding of these materials and their processing history, while elucidating nano-CT images.