Oral Presentation Abstracts

<u>Session 1</u>

Experiential Training of STEM Teachers

Susan Ipri Brown, Assistant Professor of Engineering Instruction, Hope College, BSE/MS Mechanical Engineering

Preparing STEM Teachers will increase the capacity to meet the quickly growing need for STEM (science, technology, engineering, and math) education teachers in the state. Specifically, attention will be given to providing pre-service teachers exposure to effective, inquiry-based techniques for working with diverse learners and students from a range of socioeconomic and demographic backgrounds. Empowering future STEM educators to combine best practices in inquiry-based learning as well as techniques for inspiring diverse learners to enter STEM fields will significantly impact multitudes of students across those teachers' careers. This proposal seeks funding for pre-service teacher stipends, mentoring, evaluation, and materials to support our unique hands-on training in the context of Hope College's Summer Science Camps. Complementing in-classroom learning, this impactful experiential learning immerses pre-service teachers in STEM classroom experiences and builds a pipeline of teachers that can inspire and mentor a diverse future workforce.

COVID Camp: Process and outcomes from a remote summer STEM camp experience

Kris Pachla, PhD., Director, GVSU Regional Math and Science Center. GVSU
Chelsea Ridge, MEd., Mathematics Program Coordinator, GVSU Regional Math & Science Center, GVSU
Diane Miller, MPA, Business and Community Outreach Coordinator, GVSU Regional Math & Science Center, GVSU

The GVSU Regional Math and Science Center designed and implemented Energizing our World: A remote, virtual summer camp experience for middle school students to explore learning and careers in renewable energy and sustainability. Using a delivered kit, campers engaged in a week of hands-on guided activities, culminating with a career fair with business partners and a presentation of a design prototype to experts and their

peers. Camp activities were designed and prototyped by GVSU pre-service teachers and STEM students and were enacted and revised before posting as open-source resources. Campers utilized the Design Thinking process/Innovators Compass and incorporated new content learning throughout the week while revising their designs. Campers focused on answering the question: How might we make our communities more sustainable? This presentation explores the structure and planning associated with camp, camper outcomes, and potential implications for future summer experiences.

The Hygiene Hypothesis: Far-reaching implications for immune health

Kristin Renkema, PhD, Assistant Professor, Biomedical Sciences Department, GVSU

My lab investigates how environmental exposures influence the immune system during homeostasis and disease. Specifically, we measure how microbial experience shapes immune cell signaling pathways and ability to respond. Previous research has shown that traditional specific pathogen free (SPF) mouse models do not replicate human adult immunity, at least in part due to the lack of microbial exposure. We expose SPF mice to diverse microbes by cohousing SPF mice with mice purchased from pet stores to study how the microbial environment shapes the immune cells throughout development, and how microbial exposure translates into signals that are interpreted by immune cells. Space flight results in both immunosuppression and microbial exposure for astronauts, yet very little is known regarding how these microbial exposures impact their immune systems and overall health. Our studies have significant implications for a wide-range of immune-related diseases and health implications.

Surface Coatings from Composite Dry Lubrication Schemes

Alana Policastro, Chemistry Department, Hope College
Meagan Elinski, PhD, Chemistry Department, Hope College

Two-dimensional (2D) solid materials are at the forefront of dry lubrication research due to their surface compatibility, unique structural-chemical properties, and potential to function as multifaceted coatings with specialized mechanical, electronic, and optical properties for emerging technologies such as space-based lubrication needs. Moreover, when specific 2D materials are combined with nanoparticles, the composite system facilitates superlubricity (ultra-low friction). Other nanoparticles can independently form tribofilms, protective surface coatings that build up from friction in situ (during sliding). Bringing together distinct optoelectronic properties, superlubricity sliding behavior, and film-forming surface protection into a tailored surface coating, however, remains challenging due to the lack of predictive capabilities for composite lubrication schemes. To better understand composite film formation, this work focuses on determining the impact of interfacial parameters on tribofilm properties. Interfacial chemistry was controlled through self-assembled monolayers on silica (e.g., aminopropyltriethoxysilane, APTES). Interfacial roughness was controlled through spincoated silica nanoparticles. A series of nanomaterials (molybdenum disulfide, phosphorene, and nanodiamonds) were deposited onto the controlled surfaces, comparing dropcasting vs spincoating methods. The composite interfaces were then both imaged and subjected to high stress sliding tests in an atomic force microscope (AFM). Preliminary results suggest scrolling of the 2D materials is one possible film formation mechanism. Future work will continue to isolate what surface parameters are needed for controlled tribofilm formation, ultimately leading to the design of tailored multifaceted surface coatings.

Land use, but not altitude, affects airborne bacterial community composition

Christian Smith, BS, MS Student, Department of Biological Sciences WMU
Kathryn Docherty, PhD, Associate Professor of Biological Sciences, Dept. of Biological Sciences WMU

Bacteria are ubiquitous in the air, yet our understanding of airborne microbial ecology is in its infancy. Airborne dispersal of bacteria is important for ecosystem health and function. Continental scale investigation of urban areas reveals convergence patterns of ecological processes, plant and animal communities. Similarly, there are site-specific effects of land use on airborne communities, but these effects have not been quantified on a continental scale. This study analyzed airborne bacterial community composition at two altitudes across four biomes to investigate continental scale effects of urbanization. Urban communities were significantly less dispersed than rural communities, on a continental scale, exemplifying the urban convergence observed in other ecosystem properties. However, altitude had no significant effect on community composition indicating that near-surface airborne communities are elevated to 150m where they are dispersed greater distances. Land use change affects the microbes available for dispersal, impacting ecosystem health and function in a broader region.

Forward Image Prediction for Environment Exploration Using Model Predictive Control

Dominic Messina, B.S. Chemical Engineering, Dept. of Chemical Engineering & Materials Science, WSU
Helen Durand, Ph.D. Chemical Engineering, Dept. of Chemical Engineering a& Materials Science, WSU

When operating in uncertain environments, an autonomous system may need to collect more information about its surroundings in order to adequately perform the tasks required of it. As the collection and processing of visual data has become important in facilitating the interaction between an intelligent agent and its environment, using this data to predict how an environment will evolve as camera sensor positions change may enable an agent to choose from a number of potential actions. In this work, we use OpenGL to simulate the navigation of a camera near an unidentified object under model

predictive control (MPC) using image predictions to determine an optimal course for collecting the data needed to identify the object.

Session 2

Constructing Digital Terrain Models from Lake Michigan Dune Imagery

Blake Harlow, Undergraduate Student, Mr., Hope College

Lake Michigan dune complexes evolve as winds and waves erode the sand, causing major topographic changes over time which are not fully understood or modeled. Drone photography is an efficient method for collecting precise multispectral imagery for these areas. The Hope College Dune Group has been using this remote sensing data to model various aspects of the dune, although much remains to be understood about sand transport mechanisms. In this research, we have used machine learning to create digital terrain models (DTMs) which map the bare-ground surface of the dune. One of our overall aims is to use machine learning along with DTMs created at different points in time to model changes in surface topography. In this talk, we report on our method of constructing DTMs for this unique terrain. Modeling changes of the dune surface in this way will provide useful information for protecting and maintaining healthy dune ecosystems.

Lake Responses to Elevated Levels of Chloride and Phosphorus

Ellen Foley, Graduate Student, Annis Water Resources Institute, GVSU
Alan Steinman, Ph.D., Allen & Helen Director, Annis Water Resources Institute, GVSU

Increasing chloride concentrations from road salt runoff have been observed in lakes throughout the north temperate region. Excess salt can negatively impact the biological, chemical, and physical properties of freshwater systems. For the past year, we have monitored the water quality of a chloride-impaired lake in Grand Rapids, Michigan. Preliminary results reveal the lake has not fully mixed during the study period due to this salt-induced concentration gradient, and the hypolimnetic waters are permanently anoxic with chloride levels exceeding the EPA chronic toxicity threshold, at times reaching 324 mg/L. The absence of dissolved oxygen (DO) in the bottom waters has significant implications for internal phosphorus loading, which increases under low DO conditions. Should the lake turn over, either partially or totally, the high phosphorus levels may induce algal blooms. An ongoing study is examining the impacts of excess chloride on sediment phosphorus release and will help inform lake remediation efforts.

Topography-Based Tectonic Analysis for Interpretation of Magma Migration Under the Southern Mid-Atlantic Ridge

Simon Detmer, Geology major, Dept. of Geology, Geography & Environmental Sciences
C. Renee Sparks, Phd Geology, Hope College, Calvin University

Tectonic forces govern processes at depth under mid-ocean ridges leading to volcanism and crustal growth as well as brittle deformation of the oceanic crust. In this study of the Mid-Atlantic Ridge system between 0 and 30¬∞S latitude, ocean-floor topography is used to identify fault patterns and examine relationships between ridge and transform segments to develop a conceptual model for underlying magma migration. Our model incorporates the stresses exerted by magma migration in the 3-D melt prism under the ridge system. Lithostatic loads, calculated to a depth of 50 km below sea level for ridge and transform junctures, reveal a pressure gradient associated with equatorial bulge that could drive horizontal magma migration. Shearing forces, including the Coriolis parameter, could influence the stresses exerted on existing faults producing the observed geometry. Rotation and drift connected with this conceptual model provide variables not previously addressed within the context of global plate tectonics.

Investigating the Photochemical Fate of Dissolved Free Amino Acids in Natural Aquatic Environment through Coupled Experimental and Theoretical Approaches

Benjamin Mohrhardt, Graduate Student, Dept. of Civil & Environmental Engineering, MTU
Benjamin Barrios, Graduate Student, Dept, of Civil & Environmental Engineering, MTU
Ryan Kibler, Graduate Student, Dept. of Civil & Environmental Engineering, MTU
Paul Doskey, PhD, Co-Principal Investigator, School of Forest Resources & Environmental Science, MTU
Daisuke Minakata, PhD, Principal Investigator, Dept. of Civil & Environmental Engineering, MTU

Dissolved free amino acids (DFAAs) and AA-based molecules are key sources of nitrogen in natural waters, providing building blocks for protein synthesis and energy for microbial growth. In sunlit waters, abiotic transformation such as photochemical oxidation plays an important role for the fate of DFAAs Photochemical oxidation occurs via direct and indirect photolysis by photochemically produced reactive intermediates (PPRIs), such as excited triplet state chromophoric dissolved organic matter (3CDOM*), singlet oxygen (1O2), and hydroxyl radicals (HO‚Ä¢). Due to the complex nature of CDOM and subsequent radical-involved reaction mechanisms, little is known about the fate of DFAAs in natural waters. Thus, there is a need to understand and predict the fate and transformation of DFAAs and their role in the nitrogen cycle. In this talk, we present the experimental and theoretical initial reactivities of three structurally unique, photo-viable DFAAs: tyrosine, histidine, and methionine in the presence of three surrogate CDOM.

Mineral film growth at the air/liquid/iron interface and the effect of cations from chloride electrolytes

Kathryn A. Perrine, Ph.D., Assistant Professor, Dept. of Chemistry, MTU

Earth and planetary soils are largely comprised of iron oxides. The surface of iron materials will undergo chemical and physical transformations through redox processes where ions are known to catalyze surface corrosion to produce complex oxides. This study investigated how cations in ionic electrolytes affect the transformation of iron surfaces at the air/liquid/solid interface to produce minerals. The surface reaction at complex interfaces was investigated using surface infrared spectroscopy and atomic force microscopy. The effect of KCl(aq) and $MgCl_2$(aq) electrolytes and atmospheric CO_2 and O_2 was found to produce carbonate films at the air/electrolyte/iron interface that is unique to the type of cation in solution. At either electrolyte/Fe interface, the same heterogenous mixture of lepidocrocite and iron hydroxy carbonate minerals were grown. These surface reactions and transformations to minerals are critical for understanding environmental and atmospheric surface chemistries for planetary processes.

Exploring the Effects of Prairie Restoration Management on Soil Microbial Carbon Storage

Ellen Badger Hanson, PhD Student, Biological Sciences, Western Michigan University; Kathryn Docherty, PhD, Associate Professor, Biological Sciences, Western Michigan University

Agricultural ecosystems are a major contributor to greenhouse gas emissions. One mitigation method involves integrating native prairie vegetation in marginal lands within agroecosystems. However, these restored prairies often do not regain the soil microbial community structure nor soil carbon storage found in untouched remnant prairies. Further study on the mechanisms behind these discrepancies is necessary to restore prairies more effectively for carbon storage. This study leverages a long-term, ongoing experiment at Kellogg Biological Station in southwest Michigan. In Summer 2021, we examined the effects of restoration size and plant seed mix diversity on soil microbial communities and soil carbon. We hypothesized that restorations with high seed mix diversity would have more soil carbon than those with low, and that soil carbon would increase with restoration size. Trends in initial microbial biomass carbon data support these hypotheses. This study aims to provide insight to inform better land management strategies.

Session 3

Meteorite or Meteor-Wrong: Recognizing minerals and textures that are out-of-this-world

C. Renee Sparks, PhD, Visiting Professor, Hope College

The focus of this project was to provide educational outreach opportunities through the development of a meteorite-specific display and accompanying materials in the Bruce Dice Mineralogical Museum at Calvin University. As with many projects in 2020, plans were rerouted due to COVID19 restrictions, and we shifted to the college community. In August 2020 the project launched with acquisition of several meteorites including the Seymchan stony-iron, Dimmitt H4 chondrite, as well as the Aba Panu L3.6 chondrite and corresponding thin section microscope slide. These new meteorites complemented the existing collection including the Allende carbonaceous chondrite, Canyon Diablo iron, a sliced Lodranite, and small pieces of meteorites in the teaching collection. Materials were developed for courses in Earth Science and Petrology ranging from a guided examination of the display to a three-hour laboratory exercise using textures, minerals, presence of a fusion crust, and geochemical methods to differentiate between meteorites and meteor-wrongs.

The cosmic-ray positron spectrum and its implications on the properties of Milky Way pulsars

Ilias Cholis, PhD, Ass. Prof., Physics, Oakland University

Measurements of cosmic-ray electron and positron spectra at energies from a GeV to 5 TeV, as well as radio, X-ray and a wide range of gamma-ray observations of pulsar-wind nebulae, indicate that pulsars are significant sources of high-energy cosmic-ray electrons and positrons. To probe the physical properties of the high-energy emission from pulsars we generated 8000 distinctive simulations on their contribution to the locally observed cosmic-ray electron/positron energy spectra. Our models account for (a) the initial properties and time-evolution of pulsars energetics; (b) the emitted spectra of cosmic-rays from pulsars; (c) their occurrence in the Milky Way and (d) the physics of cosmic-ray propagation through the interstellar medium and the Heliosphere. I will discuss the implications that measurements from AMS-02 and CALET on-board the International Space Station and the DAMPE satellite have on the properties of pulsars and the interstellar medium.

Using MESA to Test our Theory of Contact Binary Star Evolution

Lauren Henderson, Undergraduate, Calvin University Physics and Astronomy
Jenn Lau, Undergraduate, Calvin University Physics and Astronomy
Larry Molnar, Ph.D., Professor, Observatory Director, Calvin University Physics & Astronomy

A contact binary star system consists of two stars orbiting so closely together that they share an outer atmosphere. Although common, there is not yet a consensus on how these systems form, evolve, and ultimately die. Over the past two years, we have developed a comprehensive theory describing the lifetime of these systems, from how the two stars come together to how they eventually spiral together and explode. In this presentation, I will describe the MESA models we calculated this summer. Based on our calculations, we have added two new insights to our theory: 1) an initial instability in stars that form with a high mass ratio, and 2) two possible mechanisms for contact binary mergers. I will also compare the temperature distributions of our models with contact binary data from the Kepler space telescope.

BLUE Program: Student-Developed Spacecraft

Owen Marr, BSE Aerospace Eng, pursuing MEng in Space Eng, UM
Lucas Lorenz, pursuing BSE Computer Eng. UM
Marlee Trager, pursuing BSE Aerospace, Eng. UM
Jack Liu, pursuing BSE Computer Science, UM
Liam Spence, BSE Aerospace Eng, pursuing MEng in Space Eng. UM
Taha Teke, pursuing BS Computer Science. UM

The BLUE Program at the University of Michigan gives undergraduate and graduate students the opportunity to develop spacecraft and satellites. Our current spacecraft (BX-4) is a 3U deployable that tests our in-house developed 3-axis reaction wheel control system and a computer vision system that can detect rocket bodies in space. This presentation will highlight past projects at BLUE and summarize the current work being done on BX-4.

Multiple Stellar Populations in Globular Clusters

Willem Hoogendam, N/A, Mr., Physics and Astronomy, Calvin University
Jason Smolinski, Ph.D., Dr., Physics and Astronomy, Calvin University

Globular Clusters were once the archetype of a simple, homogeneous stellar population. However, observations made in recent decades have revealed the existence of two or more stellar populations in Globular Clusters identified by elemental differences. Our research focuses on distinguishing these different populations using photometric data. We introduce a new method of distinguishing multiple populations using photometry and apply our method to the well-studied Milky Way Globular Cluster M13. Furthermore, we also used our method to analyze eight Milky Way Globular Clusters presented in Lardo et al. 2011 with their data as well as data released in Stetson et al. 2019. We find that Lardo et al. 2011 may have biased their result due to their uncertainty normalization which makes their results inconsistent with our work and other studies in the literature. We find that when re-done using our method, the results are more consistent with other studies.

Control of Residual Stress in Powder Bed Fusion for Space Manufacturing

Kip Nieman, B.S. in chemical engineering, PhD student, Dept. of Chemical Engineering & Materials Science, WSU

NASA's long-term goals of space travel and habitation necessitate space manufacturing, as required supplies will be circumstantial and transportation from Earth will take long periods of time. Powder bed fusion (PBF) uses lasers to melt successive layers in metal powder and might meet this need. The temperature changes during PBF create residual stress that remain in and weaken the completed part. Applying heat treatment would require large amounts of energy, representing a barrier to applying PBF is space. The long-term goal of this research is to develop a data-driven model of stress in the completed part based on a high-fidelity model of PBF. Subsequently, advanced control will be applied to minimize the stress in the completed part. This talk will describe our progress toward these goals, along with a discussion of implementation problems for advanced control in space and the theoretical challenges which it introduces.