2021 Spring Research Symposium
Gustavus Adolphus College, April 30th, 2021

Session A: Oral Presentations, Nobel Hall, Wallenberg Auditorium https://hellogustavus.zoom.us/j/85690594014?	
2:30 pm	**Fungal Species and Fluconazole Resistance** Fungal pathogens have immense medical importance, as they infect 4.9 million people globally a year. One type of fungal infection, Candidiasis, is caused by multiple different yet related species. Additionally, new species capable of causing this infection have emerged in the last ten years, showing the intensity of this problem. Species that are related to pathogenic species but are non-pathogenic themselves can represent a model system to examine how drug resistance develops in organisms without prior exposure. This includes several Brettanomyces species. This summer, we began by sequencing 23 different strains to determine their identity. Next, we selected 20 strains, which included seven different fungal species, to be screened for fluconazole resistance. This involved multiple replicates of minimum inhibitory concentration (MIC) assays. We found three isolates to be resistant, six to be have some degree of resistance, and one isolate to be sensitive to fluconazole. Other isolates were unable to be classified during our time. For three strains that were thought to be resistant, we sequenced ERG11, the specific gene that is the fluconazole drug target to see if mutations had occurred. We found that while two strains had no changes, one strain had two amino acid changes. For strains with some resistance, we investigated cross-resistance, and screened six strains for voriconazole and itraconazole. In the future, we would like to continue screening for cross-resistance in resistant strains and screening for fluconazole in unclassified strains, evolve nonresistant strains, and further sequence ERG11 in more strains. **Katya McDonald** Advisor: Laura Burrack, Biology
2:45 pm (virtual)	**Implications of Dispersion in Connecting Capillaries for Separation Systems Involving Post-Column Flow Splitting** Advances in high performance liquid chromatography (HPLC) continue to improve the separating power available to chromatographers. These capabilities are expanded through extension of the technique to two-dimensions (2D-LC), or by coupling liquid chromatography with mass-spectrometric detection (LC-MS). However, these approaches sometimes have the drawback that unreasonably high mobile phase flow rates are required. These problems are often mitigated by use of a flow splitter, which diverts the majority of the mobile phase into waste while optimizing the flow into the rest of the instrument (i.e., second dimension of 2D-LC, a mass spectrometer, or both). However, the use of a flow splitter comes with its own side effects, one of which is the potential for increases in peak dispersion, which lowers peak resolution and capacity. Here, a theory accounting for the extra-column dispersion caused by a simple tee flow splitter is introduced and tested using both UV-visible absorbance and laser-induced fluorescence (LIF) detectors with various flow split ratios and post-split configurations. Theoretical predictions and experimental results match pretty well over a variety of conditions. Experimental results show that the diameter and length of post-split tubing has the greatest impact, in very extreme cases increasing the variance by over 500% from observed when using small diameter tubing. Ultimately, post-split tubing dimensions should be carefully considered when using a flow splitter in order to minimize extra-column dispersion. **Caden Gunnarson,** Thomas Lauer, Harrison Willenbring, Eli Larson, Monika Dittmann, Ken Broeckhoven, and Dwight Stoll Advisor: Dwight Stoll, Chemistry

3:00 pm	**Effect of two Arbuscular Mycorrhizal Fungi Isolates (*Rhizophagus irregularis* Ri09 and *R. irregularis* DAOM) on Water Relations of Drought-Stressed Leeks (*Allium porrum* L.)** Drought negatively impacts plant productivity and yield in agricultural systems and corresponded to $37 billion crop losses globally from 2008-2018. Arbuscular mycorrhizal fungi (AM) may improve water relations of drought stressed plants through physiological changes such as greater stomatal conductance (g_s), photosynthetic rate (A_{max}), transpiration, and water use efficiency (WUE). Leeks (*Allium porrum* L.) are drought sensitive and readily colonized by AM fungi. AM isolates *Rhizophagus irregularis* Ri09 and *R. irregularis* DAOM were investigated because it has been shown these isolates vary in nutrient uptake but it is not known whether they differ in affecting water relations of drought stressed plants. A randomized pot experiment was conducted with Ri09-inoculated, DAOM-inoculated, and uninoculated leeks (control). All leeks underwent a 3-day drought period following inoculation and growth in well-watered conditions. Both AM treatments did not significantly affect plant physiological responses (A_{max}, g_s, transpiration, and WUE) to drought conditions. However, in drought conditions Ri09- and DAOM-inoculated leeks exhibited greater photosynthetic rates, which corresponded with marginally greater stomatal conductance and transpiration, compared to uninoculated leeks, even though comparisons were statistically insignificant. In drought conditions, WUE was similar for AM inoculated and uninoculated leeks. Physiological parameters were significantly different between well-watered and drought conditions for each treatment group. These data suggest *R. irregularis* isolates Ri09 and DAOM may marginally improve photosynthetic rate of drought-stressed leeks in early developmental stages. However, these results do not negate the likely effect of AM fungi on drought stress in agricultural systems. **Brooke Bernhardt** Advisor: Pamela Kittelson, Biology
3:15 pm	**Initial Steps in the Synthesis of a Tri-Porous Covalent Organic Framework Building Block** Linking organic molecule building blocks covalently in a rotationally-restricted manner with defined shapes can yield multi-dimensional rigid polymers called covalent organic frameworks (COFs). COFs are networked, crystalline organic materials that have permanent porosity and have a diverse range of applications including catalysis, energy storage, drug delivery, and molecular separation. The composition of the different building blocks, or monomers, will impact the function of the COFs as well as the pore sizes and shapes. This experiment aims to synthesize a COF monomer which is computationally predicted to form a novel porous network when polymerized. If proven effective, it will demonstrate the feasibility of using computational 2D tilings to predict the monomers of new COFs which can then be synthesized. Specifically, the goal of this work is to determine the initial synthetic steps for producing the intended COF building block. Electrophilic aromatic substitution and the methylation of catechol were used to create a starting point from which the monomer could be synthesized. The methylation reaction yielded the desired product but with room to improve product yield and purity. The bromination of the aromatic ring did not yield the anticipated products and remains a subject of future investigation. **Maria Sylvester, Kaitlyn Perez, and Ashley Ley** Advisor: Ian Hill, Chemistry
3:30 pm 30- minutes	**Differential Plasticity and Sex-Specific Resource Allocation in Response to Nitrogen Availability in a Dioecious Forb, Silene latifolia** Dioecious plant species are those with male and female reproductive structures on separate individuals. Females of dioecious species have been found to invest more in reproduction and less in growth than males, but exactly how this investment manifests into cost remains unclear. We examined how male and female *Silene latifolia* allocate biomass to vegetative and reproductive structures in response to nitrogen availability. We compared this sex-response to investigate if differential plasticity—the phenomenon in which individuals allocate resources in a sex-specific manner—was at work. We grew *S. latifolia* from native seed in Summer 2020. Seedlings were randomly assigned to a nitrogen fertilization treatment

	group: control, low nitrogen (5 g/m^2) or high nitrogen (10 g/m^2). After flowering, females were randomly designated as early anthesis (EA) or late anthesis (LA). Flowers of males and EA females were collected within two days after opening. Flowers of LA females were hand pollinated and left to progress toward senescence. All plants (n=117) were harvested in late September 2020. As nitrogen availably increased, all plants increased aboveground biomass. Males produced roughly 3-fold and 4-fold more flowers daily than EA and LA females, respectively. However, calyces of EA female flowers were on average 39% wider and 14% longer than those of males. EA females produced more flowers daily than LA females as nitrogen availability increased. It is possible that EA females offset reproductive costs through photosynthesis in the calyx. LA females seemed to shift investment patterns from flower production toward seed development along the nitrogen gradient. **Tessa Dethlefs** Advisor: Amy Kochsiek
4:00 pm 30- minutes	**An Assessment of the Effects of Prescribed Sheep Grazing on Reclaimed Minnesotan Prairie Pollinator Habitat** Control and experimental restored prairie plots subject to sheep grazing were sampled to determine the effect of sheep grazing on pollinator prairie within solar polar-voltaic facilities. The objective was to explore the viability of prescribed sheep grazing as an alternative to mechanical and chemical vegetation management. Six operational solar energy production facilities were selected for study. Sites were planted with native prairie grasses and forbs and subjected to prescribed sheep grazing per site manager requirements. Control plots were excluded from grazing, and vegetation in both treatment plots were sampled using the point-intercept technique to assess species richness, vegetative cover, and diversity (Shannon-Weiner). Results from the 2020 season will serve as a baseline from which to monitor changes in treatment plots over the next five to ten years. In accordance with the literature, I expect grazed plots will develop higher species richness, greater diversity, and greater vegetative cover over un-grazed plots in the following years. If these predictions are supported, prescribed sheep grazing could serve as an energy efficient and chemical free means of managing and improving controlled prairies in industrial sites and elsewhere. **Jeremy Gilbertson** Advisor: Pamela Kittelson, Biology

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Session B: Oral Presentations, Nobel Hall 1412 https://hellogustavus.zoom.us/j/82556114540?	
2:30 pm	**Nitrate Reduction by Iron Oxidizing Bacteria in the Minnesota River Area** Nutant pollution continues to be a major ecological crisis around many parts of the world. An influx of high concentrations of nutrients can lead to algae blooms and eventually dead zones which can devastate aquatic environments. One of the most prevalent nutrients to contribute to this pollution is nitrate. Nitrate can leach from soil and filters into lakes and rivers via water run-off, a majority of which come from farmland. In order to try and mitigate the amount of nitrate being released into these water ways a strategy was devised to try and reduce nitrates in to N2 gases before they could leave the soil. By creating an anaerobic environment and adding furious iron into the soil It was found that in some areas along the Minnesota river, nitrate reduction could be partially increased over a short period of time. It is hypothesized that this is due to a presents of iron oxidizing/ nitrate reducing bacteria which are able to reduces higher quantities of nitrates when iron is present in the system, using the iron as an electron acceptor for the reduction proses. By adding furious iron into currant denitrification beds, it is possible denitrification could be increased and the number of nitrates released into waterways could be further reduced. **Luke Dragseth** Advisor: Jeff Jeremiason, Chemistry and Environmental Studies
2:45 pm	**Ecology and Climate Sensitivity of Ancient Polar Forest Ecosystems, Antarctica** The Permian (300-251 Ma) to Triassic (251-200 Ma) transition marks the most severe mass extinction in the history of life on Earth, and is attributed to enhanced greenhouse warming and disruption of the Earth climate state through volcanism. A significant change in high-latitude forested ecosystems occurred during the timeframe of the Permian–Triassic, however, the function and stability of these forests remain poorly understood. We applied the technique of dendrochronology to fossil wood from the Permian–Triassic in Antarctica to evaluate the effects of climate through time in this study area. We also compare two study areas, separated by ~9° of latitude, to assess whether latitudinal gradients in climate or ecology played a role in this extinction. Ring width variation, reflecting enhanced versus suppressed growth, occurs at different frequencies through Permian and Triassic time intervals. An unexpected result is that the distributions of ring width variations and periodicities are similar between the latest Permian samples and the Triassic samples regardless of sample location. Older Permian samples, however, display variation across the two study locations, reflecting the only clear spatial trend in ring width variation. To further test the hypothesis that these ring width trends are resultant from paleoclimate change, paleoclimate was independently determined by paleosol analysis, demonstrating a pronounced paleoclimate shift from Permian to the Triassic. This data supports the working hypothesis that climate gradients decreased in the study area from the Permian to the Triassic, and that a rapid climate shift occurred following the latest Permian sample set studied here. **Morgan Mellum, Aidan Dahlseid**, and Erik Gulbranson Advisor: Erik Gulbranson, Geology
3:00 pm	**Mercury Analysis and Method Development** Mercury is naturally occurring, however, human activity has greatly enhanced the environmental levels of this element. Mercury bioaccumulates and is a neurotoxin; thus, having accurate measurements is imperative to public health and indicative of the well-being of an ecosystem. Current analysis methods are time-consuming and expensive as they require two different procedures to determine the values of

	total and methylmercury (an organic form of mercury). The currently accepted procedures involve using cold vapor atomic fluorescence spectroscopy (CVAFS) to measure total mercury content, and an additional step to measure methylmercury in an inductively coupled mass spectrometer (ICP-MS) via the isotope dilution method. This procedure often also involves a distillation step. Due to the costs of current practices, the development of a new method using high-performance liquid chromatography (HPLC) coupled with ICP-MS was initiated. HPLC allows for the separation of compounds using a mobile and stationary phase, each of which has multiple manipulatable variables. The purpose of this project was divided into two components, sample and automation. The sample goals were to advance from mercury spiked water to biological standards and ultimately to field samples. The automation goal was to progress from a manual fraction method to an automatic system. Throughout the course of the project, spiked water and biological standards were successfully separated in an automated system. Should the remaining goals eventually be met, one would be able to run a single method to obtain values for both total and methylmercury, making analysis of samples less time-consuming and significantly more cost-effective. **Haley Jostes** Advisor: Jeff Jeremiason, Chemistry and Environmental Studies
3:15 pm (virtual)	**RNA Degradation via Nonsense Mediated Decay** Nonsense mediated decay (NMD) is a specific messenger RNA (mRNA) degradation pathway in baker's yeast that requires the proteins Upf1p, Upf2p, and Upf3p. The NMD pathway functions to recognize and accelerate the degradation of some of a cell's naturally occurring mRNA (referred to as wild-type mRNA), as well as mRNAs that are aberrant such that they cause premature termination of protein synthesis. Two features known to cause recognition by NMD in wild type mRNA are a short upstream open reading frame or a long 3' untranslated region. Both are hypothesized to be required for NMD recognition of CTF13, which encodes a central protein in the yeast kinetochore. To test the hypothesis, plasmid DNA expressing Upf1p protein with an HA-tag (which allows for the isolation of the protein) was introduced into baker's yeast along with plasmids containing either wild-type or one of three variants of CTF13 mRNA—a variant lacking the short uORF in the 5' UTR, a variant lacking the abnormally long 3' UTR, and a variant lacking both these features. This project aims to test Upf1p for physical association with the mRNAs, and therefore NMD targeting, with each of these combinations by isolating the Upf1p protein and quantifying the amount of the CTF13 mRNA present. In the presentation, progress to date will be described and results will be discussed in relation to the next steps. **Nick Aney** Advisor: Jeffrey Dahlseid, Biochemistry and Molecular Biology
3:30 pm	**Kinematic Vorticity and Thermobarometry Conditions of the Wildhorse Detachment in the Pioneer Mountains Metamorphic Core Complex** Metamorphic core complexes are the result of large magnitude continental extensions. Detachments, which are low-angle normal faults, bound core complexes and helped bring middle to lower crustal metamorphic rocks to the surface. During Eocene extensional deformation in western North America, the Wildhorse detachment, a low-angle normal fault, helped exhume the Pioneer metamorphic core complex in Idaho. Tectonic fabrics in the deformed metamorphic fault rocks called mylonites preserve a record of deformation in the Pioneer metamorphic core complex. The microstructures in the mylonite fabrics show evidence of deformation from the creation of the Metamorphic Core Complex, and thermobarometry provides an understanding of the conditions under which they formed. Kinematic vorticity, which is a measurement of pure and simple shear strain, can be used to study deformation through a variety of methods. Calculating kinematic vorticity involves several methods of analysis through studying thin sections under a petrographic microscope. Multiple methods were required to get the best estimate of vorticity. Each method involves different microstructures in the samples, such as oblique foliation in quartz grains,

	feldspar clast orientation, and angles between shear bands and prominent foliation. Garnet-baring gneisses and magnetite-ilmenite layers were analyzed to constrain pressure and temperature condition. Given this assemblage, the GBAQ barometer was used to provide values ranging from 625°C to 675°C, while the ILMAT barometer gave average values ranging from 470°C to 565°C. This thermobarometry work was also done with magnetite and ilmenite to get a better estimation of the temperatures and pressures. These pressure and temperature conditions gave the context for the deformation. Shear band analysis and oblique foliation provided similar results for vorticity, however, the rigid grain net results had consistently smaller values. It could be concluded that the fabrics identified were asymmetrical meaning there was a high ratio of simple shear, with an estimated stress of 84 MPa and the recrystallized grain size ranges from 10-60 μm. **Isabella Johnson, Hannah Schroeder** Advisor: Rory McFadden, Geology
3:45 pm	**Ligand Synthesis and Cobalt Complex for Dehalogenation of Organic Compounds** Cobalamin is a bacterial coenzyme that dehalogenates pollutant organic compounds. One of these compounds, dichlorodiphenyltrichloroethane (DDT), was originally manufactured as an insecticide and remains a risk to the environment and human health. Here, we report initial progress on synthesizing a ring-like ligand molecule that has the ability to combine with cobalt to create a coordination complex with function similar to cobalamin. Compounds homopiperazine and pyridine-2-carboxaldehyde were combined in DCM and reduced with water-sensitive sodium triacetoxyborohydride. Reducing agent sodium borohydride proved to be not selective enough. The coordination complex will not have to abide by any of the biological limitations of bacteria, meaning it can be used in a broader range of situations. This coordination complex could have many applications spanning from wastewater treatment to bioremediation. **Korrina Hylen** Advisor: Melissa Denler, Chemistry