# 2015 Sigma Xi Symposium
# Schedule and Oral Paper Abstracts
# Gustavus Adolphus College
# May 1, 2015

| Session 1: Oral Presentations, Nobel Hall 201 | |
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| 2:30 pm | **Characterization of Cadmium Binding in Metalloprotein II**<br>Colleen Caldwell<br><br>Nereis diversicolor, a marine worm, is unique in its ability to survive in high concentrations of cadmium that would be lethal to other organisms. Investigation into this characteristic led to the discovery of metalloprotein II (MPII), a member of the myohemerythrin family. The affinity of MPII for cadmium makes it unique among the myohemerythrins, which normally bind iron. MPII is thus an interesting model for investigating protein-metal coordination. MPII for study was purified from Escherichia coli containing a synthetic plasmid coding for the N. diversicolor MPII sequence. As purified, MPII contains iron, which is removed before exposing the protein to cadmium, iron, or both. The binding was measured using UV-Vis and ICP-MS. Structural changes of the protein as bound to iron or cadmium were determined through nondenaturing PAGE electrophoresis. Our data suggest that MPII binds both iron and cadmium, with higher affinity for cadmium. Results from nondenaturing PAGE suggest that MPII may have structural variation when it is bound to cadmium versus iron.<br><br>Advisor: Brandy Russell |
| 2:45 pm | **Stromatolites of the Shakopee Formation (Ordovician, Minnesota): Ancient Shark Bay or Relict of a Precambrian Past?**<br>Tanner Eischen, John Berger<br><br>Microbialites are organosedimentary structures, formed by accretion of carbonate through interaction with microorganisms, producing layered (stromatolite) or unlayered (thrombolite, microbialite) forms. Major mechanisms of growth include trapping and binding of detrital carbonate, precipitation of micrite within microbial mats, and precipitation of cement on and within structures. Trapped-and-bound stromatolites, typical of modern marine environments, have dominantly clastic textures. In contrast, Proterozoic marine stromatolites commonly have clotted micritic fabrics with varying amounts of isopachous cement. Because the dominant mechanisms of growth vary in time and space, stromatolite textural analysis provides useful information about ancient environments.<br>The Shakopee Formation, consisting principally of dolomite and sandy dolomite, was deposited near the shoreline of a shallow, epeiric sea that covered the interior of North America during the Ordovician. Previous work suggests that modern marine stromatolites of Shark Bay, Western Australia are robust analogues for these stromatolites. This study examines Willow River stromatolite form and texture to better characterize the mechanism of formation. |

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| | We examined stromatolite form and texture in hand sample, polished slab, and thin section and compared observations to examples of both modern and Proterozoic stromatolites. The clotted textures and isopachus laminae of Willow River Stromatolites suggest in situ precipitation of fine-grained carbonate during microbial mat growth, rather than trapping of carbonate grains. Our analysis suggests that stromatolites from the Willow River Member differ substantially from modern marine forms, like those in Shark Bay, Australia, and that the precipitated stromatolites typical of the Proterozoic may be better analogues for these Ordovician forms.<br><br>Advisor: Julie Bartley |
| 3:00 pm | **Co-Expression of Wild-Type and Histidine-Tagged Fumarase in Saccharomyces cerevisiae**<br>Colleen Caldwell, Dan Kramer, Morgan Timm, Brianna Titus<br><br>Protein purification is a biochemical technique commonly taught in the undergraduate biochemistry laboratory. The Gustavus biochemistry laboratory curriculum includes the purification and subsequent analysis of fumarase, an enzyme involved in the citric acid cycle, from baker's yeast (Saccharomyces cerevisiae). The yeast strain used for this analysis has been genetically altered to include six additional histidine amino acid residues (a so-called "histidine tag") on the fumarase enzyme, which allows for purification using affinity chromatography specific to histidine. Historically, students in the biochemistry laboratory experience a great deal of variability in the quality of results that they obtain using this method. Common observations include variations in enzyme activity, enzyme stability, or both. With the goal of facilitating fumarase purification, we designed yeast strains that co-express wild-type and histidine-tagged fumarase in various ratios in order to minimize the possible de-stabilizing effects of the histidine tag. These strains were then tested for activity, and fumarase was purified and subjected to various tests of enzyme stability to determine the ideal ratio. The results of this investigation will inform biochemistry laboratory curricular improvements, with the hope of ameliorating the laboratory experience of undergraduate biochemistry students.<br><br>Advisors: Jeff Dahlseid and Brenda Kelly |
| 3:15 pm | **Effectiveness of Remediation Processes in Eutrophic Water Conditions of Crystal Lake, Hennepin County, MN**<br>John Berger<br><br>Runoff in urban freshwater lakes and streams is a growing problem in many Midwestern watersheds due to the growth of residential and agriculture development. This runoff leads to the introduction of excess nutrients into these urban lakes, resulting in eutrophic conditions (nutrient hyper-enrichment). Crystal Lake is a small (89 acres) lake located in the Shingle Creek Watershed of Hennepin County Minnesota, and was placed on Minnesota's list of eutrophic impaired waters in 2002. As a result, a 2009 EPA study assessed the nutrient concentrations in the lake and recommended lake quality remediation. In 2011, a flocculation plant was installed to remove phosphorus from the lake by cycling water out of the lake into holding tanks. Phosphorus in the water was then removed by adding an alum to the water in these tanks, causing a precipitate to form and the bound phosphorus could then be transported out of the watershed. the flocculation plant collected water quality data in the summers of 2012 and 2013 to evaluate the impact of remediation measures. The plant was not in operation |

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| | in 2014, due to lack of funding from the City of Robbinsdale.<br><br>The aim of this study is to compare water quality data as a function of remediation efforts. Total phosphorus, dissolved oxygen, and water clarity data collected during summer 2014 is compared to past lake data to examine the effect of the flocculation plant on water quality parameters. These data will give insight into the effectiveness of the flocculation plant as a method of phosphorus remediation for Crystal Lake as well as similar eutrophic watersheds. Preliminary analyses suggest that the flocculation plant has positively impacted water quality in the lake and should be considered for continued use.<br><br>Advisor: Julie Bartley |
| 3:30 pm | **How are mRNAs Targeted for Degradation in Cells?**<br>Kiefer L. Haug, Stephanie K. Marquardt, Cole T. Tucker, Luke Sandersfeld, Nick Ulen<br><br>RNA degradation is an important process in cellular gene regulation. The exosome, a multi-protein complex responsible for 3' to 5' mRNA degradation, requires the function of associated accessory proteins such as Ski7p. Non-stop mRNAs (mRNAs lacking a stop codon) and mRNAs without poly(A) tails are aberrant RNAs which are also degraded by the exosome. Exosome mediated decay (EMD) of wild type mRNAs requires a deadenylation-dependent decay step, whereas aberrant RNAs undergo non-stop RNA decay instead. SKI7 is a gene that codes for Ski7p, a protein responsible for molecular recognition of RNAs for EMD. The carboxy-terminal domain of Ski7p is necessary for non-stop degradation, but not decay of wild type mRNA.<br><br>Previous Gustavus students identified the SOK2 gene as encoding a potential exosome sensitive mRNA; thus the exosome may regulate the degradation of SOK2 mRNA, in turn affecting SOK2 expression. Testing the effects of SKI7 partial or complete deletions against wild-type exosomes can determine its effect on SOK2 mRNA concentrations. If complete deletion of SKI7 shows an increase in SOK2 concentration compared to wild type, then the EMD pathway is supported. Further, if a partial carboxy-terminal Ski7p deletion and wild-type exosomes show equivalent SOK2 concentrations, then the deadenylation-dependent step of the EMD pathway will be verified. In contrast, if the partial carboxy-terminal Ski7p deletion shows an increase in SOK2 concentration when compared to the wild type, then the non-stop degradation decay step is verified. Determination of the mechanism of recognition will further our understanding of how RNAs are targeted for decay.<br><br>Advisors: Jeff Dahlseid and Brenda Kelly |
| 3:45 pm | **History and Taphonomy of Bison Bones from the Des Moines River**<br>Dominic Delmont<br><br>Bison were extirpated in Minnesota before the 1850s. A recent discovery of a large number of bison bones in the Des Moines River near Jackson, MN raised questions about how these mammals became locally extinct and about the age and origin of these bones. Research last spring determined that the oldest bones had radiocarbon ages around 1000 BP and the youngest bones being approximately 200 BP, predating European settlement in the area. This project examines the transport history of bones in the river and seeks to determine the extent to which humans butchered or hunted these bison. |

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| | To answer those questions, we collected a total of 865 bones, with most of them being bison, from sandbars, banks, and within the shallow portions of the Des Moines River channel. Each bone was identified, catalogued and evaluated for taphonomic alteration, including burial, transport, predator/scavenger markings, and human modification such as cut marks. Most bones showed evidence of substantial transport in the river, with an average taphonomic grade of 2-3, indicating a substantial degree of transport. Many bones showed teeth marks from rodents, and a few showed evidence of modification by larger animals. Many bones show evidence of butchering, mainly cut marks on ribs and long bones. Because a substantial number of bones have tool markings indicating human modification, combined with the extraordinary concentration of bison compared to other bone types, we hypothesize that the Des Moines River in this area was a long-lived kill site that predates European bison hunters.<br><br>Advisor: Julie Bartley |
| 4:00 pm | **Improvement of Protein Purification for Biochemistry Laboratory through Elongation of the Yeast Fumarase Histidine Tag**<br>Haley J. Kubista, Alba Murillo Quiroga<br><br>Pure, isolated proteins are essential materials for enhancing our understanding of how biomolecules behave in cellular systems within organisms. Thus, a key focus of the biochemistry course laboratory curriculum at Gustavus Adolphus College is the technique of protein purification. Yeast fumarase is a protein enzyme that has a role in the citric acid cycle of the cell. A so-called tag, made up of six histidines and attached to the end of the fumarase structure, is used to facilitate the purification of this enzyme. The six histidine-tagged yeast fumarase is used as a tool to teach protein purification in the biochemistry course laboratory, and we sought to improve use of this system. It has been hypothesized that a longer, ten histidine tag may lead to more effective purification of yeast fumarase. Our project focused on elongating the original six histidine tag of yeast fumarase to a ten histidine tag using molecular genetic techniques. The expression and function of the resulting protein was tested to confirm that the ten histidine tagged fumarase is expressed in yeast and that it is still able to function as an enzyme. Our desired outcome is for the ten histidine tag to be effectively attached to the yeast fumarase protein without hindering the function of the enzyme. If we succeed, then the ten histidine-tagged yeast fumarase can be used in the biochemistry labs at Gustavus to help future students achieve greater success in learning protein purification technique.<br><br>Advisors: Jeff Dahlseid and Brenda Kelly |
| 4:15 pm | **Measuring Knickpoint Migration in Ravine Z, Seven Mile Creek Park, Nicollet County, MN**<br>Michael Dickens<br><br>The Minnesota River is facing increased amounts of sediment loads, which are a result of sediment erosion in the rivers watershed. One main way that ravines erode is through knickpoint migration, which happens as water flows over a tougher material, and falls onto a softer material, creating a back-cutting and over-steepening effect at the toe of the knickpoint; material from the bottom of the ravine is mobilized in this process and is transported down the ravine into the Minnesota River. Deciphering the role of knickpoint migration in sediment loading on the Minnesota River requires examination of a single ravine and its knickpoints over a span of several years. Seven Mile Creek, a tributary to the Minnesota River in Nicollet County, is an ideal location to study the factors that |

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| | contribute to knickpoint migration. Ravine Z, a prominent ravine in Seven Mile Creek Park, Nicollet County, MN, is a very active eroding channel that is largely fed by farm drainage tiles. A digital elevation model and surveying tools were used to make a series of slope profiles. Those rates where then compared when looking at the time and the amount of precipitation happened between each series of slope profile. Rapid knickpoint migration in Ravine Z was found when there were larger amounts of high intensity precipitation events.<br><br>Advisor: Laura Triplett |
| **Session 1: Oral Presentations, Nobel Hall 222** | |
| 2:30 pm | **Sodic Amphibole in the Ely Greenstone: What Can We Learn about Ancient Plate Boundaries?**<br>Scott Hauer<br><br>Metamorphic rocks, formed by heat and pressure, are one of the best geological records of conditions deep within the earth. The Ely Greenstone, in northeastern Minnesota is an Archean (~2.7 billion years old) metamorphic rock formed at a plate margin, when two pieces of earth's crust collided. Did this plate boundary have temperature and pressure conditions similar to modern collision zones, or were they very different?<br><br>Previous studies have suggested that the collision that produced Ely Greenstone experienced moderate temperature and pressure conditions (greenschist and amphibolite facies metamorphism), contrasting with rock formed in similar settings today, which experiences lower temperature relative to pressure (blueschist facies). Recent examination of the Ely Greenstone revealed a sodic (blue) amphibole. This blue mineral is intriguing because the sodic amphibole glaucophane is indicative of high pressure, low temperature metamorphism (blueschist facies). A different blue amphibole, riebeckite, would indicate greenschist or amphibolite facies. Thus, identification of this mineral will help constrain the temperature and pressure conditions that produced the Ely Greenstone, perhaps challenging previous hypotheses about Archean plate tectonics. To answer this question, thin sections were analyzed by transmitted and reflected light microscopy, electron microprobe and x-ray diffraction, to determine the chemical composition of the amphibole.<br><br>These analyses indicate that the Ely Greenstone experienced at least two episodes of metamorphism and the sodic (blue) amphiboles are most likely riebeckite and magnesio-riebeckite, suggesting that greenschist to amphibolite facies metamorphism, rather than modern style blueschist facies metamorphism, characterizes the Ely Greenstone.<br><br>Advisor: Jim Welsh |
| 2:45 pm | **Possible Temporal Differences in mRNA of Arabidopsis Thaliana Ribosomal Protein S15 Gene Family**<br>Michelle Hulke<br><br>rpS15-1 and rpS15-4 are homologous genes that code for the S15 protein present in the small subunit of the ribosome. While six homologous genes exist in the S15 gene family, only rpS15-1 and rpS15-4 are transcribed at a noticeable frequency. The resulting proteins |

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| | differ by a single amino acid causing a large chemical property difference and could have resounding effects in the structure and function of the S15 protein. The S15 protein is located within the ribosome so as to interact with mRNA being transcribed in the a site of the ribosome, possibly functioning in codon recognition. Ribosomal function may change depending on which S15 protein is present and may infer benefit to different developmental stages in the early growth of the plant. mRNA levels of rpS15-1 and rpS15-4 are currently being quantified using two-step quantitative real time polymerase chain reaction (qRT-PCR) to analyze changes in mRNA during the first two weeks after seed germination. mRNA quantities within whole plant tissue suggests the ratio of S15-1:S15-4 protein present within the ribosomes. By better understanding the distribution of mRNA levels between the two homologs, the role of the S15 protein within the ribosome and how it contributes to the overall ribosomal function in cellular and tissue development can be extrapolated.<br><br>Advisor: Colleen Jacks |
| 3:00 pm | **Image Analysis of Impact Breccias in Victoria Crater on Mars Supports the Presence of Water in Mars' Distant Past**<br>Serenity Mahoney<br><br>Large impact craters on Mars, like Victoria Crater located in Meridiani Planum, are windows into the planet's past. Impact craters mark every planetary body in our Solar System, and unlike Earth, Mars is free of the vegetation and liquid water that can obscure these craters. Visible craters are commonly used by geologists to study the geology of an area, and even more intriguing on Mars, the geology of the subsurface. Bordering these craters are breccias, rocks composed of broken fragments of minerals or rocks cemented together by a matrix, which were analyzed by the Martian Exploration Rover Opportunity. Breccias are especially useful rocks to derive information from, as their formation is a result of a series of events; the breaking up the original rock, transporting it to another location and finally the re-deposition and cementation of the material. After careful analysis of Victoria Crater by the rover Opportunity, the pancam instrument found evidence of bedded layers in the crater, which were deposited by fluvial processes, which was confirmed by sulfate-rich material detected by the rover's Alpha Particle X-ray Spectrometer. By analyzing images of the breccias taken by Opportunity's pancam instrument using software like the program ImageRover, direct measurements of the orientation of the clasts within the breccias, and their shape and size, are obtainable. Studying the specific characteristics of the breccias supports the hypothesis that the breccias interacted with water, suggesting that calibrated, high-resolution images can be used instead of, or in addition to, chemical analysis to detect activity of water in Mars' distant past.<br><br>Advisor: Julie Bartley |
| 3:15 pm | **Characterization of the Binding Between Clock and Per Circadian Proteins Via Mammalian Two-Hybrid Assay**<br>Hana Fischer, Stefano Rosati, Monica Johnson<br><br>The circadian clock is a 24 hour cycle that is tightly regulated by various circadian proteins within many organisms. The proteins cryptochrome (CRY), period (PER), and circadian locomotor outlook cycles kaput (CLOCK) are some of the key players of this signaling pathway. In this study, we aim to further elucidate the mechanism of the circadian cycle by characterizing the binding interaction between these central proteins. In previous |

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| | work, binding interaction between CRY and PER was characterized via mammalian two-hybrid assay. Findings from the negative control of this assay showed that PER fused to a DNA binding domain (BIND) interacted strongly with a transcriptional activation domain (ACT). Since ACT and CLOCK have similar sequences and share similar surface residues, it is predicted that PER will also bind CLOCK. for this experiment, PER and CLOCK were cloned into plasmids to fuse them to ACT and BIND, respectively, and these components were used to carry out a mammalian-two hybrid assay utilizing a luciferase reporter. Mutations were made on CLOCK surface regions that were highly charged and projected outwards. Evidence of binding between PER and CLOCK could suggest that CLOCK has transcriptional activating roles in addition to its other functions. Furthermore, since PER-CLOCK binding has yet to be characterized in other studies, evidence of binding would represent a novel finding within the circadian cycle mechanism.<br><br>Advisor: Karla Marz |
| 3:30 pm | **Sediment Analysis in Ravines, Seven Mile Creek Park, Nicollet County, MN**<br>Zach Severson<br><br>Seven Mile Creek is fed by a network of ravines as it enters the Minnesota River in Nicollet County, Minnesota. The Tributaries that feed the Minnesota River flow across unconsolidated glacial till. The abundance of easily eroded material makes the Minnesota River receives enormous amounts of sediment from its tributaries. Tributaries change very rapidly and experience significant sediment migration within the ravines they form. Ravines are a major part of the Seven Mile Creek Watershed, understanding the sediment in the ravine can help comprehend how the watershed formed. This project analyzes the size and distribution of sediment throughout a ravine in Seven Mile Creek Park. The sand reveals patterns in size from the head of the ravine to the path of Seven Mile Creek. The sand reveals a common pattern comprised of mostly very fine to fine grains but also including silt and medium grains. The Ravine had many layers; samples were taken from these sand layers to understand the sand distribution and size. Data is still being gathered and tested. Maximum grain size will be an indicator of water flow energy in the ravine. The degree of sorting will indicate the flow consistency in the ravine. A very poorly sorted sediment may have been deposited mainly by gravity, while a layered, well sorted deposit may indicate many alluvial flow events.<br><br>Advisor: Julie Bartley |
| 3:45 pm | **Deposition of Polymer Films in DC Plasma**<br>Nathan Huber<br><br>Polymer film deposition is widely applicable for corrosion prevention. In this study polymer films were applied to metal surfaces by way of DC plasma. The project goals were to better understand how these polymer films form, how to analyze surfaces on the micrometer scale, and how to create the films in a consistent manner. This presentation will introduce the process of depositing polymer films, summarize the results from the research program, and cover future goals of this project.<br><br>Advisor: Charles Niederriter |

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| 4:00 pm | **Stratigraphy of Gale Crater and Mount Sharp: Implications for Martian Paleoenvironment**<br>Zach Van Orsdel<br><br>As Curiosity continues to traverse the surface of Mars, we are presented with a unique opportunity to decipher the processes that formed the sedimentary rocks of both Mount Sharp and the surrounding Gale Crater, the region that Curiosity now explores. Prior to rover exploration, several hypotheses had been advanced to explain the horizontal layers seen in the lower portions of Gale crater, the slightly dipping layers, whose chemistry varies between phylosilicates and sulfates, of the lower portion of Mount Sharp, the slightly steeper dipping beds of the upper portion of Mount Sharp, and the unconformity between the two portions of Mount Sharp. The se hypotheses vary widely – invoking ancient geologic processes as disparate as lake deposition, hot springs, glaciers, and wind transport. Each of these hypotheses makes a distinct set of predictions about the rocks in Gale crater; therefore, Curiosity's observations can be used to test hypotheses about ancient and ongoing geologic processes on Mars. This project examines several hypotheses and links each to a set of expected geological features, which are then tested against orbiter and rover data. Based on the literature and this author's examinations of the available data, the sedimentary rocks of Mount Sharp were most likely formed by sediments transported by wind and deposited in the complex impact structure of Gale crater.<br><br>Advisor: Julie Bartley |
| 4:15 pm | **Assessing Botrychium Populations Based on Belowground Gametophytes and Root Fragments**<br>Matthew Gullickson, Reina Nielsen<br><br>Botrychium are small ferns in the Ophioglossaceae family which reproduce via spores that develop into belowground gametophytes. The globular shaped gametophytes have the potential to stay dormant belowground for several years. Botrychium depend on mycorrhizae, which are negatively affected by invasive earthworms. Invasive worms are known to affect rare populations such as B. mormo. To estimate the impact of earthworms, this study repeated a study conducted in 2002. Belowground samples were collected in 2012 and compared with the results in 2002. Additionally, permanent plots were established and soil samples collected to gather baseline data. The soil samples were centrifuged and analyzed for belowground structures. Relatively few belowground structures were found in 2012. We conclude that Botrychium populations have not rebounded since 2002, and it appears these populations are nearing local extinction.<br><br>Advisor: Cindy Johnson |

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| 4:30 pm | **UV-Vis Characterization of Copper(II) and Nickel(II) Metal-Ligand Complexes**<br>**Guillermo Turcios**<br>Anna Huff<br><br>The Copper(II) and Nickel(II) transition metal ions were partially ligated by pyrazole and indazole in ethanol. The metal-ligand complexes were characterized by UV-Vis absorption spectroscopy by collecting spectra for solutions (over the 370-800 nm range) in which the metal ion concentration, ligand concentration, and ionic strength are varied. Statistical deconvolution on the resulting spectra is employed to determine individual absorption profiles and equilibrium constants for the sequential complexation reactions which drive formation of the complexes.<br><br>Advisor: Steve Miller |
| **Sigma Xi New member reception**<br>**5:00 Nobel Hall Atrium** | |