

2012 Sigma Xi Symposium Abstracts

Gustavus Adolphus College

May 4, 2012

Session 1: Oral Papers

Nobel 201 and Nobel 222

Session 1A: Nobel 201	
2:30 pm	<p>Spatial Distribution and Fate of Trace Metals in Ombrotrophic Peat Bogs Nick Alverson Advisors: Jeff Jeremiason and Laura Triplett</p> <p>Atmospheric deposition of heavy metals and other pollutants has substantially increased due to human activities over the past several hundred years. For some metals such as lead, arsenic, and mercury, these changes have been well studied due to potentially harmful impact to human and ecosystem health. However, some aspects of metal transport and storage in the environment are still not understood; for example, metal mobility in peat bogs is complex and not well constrained. Sediment cores from an ombrotrophic peat bog in the S-2 Watershed in Marcell Experimental Forest, Northern Minnesota were examined to determine potential drivers of element mobilization or remobilization in a wetland/bog environment. Sediments and pore waters were analyzed for metal concentration, and core transects showed clear trends in the metal concentration from upland sites higher in the watershed to the peat bog. The trends were then compared with the hydrology of the watershed, as well as background studies of the elements to determine their potential fate.</p>
2:45 pm	<p>Methylmercury Dynamics in the Porewaters of an Ombrotrophic Peatland Alison Agather Advisor: Jeff Jeremiason</p> <p>In this study we examined the biogeochemistry of mercury in an ombrotrophic peatland located at the S2 watershed in the Marcell Experimental Forest, MN. Mercury, methylmercury, and cation concentrations were measured to identify important zones of methylmercury formation. We also examined how the transport of mercury and cations related to the conversion of mercury to methylmercury. Results show that a significant amount of mercury and cations enter the lagg from the upland during rainfall events. Methylmercury levels in the upland were low relative to levels in the lagg and bog. The highest methylmercury levels were often found along the lagg margin that were also typically higher in total mercury, suggesting that mercury from the upland is possibly being methylated as it enters the lagg via upland runoff.</p>

3:00 pm	<p>Sediment Core Analysis of Lakes in Alaska and Newfoundland Michael Walker Advisors/Coauthors: Jeff Jeremiason, GAC; Dan Engstrom, Science Museum of MN; William Fitzgerald, University of Connecticut</p> <p>Sediment cores, dating back to the beginning of the industrial revolution, were analyzed for eight lakes in Alaska and Newfoundland, Canada to assess the potential impact of increased industrialization in the Far East on the transport of airborne contaminants to Alaska. Cores were sectioned and dated using the ^{210}Pb method prior to be sent to Gustavus. Inductively coupled plasma mass spectrometry was used to determine the concentration of many metals within the cores, with a particular focus on lead and lead isotope ratios. Significant increases in the flux of aluminum suggest heavy erosional inputs from several of the lake watersheds. Furthermore, continued increases in Pb deposition and an appreciable decrease in the ^{206}Pb:^{204}Pb ratio since the early 1970s was seen for the Alaskan lakes.</p>
3:15 pm	<p>Sediment Exchange between a Marsh and an Adjacent Submersed Aquatic Vegetation (SAV) Bed in Chincoteague Bay, MD Andrea Eglinton Advisor: Laura Triplett</p> <p>In recent years, coastal marshes and submersed aquatic vegetation (SAV) beds within the Chesapeake Bay have been diminishing in area with rising sea level and warming of the bay. Understanding what is affecting sediment deposition in the marshes could help the efforts being made to preserve them, and sediment provided from offshore SAV diebacks could be playing a major role. A transect of sediment cores, one within an SAV bed and four within an adjacent marsh, were collected and analyzed for grain size and organic matter content. These parameters, along with ^{210}Pb dating, were used to assess possible linkages between the SAV bed and the marsh. The SAV core was characterized by large median grain size (1-2 phi) and low organic content (<10%), with two separate dieback events indicated in the core. These events occurred from 2004-2006 and 2009-2011 and thinned out landward of the SAV bed. Prior to 2004 there were no SAV dieback events to be seen, but SAV diebacks due to recent increases in ocean temperature are now providing a large amount of sediment to the marsh.</p>
3:30 pm	<p>Comparison of Marine and Terrestrial Climate Models to Geologic Evidence from the Permian-Triassic Boundary Todd Kremmin Advisor: Laura Triplett</p> <p>The Permian-Triassic extinction ~252.6 million years ago represents the most severe mass extinction ever recorded. The cause of this extinction is uncertain, but recent studies in paleoclimate modeling can constrain conditions during this time. The purpose of this study is to determine how well modeled marine</p>

	<p>and terrestrial climatic conditions at the Permian-Triassic Boundary correlate to geologic evidence from that time period. The analysis is divided into three assessments: (1) a qualitative correlation of marine and terrestrial climate zones with geologic evidence, (2) a “hits” versus “misses” correlation analysis, (3) and a statistical correlation using a 1-proportion z-interval test at a 95% confidence level. The results support a strong correlation between the model results and geologic evidence, showing an average statistical 95% confidence level range of (.6788, .8533) throughout the Changhsingian and Induan stages of the Permian-Triassic Boundary. In conclusion, the model results can be used with a high degree of confidence and significantly improve our understanding of paleoclimate.</p>
3:45 pm	<p>Gunflint Iron Formation Microfossils Joe Curran Advisor: Julie Bartley</p> <p>The Gunflint Iron Formation was deposited during the early Proterozoic, shortly after the Great Oxygenation Event, when the atmosphere and oceans became oxygenated for the first time. Eosphaera and Kakabekia are two fossilized genera of microfossils that are found in the Gunflint, but they likely had different habitats, with Kakabekia living in or near stromatolites and Eosphaera living somewhere away from the stromatolites. Eosphaera’s morphological similarity with the modern Volvox genus indicates that Eosphaera most likely had a similar photosynthetic metabolism. This means that Eosphaera probably lived in an oxic zone in the water above or near the stromatolites.</p>
4:00 pm	<p>Strain Analysis of Archean, Metasedimentary Rocks in the Virginia Horn Robert Holder Advisor: Jim Welsh</p> <p>The “Virginia Horn” is a prominent anticline/syncline pair in Proterozoic rocks of the Mesabi Range. The fold pair exposes a sequence of Neoproterozoic basement rocks. This study uses Rf/Φ strain analysis on lithic and quartz clasts from these rocks to quantify their deformational history. The lithic clasts record constrictive strain (χ^2-method: $k=1.53$, $i=1.31$; harmonic mean: $k=1.69$, $i=1.41$). The quartz clasts record milder plane strain (χ^2-method: $k=0.82$, $i=0.37$; harmonic mean: $k=1.19$, $i=0.95$). If the two grain types were originally ellipsoidal, randomly oriented, and deformed equally, they should record the same strain. Due to lower precision of lithic clasts’ measurements, the quartz grains are interpreted to represent a better record of the strain history.</p>

Session 1B: Nobel 222	
2:30 pm	<p>Renewable Energy: Development of Undergraduate Laboratory Exercises in a Sustainable Energy Paradigm Amy Audette and Kevin Clark Advisors: Charles Niederriter, Jeff Jeremiason, Colleen Jacks, Dwight Stoll</p> <p>New lab experiences are being developed to take advantage of increasing environmental awareness on college campuses. A wind monitoring station capable of collecting wind speed and direction data was installed to assess the potential for energy production at that site. In addition, a Skystream turbine was installed on the edge of campus. An experimental geothermal loop was installed and plans for a heat pump capable of exchanging thermal energy are presented. Potential for undergraduate laboratory exercises based on analysis of E. coli fermentation products for ethanol content have also been investigated. Additionally, the development of a two-dimensional gas chromatography system capable of performing complex separations involving biodiesel was initiated. We will discuss incorporation into existing courses, promotion of further research, and report on preliminary results.</p>
2:45 pm	<p>Development of a Time-Of-Flight Mass Spectrometer Using Radial Extraction from a Linear Quadrupole Ion Trap Brandon J. Furey Advisor: Jessie Petricka</p> <p>The primary objectives were the development of a linear quadrupole ion trap (LQT) and a time-of-flight (TOF) mass spectrometer. The LQT functions by forcing ions into a stable trajectory controlled by radio-frequency electric fields. A general overview of the development and operation of the LQT will be discussed. The ions that are currently being studied are produced by laser ablation which produces a plume that of multiple different molecules. In order to identify the trapped ions, a TOF mass spectrometer was developed and assembled. The ions are radially extracted from the LQT with a particular energy and accelerated through the drift tube. By measuring the TOF, the mass of the ions can be determined. Further discussion of the TOF device and other projects will follow.</p>
3:00 pm	<p>Cadmium Binding and Dimer Formation in Metalloprotein II Sarah Lucht Advisor: Brandy Russell</p> <p>We examined the metal-binding properties of a new cadmium-binding protein from the cadmium-resistant annelid <i>Nereis diversicolor</i>. Though this protein, metalloprotein II (MPII), has high sequence homology to a monomeric, iron-binding protein (myohemerythrin, myoHr), there is some evidence that the cadmium-bound MPII is dimeric. We have developed an expression system for both MPII and myoHr in <i>Escherichia coli</i> and established that both proteins are monomeric and can bind iron in the absence of cadmium. In this work, native</p>

	<p>gel electrophoresis was used to monitor possible dimer formation upon exposing MPII to Cd(II). We also performed site-directed mutagenesis to replace cysteine36 with a serine to eliminate Cys36 as a potential binding site. Comparison of cadmium binding of C36S-MPII and wild-type MPII will help establish whether Cys36 is involved in cadmium binding in MPII.</p>
3:15 pm	<p>HPLC Method Development and Verification for the Analysis of Imazamethabenz-methyl Megan Crow Advisors: Amanda Nienow and Dwight Stoll</p> <p>Imazamethabenz-methyl is an herbicide commonly used in the Midwestern U.S. on crops such as corn, soybeans, and alfalfa. Imazamethabenz-methyl is from the imidazolinone class of pesticides and exists as two constitutional isomers. It has been found that the two isomers degrade at different rates when undergoing photolysis. The goal of this study was to develop a method for separating the isomers analytically using high performance liquid chromatography (HPLC). A solution containing both isomers is irradiated under UV light and analyzed using the developed HPLC method. Analytic separation allows for the determination of rate constants for individual isomers. Future directions will include determining hydrolysis rates constants of the two individual isomers.</p>
3:30 pm	<p>Hatch plasticity in sheepshead minnow embryos in response to predators Ethan Degner Advisor: Joel Carlin</p> <p>Hatch plasticity, the ability of embryos to alter hatch timing to minimize stage-specific risks, is investigated for the first time in the sheepshead minnow <i>Cyprinodon variegatus</i>, an ecotoxicological model organism. We reared <i>C. variegatus</i> embryos in the presence of a predation stimulus, the mummichog <i>Fundulus heteroclitus</i>. We measured mean hatch timing of <i>C. variegatus</i> eggs reared with two treatments of <i>F. heteroclitus</i>; those fed an innocuous diet of commercial flake food and those fed the same diet supplemented by <i>C. variegatus</i> eggs. Preliminary data suggest that eggs raised in the presence of this predator do not significantly alter hatch timing. We discuss both reasons for the lack of observed hatch plasticity in this experiment and the need for ecological studies of ecotoxicological model organisms.</p>
3:45 pm	<p>The Voices of Hidden Memories and Brain Arousal Krista Primley Advisor: Sanjive Qazi</p> <p>Brain arousal during an interview or performing a cognitive task can reveal implicit memories of human subjects. Preliminary studies have shown significant brain arousal for subjects undergoing priming in emotive interviews. The changes are a result from the activity of the sweat glands in response to sympathetic nervous stimulation—due to emotional arousal. Using XLSTAT-CCR sophisticates our data and reduces variables. We use</p>

	<p>multivariate statistical techniques and time series analysis to create correlations between the GSR readings, the interview, the surveys, and facial expressions of each subject. These correlations reduce the number of variables in the data and allow us to single out variables to test in similar further studies. We will compare statistical power of the multivariate techniques for sample size determinations for future experiments.</p>
4:00 pm	<p>Magnesium Impacts Conformational Changes in Myosin V Motor Protein Anja Swenson Advisor: Christopher Yengo, Penn State College of Medicine</p> <p>We examined the impact of temperature and free magnesium concentration on monomeric FIAsh labeled myosin V (MV FIAsh), dimeric myosin V (MV HMM), and dimeric fast skeletal muscle myosin II (SK HMM) using ATPase and motility assays. The conformation of the nucleotide binding pocket was examined using FRET in which MV FIAsh participates in energy transfer with mant labeled nucleotides. Transient kinetics studies of mantADP binding/release with actomyosin V FIAsh demonstrate the equilibrium between opened and closed nucleotide binding pocket conformations is dependent on magnesium and the closed state stabilized with magnesium, which correlates well with the ATPase and motility results. Our results indicate magnesium impacts key conformational changes in the nucleotide binding pocket, giving insight into the structural mechanism of ADP release in MV.</p>

Part 2: Poster Papers
In association with the *Celebration of Creative Inquiry*
5:00 pm – 7:00 pm; Jackson Campus Center

Mineralogy of Crystal and Matrix: Implications for Preservation of Dinosaur Bones

Amanda Adams

Advisor: Julie Bartley

The Wyoming Dinosaur Center is located on a portion of the Morrison Formation, a geologic deposit in the western US known for prolific dinosaur fossils. In about 15 years of operation, the quarries have produced at least 3 genera of dinosaurs belonging to more than 15 individuals. The WBS quarry has yielded a single sauropod called *Camarasaurus*, buried in a matrix of lithified clay and silt. Early preparations of a premaxilla found in 2011 have uncovered both isolated and clustered grains of unidentified minerals. Based on previous work done on bones recovered from the same quarry it is known that these crystals are often found in association with the fossils, on the surface as well as in the interior of the bone. Using X-ray diffraction I plan to analyze the mineralogy of all isolated crystal types to identify the specific minerals present. Furthermore, I plan to use a comparison between the mineralogy of the crystals and the surrounding clay matrix to determine the environmental conditions present at the time of fossilization and whether these conditions might explain the observed deteriorated condition of the bones.

Hatch plasticity in sheepshead minnow embryos in response to predator presence

Ethan Degner

Advisors: Joel Carlin and Sandy Raimondo, US Environmental Protection Agency

Hatch plasticity, the ability of embryos to alter hatch timing to minimize stage-specific risks, is investigated for the first time in the sheepshead minnow *Cyprinodon variegatus*, an ecotoxicological model organism. In this study, we reared *C. variegatus* embryos in the presence of a predation stimulus, the mummichog *Fundulus heteroclitus*. We measured mean hatch timing of *C. variegatus* eggs reared with two treatments of *F. heteroclitus*; those fed an innocuous diet of commercial flake food and those fed the same diet supplemented by *C. variegatus* eggs. Preliminary data suggest that eggs raised in the presence of this predator do not significantly alter hatch timing. We discuss both reasons for the lack of observed hatch plasticity in this experiment and the need for ecological studies of ecotoxicological model organisms.

Mapping the Period (PER) binding surface of the circadian clock protein Cryptochrome (CRY)

Audrey Messelt and Mariecus C. Jarvis

Advisor: Karla Marz

A circadian rhythm is an internally driven cycle with a period of 24 hours. While the effects of these rhythms (including regular variations in alertness, body temperature, and appetite over 24 hour periods) are observable on a macroscopic level, the core clock mechanisms that drive and set the rhythms must be studied on microscopic and molecular levels. Our research focuses on two circadian clock proteins, Cryptochrome (CRY) and Period (PER), and their interactions. CRY and PER act as part of a feedback loop that creates a rhythm of rising and

falling protein levels that repeats every 24 hours. The two proteins must move from the cytoplasm to the nucleus in order to accomplish their role in the circadian feedback loop and PER binds CRY in order to consistently make this change in location. Previous research by other labs has identified three mCRY1 and mCRY2 (mouse CRY1 and 2) mutations that reduce mCRY-mPER interactions. Our work involves examining the effects of mutations that fall in regions between these previously identified mutations on the binding of mPER by mCRY. Coexpression of mPER1/2 and mCRY1 in mammalian cells has allowed identification of three mCRY1 surface mutations (E108R, D184K/D185K, and E482R) that do not affect mPER1/2-mCRY1 interactions, as indicated by protein localization observed via immunocytochemistry. Other mCRY surface mutants will continue to be examined for their effects on mPER-mCRY interaction in order to determine the importance of different regions of the CRY surface for binding of the two proteins.

Awareness of Attentional System and Spatial Judgments

Jean-Paul Noel and Anthony Mefford

Advisor: Lauren Hecht

Spatial judgments and estimates play a fundamental role in the construction of the visual world. This perception is deeply influenced by the loci of an individual's attentional system and the reference point undertaken when making these estimates. In this study it was hypothesized that exocentric, but not egocentric, spatial estimates would be enhanced by meta-awareness. Furthermore, it was predicted that this effect could be replicated through the process of perceiving oneself from a third person's point of view. In Experiment 1, participants completed the Sustained Attention to Response Task while periodically making depth or segment length estimations. Results confirmed the hypotheses; performance increased for participants in a state of meta-awareness with respect to segment length estimates, but did not for depth estimates. In Experiment 2, a third set of participants estimated distances both egocentrically (i.e., relative to their body) and exocentrically (i.e., relative to an external point), either under natural viewing conditions (i.e., egocentric perspective) or when watching themselves in a virtual reality environment (i.e., exocentric perspective). Results indicated that from an exocentric perspective participants underestimated both egocentric and exocentric distances; however, from an egocentric perspective participants underestimated exocentric distances and overestimated egocentric ones. From these results it can be concluded that although participants do perceive exocentric distance more accurately when conceptually distant from their own attentional system, the processing mechanism underlying this effect is not a purely visual mechanism as the effects were not replicated when participants viewed themselves from a third person's point of view.

Toward Developing Intramolecular Diels-Alder Reaction Involving 2-trialkylsiloxyfurans

Michael Sterling

Advisor: Scott Bur

Initial attempts at developing an intramolecular Diels-Alder reaction involving 2-trialkylsiloxyfurans were unsuccessful. NMR and computational studies provided new insight into the reaction dynamics of intermolecular reactions. Based upon these intermolecular insights, new substrates for the intramolecular reactions were designed. Progress has been made on synthesizing the new substrates. Additionally, better understanding of the individual substrates has been achieved through separations and mass spectrometry.

Morphological and Molecular Genus Placement of the Gulf of Mexico Snakefish (Trachinocephalus myops)

Kimberly Sukhum

Advisor: Joel Carlin

Trachinocephalus (snakefish) and Synodus (lizardfish) are sister genera in Synodontidae, a family of eels that inhabit temperate to tropic waters along the Gulf of Mexico. The Synodus genus is species rich, and its species vary moderately in body shape and fin arrangement, while the Trachinocephalus genus has only one species, which has historically been mistaken as a Synodus species. Both genera have had little scientific investigation and represent a large area for potential study. In an effort to determine appropriate systematic placement of Trachinocephalus myops, both molecular and morphological characteristics of Synodus and Trachinocephalus fish were observed. DNA was extracted and sequenced along a mitochondrial locus, called the Barcode of Life. These sequences were used to build phylogenetic trees. Morphologically, morphometrics and meristics were compared between and within genera to build phylogenetic trees. The tree analysis further illustrated the Synodontidae evolutionary complexity, as well as adding insight into the genera placement of Trachinocephalus myops.

Determining Dispersal Patterns of Benthopelagic Fishes by Comparing Genetic Code and Calculating FST

Grant Walters

Advisor: Joel Carlin

The inshore lizardfish Synodus foetens is a small benthopelagic fish that is common throughout the Gulf of Mexico and has hardly been studied. It is an ideal organism to study due to its presence in the Gulf of Mexico and lack of focus from commercial fishing. It will be useful in studying how the Deepwater horizon oil spill and the hypoxia and anoxia have affected the Gulf of Mexico ecosystem. Samples of fish were taken from distant longitudes in the Gulf of Mexico, and samples from proximal locations were also taken. Mitochondrial Cyt-b sequencing of 18 specimens and phylogenetic analysis allowed a determination of diversity between Synodus foetens specimens.

Synthesis of Chiral "Propeller" Trisphthalocyanine Complexes

Alexandria Ceranske and Biao (Toby) Tong

Advisor: Tom Gardner

Chiral trisphenanthroline metal complexes of e.g., Co^{3+} and Ru^{2+} are conformationally resistant to inversion of stereochemistry, and therefore might make good core structures for large chiral molecules with a propeller shape, using phthalocyanine or porphyrin complexes as "blades" of the propeller. The required A3B type of benzoporphyrazine derivatives have been reportedly synthesized by ring expansion reactions of subphthalocyanines. Using such unsymmetrically substituted metallated benzoporphyrazines as the ones with selenium-containing heterocycles as precursors, complexes with potentially noteworthy catalytic properties can be produced. The goal of this project has been to synthesize such complexes and investigate their physical, spectral, and catalytic properties once they have been made. This poster will present our findings to date, as well as those of the attempted synthesis of a new type of porphyrin with edge-bound aromatic nitrogen ligands.

Preparation of Covalent and Coordination Polymers Containing Phthalocyanine Units

Greg Wiessner and Emma Motl

Advisor: Tom Gardner

Our project involves building both covalently and coordinatively bound polymers that contain phthalocyanine units that are also well-soluble in organic solvents. To do this, we needed to reduce the four-fold symmetry of phthalocyanine down to two-fold, which we are doing by a combination of steric blocking and by using reactions between donor diiminioisindoline and acceptor trichloroisindolenine precursors. The parts of the polymer that bridge the phthalocyanine rings are either covalent aromatic rings like the pyromellitic group, or coordination polymers. It is hoped that polymers such as these might someday exhibit interesting electronic, magnetic, or chemical sensing properties.

Approaches to the Synthesis of a Novel Bifacial Ligand, 1,6,7,12-Tetraazaperylene

Michael Howe

Advisor: Tom Gardner

1,6,7,12-Tetraazaperylene is a conceptually useful ligand for constructing coordination polymers with potentially interesting electronic and magnetic properties. However, the synthesis of this compound has been elusive to synthesize, and has only been reported recently through an inconvenient starting material that is not easily customizable. Our approach has been to mimic the reported synthesis of the similar compound, sampangine, which is itself prepared in two steps beginning with a hetero Diels-Alder reaction of crotonaldehyde dimethylhydrazone and a bromoquinone to yield the intermediate compound cleistopholine. In our attempts to reproduce the reported synthesis of the analogous intermediate, 4,8-dimethyl-1,5-diazaanthraquinone, we observed a different product than reported in the literature. Our poster shall discuss our attempts to circumvent this, and to achieve our desired synthetic goal.

Evaluation of phosphinic and phosphonic fluorosurfactant mixtures as possible PFOA replacements in PTFE emulsion polymerization

Anthony J. Cesnik

Advisors/Coauthors: Todd S. Sayler, Richard E. Fernandez, Joseph S. Thrasher; University of Alabama; Brian O'Brien, Gustavus Adolphus College

The emulsification capabilities of the fluorosurfactant mixture MAFS-010, produced by Merck KGaA, was evaluated and applied to fine-grained PTFE polymerization. An effective analysis procedure was developed for polymerization mixtures, including polymer sample preparation by drying and washing the latex. The stability and efficacy of MAFS-010 components in PTFE emulsion polymerizations is discussed. P-31 and F-19 NMR spectroscopies were used to determine the component structures and percent composition of MAFS-010: 85% ammonium bis(perfluorobutyl)phosphinate, 5% ammonium hydrogen perfluorophosphonate, and 10% co-products. An effective CMC determination for non-binary solutions was developed, and the mixed, micellar composition of these solutions was demonstrated. Using total surfactant concentrations, the CMC of MAFS-010 was calculated to be 70 ± 4 mM. Five PTFE polymerizations were performed using a TFE administration facility. A polymerization using PFOA demonstrated the capacity to produce fine-grained PTFE particles 1 to 8 μm in diameter and agglomerates around 20 μm in diameter, and a second using MAFS-010 demonstrated the capacity to produce similarly sized PTFE particles.