**Saint Olaf College Summer Research 2009**
**Abstracts**

**Emily Berger, Chris Conklin, and James Cederberg (Advisor).** SUCCESSES AND SNAFUS IN SPECTROSCOPY.

Using St. Olaf's molecular beam electric resonance spectrometer we have spent the summer studying the hyperfine structure of $^{23}Na^{19}F$. We have almost gathered enough data to calculate certain molecular constants more accurately than ever before.

**Karen Bieraugel, Seth Huiras, and Janice Pellino (Advisor).** CHARACTERIZATION OF C0293: A SMALL, NON-CODING RNA FROM ESCHERICHIA COLI.

Small, non-coding RNAs (sRNAs) are thought to be important in regulating gene expression in prokaryotes, but only a handful have been extensively researched. *Escherichia coli* (*E. coli*) is a model organism for *in vitro* studies using biochemistry methods for investigating sRNAs. This sRNA strand C0293 was researched to provide information regarding its intra- and inter-molecular dynamics for its characterization. DMS footprinting using reverse transcription is one method to map out the secondary structure. Mass spectrometry of denaturing protein gels and mobility shift assays yield information regarding specific protein targets. Overexpression of C0293 RNA within the cell, through cloning, can be useful when determining its function. Determining the secondary structure of C0293 sRNA was inconclusive. There must be single-stranded regions within the structure because it binds with species in bacterial lysate, one of them being protein Hfq.

**Christopher Bouxsein, Mathew Deram and Brian Borovsky (Advisor).** CUSTOM INDENTER PROBES FOR STUDIES OF FRICTIONAL MECHANISMS IN MICROMACHINES.

Challenges encountered in the development of microelectromechanical systems (MEMS) technology have revealed the need for a better understanding of the underlying mechanisms of friction. Currently, friction, wear and other surface phenomena impede the development of micromachines with sliding parts.

This is the first phase of a NSF-funded collaboration between St. Olaf College, Luther College, and Auburn University, with the intent to gather qualitative and quantitative data on frictional interactions on MEMS-type interfaces coated with alkane phosphonate monolayers. It is hoped that alkane phosphonates will prove to be an effective lubricant system for micromachines fabricated from metal oxides, an alternative to silicon in MEMS fabrication. Two devices will be used to measure sliding friction at different sliding speeds; researchers at Luther College will measure friction in the low-speed range using an atomic force microscope (AFM). We will gather information on high-speed interactions using a nanoindenter-quartz crystal microbalance (NI-QCM) developed by Prof. Borovsky and collaborators. Our colleagues at Auburn will play a large role in the preparation and characterization of the probes and substrates to be studied.

Our focus during this phase of research was development of the custom-made probe tips to be used in the NI-QCM. Through a process of prototyping and testing, we have developed a probe design that uses a single metal oxide microsphere as the tip. These probes are constructed to be as rigid as possible, and to withstand the pressures in our apparatus as well as the chemical treatments used in forming the lubricant layers.

**Steven Braun and Bob Hanson (Advisor).** USING "STRAIGHTNESS" TO CHARACTERIZE PROTEIN SECONDARY STRUCTURE.

Using quaternions, regularity in protein structure can be identified through a quantity termed "straightness." The straightness value can be measured between 0 and 1, where values close to 0 indicate low regularity and values close to 1 indicate high regularity. Straightness calculations were performed on all proteins in the Protein Data Bank. Data demonstrated that residues part of DSSP-defined sheet and helix structures tend to have high straightness; meanwhile, non-sheet and non-helix residues on average have low straightness. In addition to this correlation, high straightness values in non-sheet and non-helix regions can demonstrate structural regularity not detected by DSSP. It was also revealed that this straightness measure can be very closely approximated through the use of Ramachandran angles instead of quaternions. Overall, the straightness definition of secondary structure has been shown to be a useful alternative to the DSSP algorithm used today to make sheet and helix designations. Straightness could potentially be applied further to characterize nucleic acid structure, ligand binding, and protein folding pathways.

**Tim Buff, Blake Hedstrom, and Gary Muir (Advisor).** THE ROLE OF HEAD DIRECTION CELLS IN NAVIGATIONAL BEHAVIOR.

Head Direction (HD) cells are believed to be a biological correlate of an animal's internal sense of direction because a given HD cell will only fire maximally when the animals' head is pointing in a certain direction. Studies have led to conflicting results, however, regarding the relative contribution of the HD cell signal to spatial navigation behavior. The present study used a radial arm maze lacking external cues in order to force the animals to rely solely on internal sources of information for spatial navigation. This investigation monitored HD cell orientation and navigational behavior in order to provide evidence of a relationship, if any, between the two.

Two female Long-Evans rats were implanted with a wire electrode bundle in the Anterior Dorsal Thalamic Nucleus (ADN). Post-recovery, rats were screened for HD cells in a plexiglass cylinder containing a cue card. Rats were concurrently trained on a four arm radial maze consisting of a central platform and a box at the end of each arm. From the center platform, each box appeared to have an identical entrance but contained unique visual and tactile cues that were visible upon entry. Training emphasized a stable, food pellet-rewarded goal box and continued until rats' performance was 80% correct from any start location. If the rat chose a box other than the goal, it was allowed a second attempt to reach the goal box. Once an HD cell was isolated, a session was recorded from the center to identify the HD cell's baseline orientation. Rats were then disoriented and placed on the center in order to induce a shift in the HD cell's orientation. The relationship between changes in HD cell orientation and the animal's subsequent behavioral choices was then monitored.

Results showed some occasions where HD cell shifts were accompanied by corresponding shifts in the animal's behavioral choice. The strength of this relationship, however, differed markedly between animals making it difficult to predict an animal's behavior solely on the basis of HD cell orientation under these conditions. Animals could still successfully locate the goal while the HD cell was at various orientations, demonstrating that an uncoupling is possible between HD cell orientation and navigational behavior.

**Alex Bunkofske, Steffen Docken, and Angela Reisetter (Advisor).** NEUTRON BACKGROUNDS IN THE CRYOGENIC DARK MATTER SEARCH.

This study was done to help understand the expected background in the data of the CDMS experiment. The purpose of this study was to develop an estimate of how many neutrons from the Uranium/Thorium in the cavern walls are able to reach the detectors through the holes in the shielding that the wires go through. If in the final analysis, the number of quality events is significantly over the expected background, it will indicate that CDMS has discovered Dark Matter.

**Sarah B. Cable and Doug Beussman (Advisor).** FORENSIC DETECTION OF MDMA IN BEVERAGE RESIDUES.

MDMA (3,4-MDMA (3,4-Methylenedioxymethamphetamine), commonly known as Ecstasy, is typically used recreationally as a club drug. Recently, MDMA has gained popularity as a date-rape drug because of its effects of increased euphoria and feelings of intimacy and trust due to the drugs ability to facilitate serotonin release. A typical dose, ranging from 50-150 mg, dissolves readily when added to a beverage. Other effects of MDMA on the victim of the spiked beverage, including loss of consciousness and extreme fatigue, may prevent the victim from being tested within the 48 hours during which the drug can be reliably detected in the body.

After consumption of the spiked beverage, a few drops remain in the glass. Previous research supports liquid chromatography paired with tandem mass spectrometry as a technique to detect date-rape drugs in beverage residues. We developed an effective and reliable method for quantitative detection of minute traces of MDMA that linger in the glass. This method is capable of detecting MDMA at levels approximately 150-300 times lower than the dose expected in a typical date rape scenario.

**Sarah Carlson and Eric Cole (Advisor**). THE DEMOGRAPHIC HISTORY OF THE SCALY PEARL OYSTER IN THREE ANCHIALINE PONDS ON SAN SALVADOR ISLAND, BAHAMAS.

Scaly pearl oysters (*Pinctada longisquamosa*) have been discovered in four inland ponds on San Salvador Island. Two of these ponds are protected from severe weather, by virtue of their small size (low wave generation), dense surrounding mangrove forest providing solid "anchorage", and twice-daily flushing of a significant portion of their water volume through conduits connected with the outer coast. The other two populations are exposed to severe weather (hurricane) activities by virtue of their large surface areas, (high wave potential), lack of solid substrate, and little to no sea water turn-over making them susceptible to severe fluctuations in salinity following heavy rainfall. We observed demographic trends in 3 populations over the course of 9 years, covering three dramatic hurricane episodes. We have also performed tagging experiments to determine the relationship between size and age. We suggest that dissimilarities in population demographics are due, at least in part, to variations in habitat characteristics resulting in varying responses and sensitivities to hurricane impact. Six Pack Pond is most susceptible to disturbances. Following each of 3 hurricane events, the 6 Pack Pond population showed evidence of severe adult mortality coupled with an influx of juvenile individuals. Oyster and Mermaid Pond populations are less susceptible to Hurricane disturbance by virtue of their physical characteristics which buffer storm activity. All three populations appear to exhibit periods of progressive senescence punctuated by Hurricane correlated episodes

of spawning/rejuvenation. Scaly Pearl Oysters appear to follow a modified Bertalanffy growth curve, growing faster as juveniles and progressively slower as they reach maturity.

**Sarah Carlson and Eric Cole (Advisor**). *PINCTADA LONGISQUAMOSA* SEX RATIOS FROM FOUR INLAND PONDS ON SAN SALVADOR ISLAND, BAHAMAS.

Specimens of *Pinctada longisquamosa* (the Scaly Pearl oyster) were collected from four inland ponds on San Salvador Island, Bahamas: Oyster Pond, Mermaid Pond, Six Pack Pond and Little Lake. Oyster and Mermaid Pond populations occur in small, relatively protected ponds exhibiting conduit-supported tidal fluxes and prop-root anchorage associated with a rich mangrove habitat. The 6 Pack Pond population occurs in a larger non-tidal lake with mildly hypersaline conditions that is extremely susceptible to hurricane-driven changes in salinity. Histology was performed to determine the sex ratios of each population. Hinge measurements were taken to distinguish age-cohorts. Water chemistry from each pond, and hydrologic features were also examined. Oysters from the hurricane-protected ponds (Oyster and Mermaid), exhibit protandrous hermaphroditism with different demographic trajectories. Oyster Pond oysters progress from a purely male population to a nearly pure female population with increasing age (uni-directional protandry). Mermaid Pond oysters progress from a nearly pure male population to a 50:50 population of males & females (possibly bi-directional protandry). Oysters from the hurricane-exposed 6 Pack Pond, exhibit predominantly dioecious life history (or precocious sex-change). Histology reveals that in Oyster Pond, larger individuals frequently lack gamete production (another sign of senescence). Male and female oysters show identical growth rates despite size. Physical characteristics of the these two sets of ponds are similar raising the question, are these different life-histories driven by environmental cues or are they the result of rapid evolution?

**Revanth Chada, Kevin Crisp (Advisor), and Ted Johnson (Advisor).** GLIAL ULTRASTRUCTURE OF THE EARTHWORM CENTRAL NERVOUS SYSTEM.

Earthworms have an amazing capacity for regeneration, including the ability to functionally regenerate crushed nerve cords within 48 hours after injury (Kneeland 2008). Like mammals, earthworms have myelinated axons and richly vascularized nervous systems, making them ideal model organisms for studies on injury repair processes. Despite these similarities, however, vertebrates do not have the ability to regenerate central nervous system tissue after injury. In annelids, certain migratory cells known as microglia travel to the site of a nerve cord crush within hours after injury. While microglia contribute to mammalian cell death in multiple sclerosis and other pathologies, they do not seem to hinder earthworm recovery after injury and may even assist by phagocytosing cellular debris. Non-motile macroglia may also play a role in recovery after injury. These glial cells provide structural support and nutrition to neurons. Gliasomes, a type of lysosome in invertebrates, have been known to accumulate on glial projections during increased phagocytosis, suggesting a role for macroglia in response to inflammation. We sought to determine the effects of microbial infection on motile and non-motile glial cells in the earthworm central nervous system.

**James W. Checco, Kate E. Helmich, and Greg W. Muth (Advisor).** BIOCHEMICAL CHARACTERIZATION OF SPECIFIC FUNCTIONAL GROUPS WITHIN THE ACTIVE SITE OF CYSTATHIONINE-B-LYASE

With the continuing increase in drug-resistant bacteria, new pathways need to be investigated as targets for antibiotics. Due to its critical connection to protein synthesis and cell growth, one such novel pathway is the biosynthesis of amino acids. The synthesis of methionine is of particular interest because it is unique to bacteria, allowing for the exclusive targeting of bacterial enzymes. Cystathionine-β-lyase (CBL) is a pyridoxal 5'-phosphate (PLP) dependant enzyme which catalyses the hydrolysis of cystathionine into pyruvate and homocystine in the biosynthesis of methionine. CBL exists as a tetramer made up of four identical monomers, each with a covalently bound PLP molecule proximal to the catalytic active site.

Three models of action were developed to understand subunit assembly/PLP binding, substrate binding, and catalysis. By measuring various parameters using a model for Michaelis-Menten kinetics, we were successfully able to confirm the functions of several residues in the CBL active site. Future work will include the collection of more data, confirmation of mutant sequences (either by DNA sequencing or mass spectrometry), and an examination of CBL quaternary structure during catalysis.

**Brandon Fritz and Shelly Dickinson (Advisor).** THE EFFECT OF ENVIRONMENTAL ENRICHMENT ON ETHANOL REWARD IN SWISS WEBSTER MICE.

Much is known about certain risk factors that increase the likelihood an individual will develop a substance abuse problem, but less is known about what may help prevent the development of such a problem. Environmental enrichment has been shown by numerous studies to have a variety of beneficial neurobehavioral effects, including an increase in cortical weight and enhanced performance on a variety of behavioral tasks. Recently, exposure to enriched environments has been suggested to serve as a protective factor by decreasing drug self-administration and drug "liking" in rodent models. However, other studies have found that enriched animals showed an *increase* in responding in anticipation of drug administration. Nearly all of these studies used stimulants such as methamphetamine and cocaine, and little research has investigated the link between enrichment and alcohol's effects. The present study examined enrichment's effect on alcohol reward using adult male Swiss Webster mice assigned to "enriched" or "nonenriched" housing conditions. Enriched animals were housed 4-5 per cage with various objects, nonenriched mice were housed 2 per cage with standard conditions. In the place conditioning procedure used to measure ethanol reward one floor stimulus was paired with an ethanol injection and a different floor was paired with an injection of the vehicle. After 6 exposures to each condition, the animals were tested for a preference of a particular floor by offering them one of each following a vehicle injection. It was found that the enriched group displayed a similar preference for the ethanol-paired floor to that of the nonenriched group. Interestingly, it was also found that the nonenriched animals were significantly more active than enriched animals.

**Mike Gesme, Patrick Garrity and Dick Brown (Advisor).** RESPONDING TO MANYCORE: PLATFORM PACKAGES FOR TEACHING PARALLELISM

Because the model is a Bayesian model, it requires a priori probabilities, the probability that a location where SOD is endemic (source) is actually exporting infectious nursery stock. These probabilities are updated as more information becomes available. The model also requires

the probability that infectious nursery stock will actually cause an infection of SOD at a destination, the Unit Flow Probability of Infection, as in input parameter. The values of these input parameters are difficult to determine with precision. The effect of this uncertainty is important to investigate.

The software that implements this model requires a significant amount of time and memory. We want to improve the speed through computational shortcuts of the software while maintaining accuracy.

The recent shift in hardware design toward parallel architectures in commodity computers will require changes in the Computer Science teaching: now, parallel computing must appear throughout the CS curriculum. To support teaching parallelism in courses where it has not traditionally appeared, we have developed Parallel Platform Packages (PPPs) to provide the necessary infrastructure for teaching topics in parallelism. Thus far we have developed a remote access strategy to provide wider access to cluster resources, as well as libraries to support manycore computing.

**Mike Gesme, Patrick Garrity, Thomas McConville, Richard Brown(Advisor), Jason Engbrecht, Olaf Hall-Holt (Advisor).** USING COMPUTER VISION WITH A BEOWULF CLUSTER TO CONTROL A ROBOT IN REAL TIME.

Progress is reported on an interdisciplinary robotics/computer vision project involving student and faculty researchers in Physics and Computer Science. The goal is to control movements of a balancing robot through computer vision techniques applied to images captured by cameras on the robot, using high-performance computations on a remote Beowulf cluster. Beginning with a system in which a remote cluster computation could detect a single lighted pixel from cameras that were not attached to the robot, this summer's effort resulted in a complete in-lab demonstration in which cameras mounted on the robot generates the images, the cluster computation detects a red circle and generates motion commands for the robot to move towards that circle, and those commands are communicated to the LABVIEW program running on a "netbook" laptop mounted on the robot, using wireless communication in real-time. In addition, video feedback derived from the processed images is also delivered from the cluster to a monitoring computer located near the robot.

**Katie Halvorson, Daniel Monroe, Rebecca Rand, Nathan Van Wylen, and Gene Bakko (Advisor).** HARDWOOD FOREST RESTORATION ON ST. OLAF COLLEGE NATURAL LANDS.

St. Olaf College strives to be environmentally conscious and endeavors to lower its carbon footprint. One of the manners in which the college accomplishes this is through forest restoration. Currently there are four direct tree seeding areas on campus that cover approximately 38 acres of land. Since the time of planting, the trees in each section have been monitored for height and population growth. Over the years, some trees have shown signs of height and population growth while others have not. Height growth is natural and expected, but spikes in population growth are likely a result of reseeding or delayed germination. Some trees have shown signs of little or slower growth than expected. This could be a result of heavy deer browsing or reseeding, as new saplings would decrease the average height of the population.

**Kelly Hawley and Steve McKelvey (Advisor).** SUDDEN OAK DEATH: PREDICTING MOVEMENT OF NURSERY HOSTS USING A LINEAR NETWORK MODEL.

*Pythophthora ramorum* is a recently introduced exotic pathogen to North America and the cause of the disease Sudden Oak Death. Currently, the pathogen is endemic in the United States in only California and Oregon. Nursery plants are a potential means of transportation of the pathogen from the west coast to other susceptible regions, devastating oak forests. Probabilistic techniques and commodity-flow information for US nursery stock are used in a model which ranks the likelihood of uninfected regions becoming infected. Based on this information, limited inspection efforts can be focused on those destinations at the highest risk.

Because the model is a Bayesian model, it requires a priori probabilities, the probability that a location where SOD is endemic (source) is actually exporting infectious nursery stock. These probabilities are updated as more information becomes available. The model also requires the probability that infectious nursery stock will actually cause an infection of SOD at a destination, the Unit Flow Probability of Infection, as in input parameter. The values of these input parameters are difficult to determine with precision. The effect of this uncertainty is important to investigate. Additionally, the software that implements this model requires a significant amount of time and memory. We want to improve the speed through computational shortcuts of the software while maintaining accuracy. The model appears to be robust to varying a priori values and unit flow probabilities of infection. Using computational shortcuts yields significant improvements in running time and memory requirements of the software while maintaining consistent rankings. Preliminary results indicate these model characteristics can be generalized to non-SOD networks. Further research could provide an analysis of larger, more complex networks of sources and destinations, develop a model to handle a more complicated network structure with transshipment nodes in addition to the sources and destinations, and determine other pathogens to which the model may be usefully applied.

**Blake Hedstrom, Tim Buff, and Gary Muir (Advisor).** ETHANOL AND ANESTHESIA DISRUPT HEAD DIRECTION CELL ACTIVITY IN FREELY-MOVING RATS.

Head direction (HD) cells in the freely-moving rat fire as a function of the animal's head direction in the horizontal plane, and are thought to be an integral component of a spatial navigation system encoding directional heading. To examine the effects of ethanol and Nembutal anesthesia on HD cells, single units (n=23) were recorded from the antero-dorsal thalamic nucleus (ADN) of two male sprague-dawley rats and three female Long-Evans rats while they foraged freely in a cylinder. Under Nembutal (25mg/kg) and high doses of Ethanol (3g/kg, 2g/kg,1.5g/kg, and 1.0g/kg), HD cells would begin to fire non-directionally while the animal was immobile. This loss of directionality was accompanied by desynchronized hippocampal EEG of decreased amplitude, and an absence of theta rhythm, indicative of a loss of consciousness or sleep. A decrease in the HD cell's firing rate was also seen when the animal was immobile in the cell's preferred firing direction. Under 1g/kg Ethanol, HD cells fired in a stable, directional manner while the animal was actively moving. While immobile for several seconds, however, HD cell firing also became non-directional. This random, non-directional firing during periods of unconsciousness or sleep may represent a loss of the directional signal within the HD cell network under these conditions.

**James Jaffe, Jacob Nelson and Doug Beussman (Advisor).** *TETRAHYMENA THERMOPHILA* PROTEOMICS USING MALDI-TOF MASS SPECTROMETRY.

MALDI-TOF mass spectrometry can be used to identify isolated proteins. MS can find the mass of fragments of proteins that have been digested with trypsin. MS/MS can be used to match protein fragment sequences with a known database. Our research dealt with *Tetrahymena thermophila* proteins isolated by three different labs: Dr. Cole at St. Olaf College, Dr. Wiley at Claremont McKenna College, and Dr. Honts at Drake University. We identified 67 distinct proteins including 45 not previously identified at St. Olaf College. These proteins are relevant to the research of our collaborators.

**Allison Johnson and Steve Freedberg (Advisor).** AMONG COLONY GENETIC DIFFERENTIATION AND GROUP SELECTION IN THE CLIFF SWALLOW, PETROCHELIDON PHYRRONOTA.

The cliff swallow, Petrochelidon phyrronota, is a highly colonial species often breeding in groups of several hundred individuals, which exhibits altruistic behavior such as alarm calling and non differential care of offspring within their nests, despite high incidence of brood parasitism and extra-pair copulation. Such behavior is generally believed to evolve only under group selected conditions. For group selection to occur, populations must exhibit three qualities 1) subdivided structure, 2) differential productivity of groups, and 3) Frequent extinction and foundation of groups. Because this species exhibit's the latter two qualities, we tested for the presence of genetic subdivision between 15 colonies of cliff swallow in southeastern Minnesota, using previously found, highly informative microsatellite loci. We found no genetic differentiation between any of the sampled colonies, suggesting that traditional group selection is not driving the evolution of the altruistic behaviors observed in this species. This may reveal a novel example of group selection.

**Brain Kantor and John Schade (Advisor).** CLIMATE CHANGE FROM THE RUSSIAN POINT OF VIEW.

Tantamount to understanding the biological, chemical, and physical mechanisms of climate change is a greater socio-cultural context. Such a context is invaluable to climate science because it can help shape socially relevant research questions. As well, personal accounts can supplement ecological research of environmental change. For example, interviewing locals in Cherskiy could provide eye-witness accounts of environmental change, be it flooding, fires, or species population change, as well as reflection on how this influences local lifestyles. Thus, with the polaris project, I've designed my research project to interview Russians on or near the North East science station to determine how life in Russia influences one's conception and experience of climate change. My overarching question is how do Russian views of climate change differ from our own? In addition, I know from climate science that the manifestations of climate change are especially evident here in the Arctic. A secondary question, therefore, is how are their attitudes shaped by the evident changes in the Arctic environment? Although participants were able to describe significant changes to their living environment, and to the natural ecosystems around them, it was less clear to them that the causes are likely to be anthropogenic. This is in contrast to the situation in the United States where a scientific consensus exists. Many Russian scientists still deny anthropogenic climate change, and this seems to have influenced the general public in Russia.

**Jon Lambert and Jean Porterfield (Advisor).** MITOCHONDRIAL AND NUCLEAR GENETIC PERSPECTIVES ON HYBRIDIZATION IN FISH IN THE GENUS LEPOMIS.

The northern longear sunfish (*Lepomis megalotis peltastes*) is recognized by the Minnesota Department of Natural Resources as a Species in Greatest Conservation Need (SGCN) due to its extremely spotty distribution in Minnesota. Hybridization with other *Lepomis* species, often exacerbated by habitat destruction, may be an important factor in the integrity of longear sunfish populations. Understanding the dynamics of sunfish hybridization can also give insight into conservation methods. Samples of longear sunfish, pumpkinseeds and putative hybrids were collected from a variety of Minnesota lakes. Mitochondrial cytochrome b variation was used to construct a phylogenetic tree which indicated that putative hybrids had pumpkinseed cytochrome b sequences, suggesting that pumpkinseed eggs had combined with longear sunfish sperm. Microsatellite analysis at locus Lma21 also showed species-specific allele ranges, with hybrids interspersed between, as well as atypical hybrid genotypes. These data are consistent with hybridization as well as backcrossing of first generation hybrids.

**Karl Lapo, Jessica Olson, Jeff Stamp, Jacki Werner, Bern Youngblood, and Robert Jacobel (Advisor**). Basal Reflectivity and Ice Velocity in the East Antarctic Ice Sheet.

The Center for Geophysical Studies in Ice and Climate (CEGSIC) at St. Olaf recently participated in the United States portion of the International Trans-Antarctic Scientific Expedition (US-ITASE), an international effort dedicated to understanding climate change and ice sheet stability in Antarctica. CEGSIC constructed a ground-based radar system to gather information about flow properties of the East Antarctic Ice Sheet by measuring the strength of radio echoes returned from the ice-bed interface. The presence of water at the basal boundary greatly enhances the reflectivity of radar signals, and water provides lubrication that can increase ice flow speeds. Radar data were acquired continuously along the 1700 Km US-ITASE traverse as a part of the International Polar Year and have been used to calculate values of relative basal reflectivity (a proxy for water content) from Taylor Dome, near the Antarctic coast, to South Pole Station in the interior. We then compared our results on basal conditions with ice surface velocities measured by satellite and found a strong correspondence between ice speed and basal reflectivity. While this result is not surprising, this is the first time remote sensing results have shown thawed bed conditions in association with high ice velocity outside a few specialized locations with subglacial lakes. This demonstrates that basal melting is widespread in East Antarctica and underscores the importance of water in controlling the motion of the largest ice sheet on earth.

**Karl Lapo, Jessica Olson, Jeff Stamp, Jacki Werner, Bern Youngblood, and Robert Jacobel (Advisor).** Basal Reflectivity beneath the East Antarctic Ice Sheet

At the Center for Geophysical Studies of Ice and Climate (CEGSIC) at St. Olaf College we have constructed a ground-based radar system to gather information about flow properties of the East Antarctic Ice Sheet by measuring the strength of radio echoes returned from the ice-bed interface. Radar data were acquired continuously along the 1700 Km US-ITASE traverse as a part of the International Polar Year and have been used to calculate values of relative basal reflectivity from Taylor Dome, near the Antarctic coast, to South Pole Station in the interior. The amplitude of basal radar returns is determined primarily by water content at the ice–bed interface and wetness at the bed has been shown to greatly affect the speed of ice flow. In order

to obtain a true picture of the basal conditions, we first needed to explore methods to correct the returned radar power for losses in the ice which depend on temperature and impurities and can vary from place to place. Our work shows that several different methods gave approximately the same result for attenuation and refinements in one of these have enabled us to produce a correction function that varies smoothly along the length of the traverse. The results show that the derived basal reflectivities can be fit by a double Gaussian model where the individual curves representing the wet and dry populations of basal echoes are separated by several standard deviations, providing a powerful tool for discerning wet from dry ice-bedrock interfaces.

**Michael Marty, Chris Roberts, and Gary Miessler (Advisor).** SYNTHESIS AND CHARACTERIZATION OF NOVEL GROUP 6 ORGANOMETALLIC COMPLEXES.

Our research explored the reactivity of $[CpMo(\mu\text{-}S_2C_2H_4)]_2$ with activated molybdenum and tungsten carbonyl complexes. The dithiolate functional group on this molecule provides a reactive site that is known to undergo loss of the ethylene bridge, and we used nitrile-activated metal carbonyl fragments to replace these ethylene bridges. We first refluxed $W(CO)_6$ and $Mo(CO)_6$ in propionitrile to form trisubstituted propionitrile complexes. The nitrile-activated complexes were then reacted with $[CpMo(\mu\text{-}S_2C_2H_4)]_2$ at lower temperatures to form primarily two analogous products which were identified using $^1$H-NMR, IR, MALDI-TOF mass spectrometry, and APCI mass spectrometry. Various larger addition product and oligomers were formed with the addition of heat. Dithiolate complexes are closely related to and model dithiol*ene* complexes which are of great interest for their superconducting and non-linear optical properties. In addition, dithiolene complexes are present as cofactors in many molybdenum containing enzymes.

**Joe McDevitt and Jeff Schwinefus (Advisor).** UREA DESTABILIZATION OF DNA AND RNA DOUBLE HELICES: PREFERENTIAL INTERACTIONS WITH NUCLEOBASE CONJUGATED PI-SYSTEMS.

Thermal denaturation transition temperatures of AT (adenine-thymine)- and AU (adenine-uracil)-rich double helices decrease to a greater extent in aqueous urea solutions than GC (guanine-cytosine)-rich double helices. The work presented here seeks to identify the chemical functional groups urea preferentially interacts with to account for the greater destabilization of AT- and AU-rich double helices. Vapor pressure osmometry was used to determine the preferential interaction coefficients of urea with nucleoside 5'-monophosphates (5'-NMPs) to quantify the accumulation of urea near the 5'-NMP solvent accessible surface areas. Additionally, molecular dynamics (MD) simulations of the 5'-NMPs in explicit water and 1 molal urea predict urea preferential interactions above and below the nucleobase plane through p-p interactions. These MD simulation results are supported by the strong correlation between the fraction of accessible surface area devoted to the base conjugated p-system and the preferential interaction coefficients determined from vapor pressure osmometry. Implications for urea destabilization of DNA and RNA double helices are discussed.

**Kendra Passow, Patrick Henneghan and Charles Umbanhowar Jr (Advisor).** ELEMENT ANALYSIS OF MANITOBA LAKES.

Studying the Arctic is essential to the assessment of climate change globally. Not only is Arctic change taking place more rapidly than at temperate latitudes, but the Arctic also contains vast reserves of stored carbon. In this study, we reconstruct a history of northern Manitoba

forest-tundra using proxy data from sediments of eight lakes deposited over the past 8000 years. Iron and phosphorous are positively correlated in 7 of the 8 lakes and potassium and magnesium are also strongly positively correlated in all of the lakes. High levels of K and Mg may indicate erosional activity, while variation in Fe is likely a product of differences in the area of wetlands surrounding the different lakes.

**Kay Pelletier, Brandon Emmerich and Jason Engbrecht (Advisor).** PROGRESS PERTAINING TO A PULSED POSITRONIUM BEAM.

Understanding the interactions of Ps at low energies has challenged researchers due to the inability to create Ps near thermal energies in a directed fashion. As a result, previous attempts to understand interactions such as the scattering cross-section ($\sigma$) between Ps and other atoms have relied on indirect methods. Examples are the measurements of the thermalization rate or lifetime measurements of Ps in a gas environment. In analyzing the pore size of certain nanotube materials, we have observed 3-10% of incident positrons form long lived Ps within the sample. Due to the alignment of these tubes we expect them to emit highly directional Ps. By focusing a time tagged positron beam on these samples we will use the resulting directional Ps emitted at near thermal energies for various scattering experiments.

**Erin Seybold and John Schade (Advisor).** SPATIAL VARIATION OF NITROGEN AND PHOSPHORUS UPTAKE IN ARCTIC STREAMS.

Arctic streams are important conduits in the transportation of dissolved organic carbon (DOC) and other inorganic nutrients from terrestrial ecosystems to the Arctic Ocean. In addition to transport, recent carbon budgets indicate that a significant amount of carbon processing occurs within inland waters. Little is known about the processing potential of small, low discharge, Arctic streams underlain by continuous permafrost. Several factors make small streams potential hotspots for nutrient processing. First, small streams often have a high degree of benthic contact with the water column, which provides greater surface area for biogeochemical processing. Second, arctic streams receive large amounts of allochthonous inputs in the form of woody debris and DOC leached from peat soils. This investigation aims to assess the capacity of these small arctic streams to process nutrient and DOC inputs. To directly assess this impact, nitrogen, phosphorus and conservative tracer additions were conducted in 6 arctic streams, 4 draining old permafrost, or yedoma, and 2 draining from floodplain lakes on young permafrost. Yedoma streams showed higher uptake of N than P, suggesting N limitation of biological processes, with large variation between these three streams in the severity of N limitation. Floodplain streams both showed substantially higher P uptake than N uptake, indicating strong P limitation. Carbon processing in floodplain streams also appears to increase in bottle experiments when P is added, providing further evidence of P limitation. Given these results, it is probable that these two types of streams will respond quite differently to changes in nutrient and organic matter inputs as permafrost thaws.

**Mitchell Wade, Thomas McConville, and Richard Brown (Advisor).** UPGRADING A WIKI-BASED CONTENT MANAGEMENT SYSTEM FOR TEACHING COMPUTER SCIENCE.

After evaluating our current Computer Science wiki, we decided to upgrade to a new version rather than switch to an alternative content management system (CMS). In order to use a wiki for classes, we have added several features such as the choice of input and output language,

LDAP authentication, and UNIX-style permissions. We have also modularized our wiki by writing extensions so that future upgrades of the wiki will be easier to accomplish.