Student Titles And Abstracts Based on Summer 2007 Research

Jessica Albright and Doug Beussman (Advisor). QUANTITATIVE DETECTION OF KETAMINE IN BEVERAGE RESIDUES.

The drug ketamine is used as a general anesthetic in both human and veterinary medicine. Ketamine produces strong sedative and dissociative effects. These effects, coupled with the ready availability of ketamine, have led to its use as a date rape drug. Powdered ketamine can be surreptitiously slipped into a victim's drink to facilitate sexual assault. Following the assault, a victim may have little or no memory of the rape, making prosecution difficult. After a spiked beverage has been consumed, a small amount of residue remains in the glass. This residue might be the only evidence remaining that indicates a possible date rape has occurred. Our goal was to develop a method for detecting ketamine in water, Coca-Cola, and beer residues. Using tandem mass spectrometry coupled with liquid chromatography, we were able to consistently detect ketamine at concentrations as low as 0.0025 nmol/uL, almost 500 times lower than would be expected in a typical date rape scenario. In addition, we were able to obtain linear correlations between the concentration of ketamine and peak area over more than two and a half orders of magnitude. This application of LC-MS/MS could provide a valuable tool for forensic scientists investigating date rapes.

Matt Baudino, Kate Carroll, John Vanderlinden, Ting Ting Yang, and Gene Bakko (Advisor). HARDWOOD FOREST RESTORATION ACROSS MULTIPLE DIRECT SEEDING PLOTS.

Paul Bennett, Todd Frederick, and Dick Brown (Advisor). ST OLAF CS WIKI.

Katie Block, Elysia Jeavons, and Paul Roback (Advisor). STATISTICAL MODELS FOR OPERON PREDICTION IN MTB.

Identifying operons, which are groups of adjacent genes that are transcribed together, creates a deeper understanding of cellular function. The goal of this research was to improve operon prediction in *Mycobacterium tuberculosis* by researching alternative statistical models. We tested many types of models, including logistic regression, naïve Bayes, decision trees, and random forest. With each of these types of models, we searched for parameters that optimized model performance. Our two best predictive models were naïve Bayes with logistic regression variable selection and random forests, which both yielded 10-fold cross-validated sensitivities and specificities higher than .90 and were relatively robust compared to other models. We plan to continue research, improving prediction accuracy by incorporating new explanatory variables, including information on promoters, and further optimizing model performance. We will be able to test and update our models as more operons are confirmed.

Andy Brasser, Greg Muth (Advisor), and Jeff Schwinefus (Advisor). SYNTHETIC METHODOLOGY TO STABILIZE DNA STRUCTURE.

The sugar phosphate backbone of DNA and RNA is an area of active research. This backbone is responsible for both the stability and flexibility of the nucleic acid polymers, thus its properties determine to the characteristics of the molecule. Numerous modifications to this backbone have been investigated in order to alter such characteristics. In our research we sought to incorporate aromatic linkers into the backbone of single stranded DNA as a way to confer additional stability to the DNA strand. We modified *ortho*, *meta* and *para* benzenedimethanol molecules to contain a single DMT protecting group with yields of 72%, 67% and 25% respectively. Next we added 2-cyanoethyldiisopropylchloro phosphoramidite to the DMT protected alcohols in preparation for incorporation into a DNA strand. The para isomer showed a yield of 46%, while the *ortho* and *meta* had yields of 21% and 23% respectively.

These aromatic linkers were then incorporated at specific positions into different length random sequences of DNA using standard coupling chemistry on an ABI 394 DNA synthesizer. The *meta* isomer showed the most success as it was able to incorporate into a 19 mer (a random sequence of 19 bases) with an overall yield of 42.6% as determined by a trityl cation assay. The *ortho* was successfully incorporated into an 11 mer with a yield of 22.5%, and the *para isomer* was incorporated into a 15 mer with 29.2% yield. The

identities of the DNA oligonucleotides were confirmed by MALDI-TOF mass spectrometry and polyacrylamide gel electrophoresis.

Alaina Burkard and Shelley Dickinson (Advisor). THE EFFECTS OF ETHANOL PRE-EXPOSURE ON THE AVERSIVE EFFECTS OF ETHANOL.

The effects of ethanol pre-exposure on the aversive effects of ethanol were examined in adolescent DBA/2J mice. Mice underwent two pre-exposure trials in which they were given ethanol (20% v/v) at a dose of 2.0 g/kg in their home cages, with 48 hours between pre-exposure trials. A control group received injections of saline. The aversive effects of ethanol were measured using an unbiased place conditioning procedure, 24 hours after the final pre-exposure. During this procedure, mice were injected with ethanol immediately after being exposed to either a grid or a hole floor stimulus. Each conditioning trial consisted of two days: on alternate days mice were exposed to the non-ethanol-paired floor and injected with saline. After two conditioning trials, mice were tested on a floor that was half hole and half grid. Mice who did not receive ethanol pre-exposure exhibited a conditioned aversion to the ethanol-paired floor, while ethanol pre-exposed mice did not exhibit this aversion. This study replicated the results of an earlier study done in this lab, which suggest that mice receiving ethanol pre-exposure might be displaying tolerance to ethanol's aversive effects. A second, learning-based hypothesis, however, suggests that exposure to ethanol before conditioning trials inhibits learning of the association between ethanol and the ethanol-paired floor. To further explore the effects of ethanol pre-exposure, four more conditioning trials were administered, after which both the pre-exposed and non-pre-exposed mice displayed aversion. These results appear to support the learning-based hypothesis rather than the tolerance hypothesis.

Barry Costanzi, Dan Endean, David Green, Anna Legard, Jackson Williams, and Jason Engbrecht (Advisor). POSITRON STUDIES: THERMALIZATION, NANOTUBES, AND POSITRONIUM BEAMS.

Elizabeth Cunningham and Mike Swift (Advisor). PREY CAPTURE BY *CHAOBORUS* LARVAE.

Chaoborus larvae are important planktonic predators in lakes. I studied prey capture by fourth-instar *C. americanus*, *C. flavicans*, and *C. punctipennis* larvae feeding on the cladocerans *Scapholeberis* and *Daphnia*. I observed larvae feeding on prey of various sizes and recorded strikes, captures, ingestions, and handling times. Capture efficiencies were higher than strike efficiencies in all experiments. In almost every case, higher capture and strike efficiencies were correlated with larger *Chaoborus* larvae. Head capsule length and width were significantly different among the three *Chaoborus* species (*C. americanus* > *C. flavicans* > *C. punctipennis*). All of the prey size classes were significantly different in both length and width, with the exception of the similar widths of *Scapholeberis* 350-500 μm and *Daphnia* 250-350 μm. In general, as prey size increased, capture and strike efficiencies decreased. My results suggest that while *Chaoborus* larvae have no problems ingesting prey with lengths greater than their mouth gape, predation is strongly inhibited when prey width is similar to mouth gape. Understanding these aspects of *Chaoborus* prey capture may aid in explaining the effect of *Chaoborus* species composition on the size and structure of zooplankton communities.

Dave Dassenko, Kevin Friede, and Doug Beussman (Advisor). A PROTEOMIC INVESTIGATION OF *TETRAHYMENA THERMOPHILA* USING MALDI-TOF MASS SPECTROMETER.

Tetrahymena thermophila is a unicellular, ciliate freshwater protist that is an important model organism for biologists. As part of an ongoing proteomics project, we are interested in identifying proteins expressed at the cytoskeleton. Proteins were isolated from the cytoskeleton using several different methods, and were subsequently separated using SDS-PAGE. Bands were excised from the gel and subjected to trypsin digestion. The resulting peptide mixture was purified using C_{18} pipette tips and analyzed using a MALDI-TOF/TOF mass spectrometer. Peptide mass data from tryptic peptide mixtures as well as fragmentation spectra were searched against two databases of theoretical *T. thermophila* proteins. Proteins were identified in 37 of 44 bands analyzed, representing 22 distinct proteins, including 11 proteins not previously observed in our lab. Based on these results, it appears that three major classes of structural proteins are strongly expressed at the cytoskeleton: epiplasmins, major components of the membrane skeleton; tetrins, structural proteins of the oral filaments and cytoskeleton; and tubulins, constituents of microtubules. The new MALDI-TOF instrument allowed much quicker and simpler analysis than with the previous method, which used LC coupled to an ESI mass spectrometer.

Spencer Debenport and Dick Brown (Advisor). BIOWOLF: COLLABORATIONS BETWEEN BIOLOGY AND BEOWULF COMPUTING.

Katie Evans, Christina Koch, and Tina Garrett (Advisor). PERMUTATIONS AND PERMUTATION TABLEAUX.

We explored properties of Sylvie Corteel's bijection between permutations and permutation tableaux. We studied a bijection found by Sylvie Corteel, and came up with basic lemmas about the shape and manipulation of tableaux and several theorems. These theorems include properties of direct and skew permutation sums, pattern avoiding permutations, and transposition of elements within a permutation, as well as correspondences between certain classifications of tableaux and common combinatorial phenomena such as Bell and Catalan numbers. We also wrote a Mathematica program that converts a permutation to its corresponding tableau.

Janae Fabini, Ryan Vink, Dan Kohler, and Robert Hanson (Advisor). GREEN CHEMISTRY AND WEB 2.0.

The community interested in Green Chemistry is large and growing. The web provides a good way to connect and share resources. Two websites, the Green Chemistry Resource Exchange (GCEx) and Greener Education Materials (GEMs) have been created with the intention of meeting the needs of the Green Chemistry community. The purpose of our work was to increase the accessibility and facilitate the growth of these two websites. To accomplish this we examined and implemented cutting-edge web development systems that are ubiquitous with complex websites such as GoogleEarth, del.icio.us, and Wikipedia.

Dan Edwins, Thomas McConville, and Olaf Hall-Holt (Advisor). SEGMENTATION FOR STEREO IMAGING.

Recent results in stereo vision suggest that accurate image segmentation may lead to a good stereo result. We developed a quality function to measure the accuracy of a segmentation. To search the space of possible segmentations, our algorithm efficiently optimizes the quality function by using local search. Given a pair of segmentations we match the individual segments. For each segment in the left image, we have a shape similarity function to find the corresponding segment in the right image. Once we have segments matched, we calculate the disparity depth map. Using this method and comparing our disparity map to the ground truth depth map, we obtained 5.1% error on the standard Tsukuba dataset.

Brian R. Gallagher, Patrick J. Nelson, Windy S. Lynch, XX Mesce (Advisor) and Kevin Crisp (Advisor). NOT QUITE CRAWLING: AN ANALYSIS OF RHYTHMIC LEECH MOTOR NEURON ACTIVITY INDUCED BY IBMX.

Anne Gatzlaff and Urmila Malvadkar (Advisor). PROTECTION OF A SPECIES AND AN INDUSTRY: USING FISH RESERVES TO PRESERVE A POPULATION AND MAXIMIZE FISHING YIELD.

With marine resource preservation as the topic of many biological conversations these days, the inevitable question arises: what is the best strategy for managing marine fisheries? Regulation geared towards sustainable fishing often results in damage to, if not total destruction of the fishing industry. Recent interest in preventing industry collapse led us to ask how a fish population could persist while simultaneously allowing marine fisheries to thrive.

Using partial differential equations, logistic growth, Fickian diffusion and spatially dependant harvest efficiency, we built a model to simulate population behavior within a linear habitat. We went on to investigate how the different parameters of the model affect total yield, and finally, determined what combination of size reserve and harvest efficiency would lead to maximum sustainable yield (MSY).

Matt Germscheid and Paul Jackson (Advisor). ANALYTICAL SPECTROSCOPY USING MINIMAL SAMPLE PREPARATION.

Philip Gipson and Kris Keuseman (Advisor). PROGRESS TOWARDS ASYMMETRIC OXY- AND CARBOPALLADATION OF 2-ALKENYL-2-OXAZOLINES.

A variety of enantiopure 2-alkenyl-4-alkyl 2-oxazolines were synthesized via mesyl chloride cyclization of hydroxyenamides. These oxazolines were then reacted with Pd(II) salts under non-nucleophilic and nucleophilic conditions.

It has long been known that the effect of large, bulky (steric) groups contributes significantly to the reactivity of a compound. Most importantly, certain atoms on the molecule can be made far less reactive, or only reactive in a specific way, towards any number of chemical processes. The research conducted this summer was focused on the way in which a steric group could possibly influence the stereochemistry of an oxy- or carbopalladation reaction.

Camille A. Eggebroten, David B. Gruner, Julie K. Rolfes, Jean Porterfield (Advisor) and Pat Ceas (Advisor). INVESTIGATION OF GENETIC VARIATION IN LONGEAR SUNFISH (*LEPOMIS MEGALOTIS*) USING MITOCHONDRIAL AND MICROSATELLITE ANALYSIS.

Our research focused on the distribution of genetic variation within and among longear sunfish (*Lepomis megalotis*) populations. This species is listed as a Species of Greatest Conservation Need in Minnesota and thus information about its habitat preferences and genetic diversity is important for future management purposes. The first three weeks of Summer 2007 were spent surveying Minnesota lakes where *L. megalotis* has been found historically as well as previously undocumented lakes that had potential *L. megalotis* habitat. At each collection site, ecological data were noted and fin clips were taken from *L. megalotis* specimens as well as from any congeners collected. Genetic diversity was assessed from both mitochrondrial cytochrome *b* DNA sequences (645 base pairs) and microsatellite loci. Total DNA was extracted from each fin clip and used as template in polymerase chain reaction (PCR) amplification for both types of molecular markers. Cytochrome *b* sequence was obtained for 94 fish, including *L. megalotis* sequences from six states in addition to Minnesota (some from GenBank), and grouped in to nineteen haplotypes. Phylogenetic and network analyses suggested two distinct haplotype groups, one including fish from Missouri and one from Tennessee (total N = 12) and the other including fish from Minnesota and Wisconsin and one each from Alabama, Kentucky, and Maryland (total N = 82). While the average pairwise genetic distance for all 94 samples was 1.28%, the average distance within haplotype groups was much lower (0.38% for the Missouri/Tennessee group and 0.2% for the other group; all uncorrected p distances). More genetic diversity in the southeastern populations in general is consistent with Pleistocene glaciation history, but it is curious that the most common Minnesota haplotype is shared with the Kentucky specimen and only differs from the Maryland and Alabama haplotypes by two substitutions each. Analysis of microsatellite markers in *L. megalotis* began with PCR optimization for nine sets of primers designed for sister taxon *L. marginatus* (Schable et al 2002). Reaction products were visualized first with agarose gels and then with polyacrylamide gels using a LiCor 4300 DNA Analyzer. While no loci were optimized to the point of reliable genotyping by the end of Summer 2007, this work will be the focus of research conducted in Fall 2007.

Suzi Hintz, Wolf Merker, Greg Muth (Advisor), and Jeff Schwinefus Advisor). THERMO-DYNAMICS OF RNA RIBOSWITCHES AND METABOLITE BINDING.

Riboswitches are recently discovered RNA sequences that have been shown to regulate gene expression by undergoing conformational changes as they bind small metabolites. This conformational change affects the transcription and/or translation process, thus switching the gene either on or off. Our study focuses on the aptamer region of the AR7 riboswitch, which binds purine metabolites and regulates genes involved in purine biosynthesis. Our goal is to correlate these RNA structural changes with metabolite binding to gain further insight into the riboswitch gene regulation mechanism. Differential scanning calorimetry (DSC) was used to thermally unfold the aptamer region of AR7 in the presence of the binding metabolite 2,6-diaminopurine (DAP). Without DAP, only two sequential non-two state transitions were resolved in DSC scans: the first was a tertiary structure unfolding transition followed by a large secondary structure transition. With DAP, the initial tertiary structure was resolved into two transitions, the first corresponding to a tertiary transition independent of DAP concentration and the second corresponding to the binding pocket unfolding transition. As the concentration of DAP was increased, the binding pocket transition shifted to a higher temperature and the unfolding enthalpy increased and remained constant. From the dependence of the binding pocket transition temperature on DAP concentration, the AR7-DAP binding constant was estimated to be 0.055 ± 0.006 M^{-1} at 60 ^{o}C. The AR7-binding metabolites 2-

aminopurine, purine, adenine and hypoxanthine showed significantly less affinity for AR7, giving insight into the role amine functional groups play in binding.

Liv Hoversten, Aly Yarnall, and Gary Muir (Advisor). USING SINGLE UNIT ELECTRO-PHYSIOLOGY TO EXPLORE THE NEURAL BASIS OF NAVIGATION IN THE FREELY-MOVING RAT.

Head direction (HD) cells in the freely moving rat fire as a function of the animal's head direction in the horizontal plane. HD cells are thought to be an integral component of the spatial navigation system that provides an animal with information about directional heading and are found in several areas of the brain, including the anterior dorsal nucleus of the thalamus (ADN) of the rat. Although the firing of these HD cells can be influenced by manipulation of external (or allothetic) cues, HD cell activity is generated endogenously and relies on an intact vestibular system for normal functioning. Previous data recorded in our lab has shown that vestibular input is not sufficient for the generation of a HD signal in the ADN of the rat under anesthetized conditions. Work in the lab this summer enabled us to record our first ever HD cell data from freely-moving animals, thus extending our findings from anesthetized conditions.

Vanessa Iiams, Anne Walter (Advisor), and Doug Beussman (Advisor). ANALYSIS OF THE *BETA VULGARIS* TONOPLAST ATPASE.

This project focuses on the isolation and proteomics of Beta vulgaris (red beet) vacuoles. Vacuoles are plant storage organelles involved in plant growth and defense, homeostasis and turgor. The vacuoles are surrounded by a large tonoplast, which supports a pH gradient between the vacuole space and the cytoplasm.

SDS-PAGE, MALDI-TOF mass spectrometry and the MASCOT Viridiplantae database were used to investigate vacuole proteomics, and vacuole purity was assessed through ATPase activity and transport capacity. Activity of the H-ATPase, a signature tonoplast protein, was measured through a highly sensitive malachite green-molybdate-citrate protocol, while proton transport was evaluated using fluorescence of acridine orange and quinacrine, weakly basic dyes that will accumulate in a low pH space.

An aquaporin has been identified through a proteomics approach, and further analysis with higher protein concentrations of pure vacuoles is in progress. ATPase activity was found to be vanadate-insensitive, nitrate-inhibitable and on average produced 60μmol phosphate per mg protein-hr, suggesting a high purity isolation of B. vulgaris tonoplast.

Subsequent work with reconstituted ATPases will help assess the function of specific lipids, other proteins, and lipophilic proton gradient uncouplers in this system.

Phyllip Johnson, Ellen Wann, and Howard Thorsheim (Advisor). INVESTIGATIVE PSYCHO-PHYSIOLOGY ACTIVITIES FOR COMMUNITY COLLEGES: A PHASE II NSF NATIONAL DISSEMINATION RESEARCH EVALUATION PROJECT.

Phyllip Johnson and Ellen Wann served as Research Assistants working in partnership with Co-PIs Howard Thorsheim (St. Olaf) & Robert Gephart (Itasca Community College) in developing and carrying Year 1 of a two-year NSF Phase II National Dissemination of psychophysiology laboratory teaching innovations developed at St. Olaf in a prior NSF Phase 1 CCLI grant. Though psychophysiology is part of top four-year college and university neuroscience programs in the country, it is not commonly taught in community colleges; therefore, the goal of the NSF project was to introduce psychophysiology neuroscience nationally to community college teachers, and several thousand of their students. Ellen and Phyllip participated in two main stages of the NSF project:

1. They helped develop Educational Materials and Processes Development to introduce neuroscience psychophysiology in community college introductory psychology courses across America.

2. They helped design, implement and assess a replicable National Workshop Model to disseminate the Educational Materials and Processes, and to train community college teachers across America how to teach their students to think critically as scientists about behavior and experiences as understood through study and experimentation in psychology.

In more detail, Ellen and Phyllip helped in the following ways: recruiting the national sample of community college teachers; developing skills in several software programs they then used to develop psychophysiology curriculum neuroscience materials (printed, video and WIKI); collaborating with national consultants Jeanne Narum (PKAL), Critical Thinking authority Diane Halpern (Claremont-McKenna), Psychophysiologist Louis Tassinary (Texas A & M), and assessment expert Chandra Mehrotra (St. Scholastica, MN); planning and then co-teaching elements of the national workshops for community college teachers; participating in the important stages of the assessment experimental design, a Solomon Four-Group, multivariate, pre-post, control-group design with random assignment to treatment conditions; and coordinating travel plans for workshop participants in concert with the project travel agency. (Psychophysiology is the neuroscience investigation of the reciprocal influence of mental and emotional processes and physiological processes. The workshop trained teachers in the use of tools such as electroencephalography, electromyography, electrocardiology and electro-oculography.)

Sarah Kashawny and Shelley Dickinson (Advisor). DOSE-DEPENDENT ETHANOL-INDUCED CONDITIONED PLACE PREFERENCE IN ADOLESCENT MICE.

Recent work in our lab has suggested that adolescent mice do not show an ethanol-induced conditioned place preference with a 2.0 g/kg dose, unlike adult mice. In a follow-up experiment, ethanol-induced place preference was examined in adolescent DBA/2J mice comparing two different doses of ethanol (2.0 and 4.0 g/kg), and a saline control group. Six conditioning trials were conducted, each trial consisting of one day in which an ethanol injection was given immediately before exposure to a particular floor stimulus (grid or hole), and another day in which a saline injection was given immediately before exposure to the other floor stimulus. A test was performed following the fourth conditioning trial, in which all mice received saline injections immediately before being placed on half grid, half hole floor for 60 minutes. This test revealed a trend toward preference in the 4.0 g/kg group, and in order to further explore the findings, two more conditioning trials were performed, followed by a final test. Consistent with previous findings, a significant conditioned place preference was not seen in the 2.0 g/kg group. However, the mice which received the 4.0 g/kg dose showed a significant conditioned place preference in the first 30 minutes of the final test. These results suggest that a higher dose of ethanol is needed in order for adolescent mice to experience its rewarding effects.

Lauren Kunz and Paul Jackson (Advisor). GREENING THE ANALYTICAL CHEMISTRY LABS.

Reducing the environmental impact and the overall hazards associated with experiments in the analytical chemistry laboratories is an ongoing process at St. Olaf College. Previous work has attempted to benchmark the experiments and revise existing experiments for the unique "Company-based" role-playing groups. Our current work continued to emphasize revision of existing experiments and the development of new experiments. We verified the resolution quality and solvent reductions established by reducing the HPLC column length, column diameter and particle size. Using new microwave technology, we digested metals used in two different experiments, which decreased dissolution time and amounts of strong acid. A replacement lab, based on analyzing the metal content of water in St. Olaf retention ponds, is in the development stage. It incorporates the newly acquired Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES). Additionally, we measured the actual power requirements of different analytical instruments and equipment using in-line and inductive power meters. The aforementioned developments, along with an information box highlighting green aspects of each experiment, have been incorporated into the analytical lab manual. Our improvements preserve the pedagogical goals of the experiments, ensuring that students receive a strong background in analytical chemistry methodology, but also minimize the experiment's hazard risk and environmental impact.

Robby Kluver, Urmila Malvadkar, and John Schade (Advisor). AN ASSESSMENT OF THE EFFECTIVENESS OF NITROGEN RETENTION FOR RIPARIAN ZONES: IMPLICATIONS FOR FUTURE IMPROVEMENT AND OPTIMAL VEGETATION.

Riparian buffer zones are strips of vegetation grown along a body of water that are used to limit the amount of runoff that enters lakes and streams. This study was intended to 1) find out if riparian buffer systems will reach a stable nitrogen availability equilibrium or remain unstable indefinitely and 2) investigate riparian buffer system site and vegetation characteristics that maximize the performance of these systems. The findings of this study suggest that for the right parameters, a stable equilibrium might exist. The major differences in the equilibrium point reached between the two models that were studied

suggested that it may be difficult to accurately mimic any riparian system. The sensitivity analysis revealed the parameters that were most influential at causing the system to arrive at the lowest nitrogen availability equilibrium as well as the best combination of these parameters.

Abby Lane, Eric Graalum, and Matt Richey (Advisor). STATISTICAL ANALYSIS OF CALCULUS COURSE RETENTION RATES.

As the Mathematics Faculty begins assessment of the department, one major issue is the retention of students in various mathematics courses. Preliminary analysis showed a noticeable and consistent gender gap for the retention of students in Math 128 (Honors Calculus II). Our analysis sought to find factors that explained low female retention rates in Math 128, a phenomenon not seen in other introductory calculus courses to such a severe extent. Specifically, we examined professor gender and long-term status effects, grade point, intended major, co-enrollment in other natural sciences and several factors from placement test data (number of math courses a student plans to take, why a student is enrolling in math at St. Olaf, their level of anxiety toward taking math at St. Olaf, etc.). Using binary logistic regression, we found that females and intended majors in biology or a medically related field were less likely to retain, while males, students with higher grades, intended math and physics majors, and students co-enrolled in introductory major track physics courses were more likely to retain.

Elizabeth Leslie, Eric Scholten, and Steve Freedberg (Advisor). THE EFFECTS OF GLYPHOSATE AND SURFACTANTS ON TURTLE SEX DETERMINATION.

Elizabeth Leslie, Eric Scholten, Steve Freedberg (Advisor). THE EFFECT OF SEX-DETERMINING SYSTEMS ON GENETIC DIVERSITY.

Matt Majerus, Megan Rooney, Eric Cole (Advisor), and Doug Beussman (Advisor). THE ISOLATION AND CHARACTERIZATION OF THE NUCLEAR EXCHANGE JUNCTION.

Charles McEachern and Jim Cederberg (Advisor). MODIFYING THE MOLBEAM'S BRAIN.

Using St. Olaf's molecular beam electric resonance spectrometer we have mapped hyperfine spectrum of $^{39}K^{127}I$. We are in the process of preparing our findings for publication. Our work is heavily dependant on software written by previous student researchers. Modifications were made this summer to this software in the interest of increasing the efficiency of several routines and streamlining the project overall.

James McKone and Gary Miessler (Advisor). NEW COMPLEXES OF GROUP VI METALS.

Certain oxygen-transfer enzymes utilize cofactors containing the group VI metals molybdenum (Mo) or tungsten (W), bound to the protein framework through sulfur. Smpler organometallic complexes utilizing the dithiolene ligand trifluoromethyl dithiolate (*tfd*; $S_2C_2(CF_3)_2$; Fig. 1), are potentially useful as structural models of enzyme active sites. Building on previous research in the Miessler lab, several new tungsten-tfd complexes were synthesized, separated using column chromatography, and analyzed using ^{1}H-NMR and IR spectroscopy as well as APCI mass spectrometry. These results uggest the following formulae: $[CpW(tfd)]_2$; $[CpW(tfd)]_2(\mu\text{-}S)_2$; $Cp(tfd)W(\mu\text{-}S)_2W(=O)Cp$; $Cp(tfd)W(\mu\text{-}S)_2W(=S)Cp$. Attempts at crystallization for X-ray crystallographic characterization are ongoing.

Another sulfur-containing complex, $CpMo[\mu\text{-}S_2(C_2H_4)]_2MoCp$, has long been known to engage in reactions whereby the bridging ethylene groups are replaced by other alkenes. Reaction of $CpMo[\mu\text{-}S_2(C_2H_4)]_2MoCp$ with $Ru_3(CO)_{12}$ yielded a variety of products. Of these, so far three have been purified, crystallized, and characterized using X-ray Crystallography: $CpMoS_3(\eta^2\text{-}\mu_4\text{-}CO)Ru_3(CO)_7MoCp$; $CpMo(\mu S)_3[Ru(CO)_3]_2CpMo$; and $CpMo(\mu\text{-}S)_4[Ru(CO)_2]_2$. APCI mass spectrometry has not provided useful spectra for these compounds, and efforts at further analysis using MALDI-TOF mass spectrometry are ongoing.

Andrea Mulhausen, Bern Youngblood, Martina King, Bob Jacobel (Advisor), and Brian Welch (Advisor). INITIAL RADAR RESULTS FROM SOUTH POLE TRAVERSE (US-ITASE - YEAR 1).

This is a preliminary study of the internal characteristics of the East Antarctic ice sheet using deep-penetrating radar. Data were collected using a 3 MHz radar system on the U.S. portion of the International Trans-Antarctic Scientific Expedition (ITASE) – a traverse from Taylor Dome to the

Amundsen-Scott Station at the South Pole. Later processing combined radar and positioning data and corrected for system noise. Data were then digitized to extract bedrock and layer characteristics.

Upgrades to the St. Olaf College radar system this field season enabled the collection of data within ~50 meters of the surface – shallower than was thought possible for a 3 MHz system. This introduces the prospect of matching layers found in the 3 MHz data with layers found by higher-frequency (shallower) systems on the same traverse. Initial results show much greater variation in stratigraphy than was assumed to exist on the eastern half of the continent.

Increased knowledge of internal ice stratigraphy and bedrock characteristics is important for the study of dynamic properties of the ice, which affect sea level change and global climate change. Ongoing work includes further processing of the data for use in dynamics modeling and the completion of the US-ITASE traverse to the South Pole in the 2007 field season.

Pat Nelson, Kevin Crisp (Advisor), and Doug Beussman (Advisor). EFFECTS OF SEROTONIN ON KINASE ACTIVITY IN THE LEECH NERVOUS SYSTEM: DEVELOPMENT OF A PROTEOMICS PROTOCOL.

Serotonin (5-HT) is a neurotransmitter in leeches that affects kinase signaling pathways in specific neurons with diverse effects, such as synaptogenesis, arousal, sensitization, and activation of the swimming motor pattern. The purpose of this project is to isolate and analyze proteins that change tyrosine phosphorylation states in the presence of serotonin. The phosphotyrosine protein molecular weight profile can be determined through SDS-PAGE and immunoblotting with clone 4G10 anti-phosphotyrosine from Millipore. Comparing serotonin-treated tissue to the negative control (treated with saline containing no serotonin) will discern molecular weights of serotonin-sensitive phosphoproteins. Phosphotyrosine can be isolated by immunoprecipitation with recombinant antibody clone 4G10. Eluted proteins can be separated using SDS-PAGE and analyzed using MALDI-TOF mass spectrometry and comparative databases. Nerve cords were removed from leeches and other invertebrates including *Lumbricus* and *Pyralidae* and treated with neurotransmitters. Isolation protocols were developed that produced higher yields of proteins and improved protein detection. A cell lysis protocol was developed that yielded up to 80 mg/ml of nervous tissue proteins. SDS-PAGE and Coomassie stain were used to show that cell lysates contained sufficient protein. Identifying the phosphoproteins in this pathway may suggest a model for how serotonin controls neural development and behavior in the leech.

Paul Nichol, Greg Muth (Advisor), and Jeff Schwinefus (Advisor). MEASURED CONFORMATION CHANGE IN THE THIM RIBOSWITCH INDUCED BY METABOLITE BINDING.

Gene regulation is the process by which a cell selectively turns on or off genes in response to metabolic needs and environmental conditions. Riboswitches are mRNA sequences that regulate gene expression independently of protein cofactors. The binding of a small metabolite molecule to a riboswitch causes a conformational change in mRNA structure that can turn a gene on or off. We used differential scanning calorimetry (DSC) to study the conformational changes of the *thiM* riboswitch in the presence and absence of the metabolite thiamine pyrophosphate (TPP). DSC data for the unbound aptamer showed a transition at 57.7 °C and a transition at 75.3 °C. The first transition had a ratio of ΔH_{cal} to ΔH_{HV} of 2:1, and the second a ratio of 8:1. In the presence of TPP, the first transition shifted to 49-51 °C and the ratio of ΔHcal to ΔH_{HV} changed to 1:1. At a TPP to RNA ratio of 1 to 1 a second transition appeared at 66-68 °C and remained observable at all higher TPP concentrations tested. The transition at 75 °C remained fixed regardless of TPP concentration. We suggest that the transition at 75 °C corresponds to the unfolding of the aptamer 2° structure; this is consistent with a crystal structure that includes five stems and several intimate loop-loop interactions. The appearance of the second transition in the bound aptamer, and the corresponding change in ratio of ΔHcal to ΔH_{HV} from 2:1 to 1:1, suggests the presence of a preformed binding pocket in the unbound aptamer.

Cullen O'Neill, Daniel Pluth and Brian Borovsky (Advisor). DEVELOPMENT OF THE PHYSICS CURRICULUM AND IMPROVED EQUIPMENT FOR NANOSCALE FRICTION RESEARCH.

Curriculum development: Half of the summer was devoted to curriculum development for the Physics program at St. Olaf College, supported by funding from HHMI, the Hardy Chair in Natural Science (Ted Johnson) and by the College. Four projects were completed: 1) Revising, editing, and developing the laboratory component of Physics 228, a sophomore-level course in electricity and magnetism. This

laboratory series was recently overhauled to include both computer simulations and hands-on experiments. The series of labs needed significant work to make them more integrated, easier to follow, and more focused on essential concepts. Another major issue was developing a programming primer to help students unfamiliar with the language used in this course (VPython). 2) Editing the Physics 125 lab manual. This manual was in need of more figures, diagrams, and photos (and removal of extraneous text) in order to make the series of labs easier to understand and perform. 3) Setting up newly purchased advanced laboratory equipment. This work will benefit the advanced laboratory sequence in the physics major, by making new experiments available. 4) Creating a group research website. The web site gives our nanotribology program a public presence for information and recruiting purposes. ***Research:*** A better understanding of friction is needed to further the development of a new generation of microscopic machines that may improve everything from communications to medical diagnosis. Currently we are studying ultrathin lubricant films made from chain-like hydrocarbons. Our ultimate goal is to determine the ideal molecular structure of the film for effective lubrication of high-speed microscopic contacts. This summer, we made several improvements to the equipment and acquired a series of data that reveals the stability and resolution of the instrument. Looking ahead to a collaborative study of ultrathin lubricant films involving groups at Luther College and Auburn University, we studied the extent to which the contact size can be reduced by using smaller probes and decreasing the applied load.

David Osterhouse, Bob Jacobel (Advisor), and Brian Welch (Advisor). WET VERSUS DRY BED CONDITIONS ON KAMB ICE STREAM DETERMINED FROM RADIO ECHO SOUNDING.

Recent research on the fast flowing ice streams of West Antarctica has shown that rapid motion is the result of sliding, aided by the presence of liquid water at the bed. Ice-penetrating radar profiles of bed reflectivity provide a way to remotely sense conditions at the ice-bed interface and test for the presence or absence of water and water-saturated deformable tills that enable sliding. We have conducted radar surveys of portions of Kamb Ice Stream in West Antarctica that ceased rapid sliding approximately 200 years ago, but may be reactivating. Our results show liquid water is still present at the ice-bed interface over much of the area surveyed and that fast motion is restricted in a few locations where the bed is dry.

Katherine Oyster, Elyse McFarland, Beth Abdella (Advisor), Jeff Schwinefus (Advisor), and Kim Kandl (Advisor). BRINGING TWO SCIENTIFIC WORLDS TOGETHER: INTEGRATING BIOLOGY AND CHEMISTRY IN INTRODUCTORY LABS.

The Biology and Chemistry Departments at St. Olaf College are committed to preparing students for the modern, increasingly interdisciplinary practice of science. As such, the goal of this summer's research was to integrate biology and chemistry in labs for a three-course sequence called CH/BI (affectionately called "chubby"). These goals were met by renovating and revising labs previously used at St. Olaf, adopting and modifying labs used at other institutions, creating new labs, and adapting labs that are currently part of the introductory departmental sequence at St. Olaf to include interdisciplinary relevance. In total eighteen labs, which follow the progression of lecture topics, were developed for this lab sequence.

Any first-year student who tests at the 125-level and is committed to the three-course sequence will be eligible to enroll in CH/BI. This sequence will allow students to complete the equivalent of three semesters of introductory science in their first year. Because CH/BI is intended for students who will presumably enroll in advanced courses in both departments later in their academic careers, a month-long interim term (in addition to two full-length semesters) will be used to increase time efficiency. CH/BI will be implemented beginning in Fall 2007. Depending on the success of this pilot it is possible that larger numbers of students will be able to enroll in this sequence in the future.

Bjorn Paulson and Jim Cederberg (Advisor). A GOOD UNDERSTANDING OF THE 39K127I NUCLEAR INTERACTIONS.

Taylor Reece, Todd Frederick, and Dick Brown (Advisor). THE BEOWULF PROJECT AND PARALLEL COMPUTING.

Rebecca Ross and Diane Angell (Advisor). SURVEYING PRAIRIES FOR SMALL MAMMALS IN AND AROUND RICE COUNTY, MINNESOTA.

Tall-grass prairies are important as sources of food and habitat for plants, animals, and humans alike, however less than one percent of the Midwest's historic tall-grass prairies remain today. This decline in

prairies has been accompanied by a reduction in prairie-dependent small rodents. Although people have actively started recreating prairies, it is not clear that these reconstructed prairies support populations of prairie rodents. Through live trapping, this study found that there is little correlation between the age of reconstructed prairie sites and the number of small rodent individuals and species. In Carleton College's Cowling Arboretum it was also found that more rodent species occupy prairie sites with higher numbers of plant species. This trend was not found in St. Olaf College's Natural Lands however, possibly due to a lower overall number and quality of plant species in the prairies sites. A rodent survey of reconstructed and remnant prairies in and around Rice County, Minnesota found two sites with prairie voles, a Minnesota species of special concern. This suggests that prairie voles can and do still occupy prairies in the area.

Eric Smith, and Kathy Shea (Advisor). BIOMASS PRODUCTION AND SOIL NUTRIENT ANALYSIS IN RESTORED PRAIRIES.

We compared soil nutrient levels, % moisture, % organic content and biomass production in several different restored prairies on the St. Olaf College campus in Northfield, Minnesota. The goal of the study was to examine prairie biomass production as a result of species composition and age. The prairies studied were planted in years ranging from 1989 to 2004 and have been maintained through periodic fire disturbance. Nitrogen levels showed little variation throughout the prairie and no correlations were observed within the different prairies. The phosphate analysis showed a much larger range than the N tests. Orthophosphate phosphorus levels varied throughout the prairie sites with the lowest concentration of 26ppm in the 1989 prairie and the highest of 83ppm in the 1998 prairie. Biomass was harvested in .5x.5m plots from the same prairie sites and analyzed for total dry weight. The most recently planted prairie, restored in 2004, showed the highest biomass production. Interestingly, the restored prairies showed an inverse relationship between age and total biomass. To expand on our examination of restored prairies we began our own diversity and biomass study by seeding five 9x9m plots with native prairie species in varying densities. Our plots contained 4 or 8 different species and one plot was planted as a monoculture of switchgrass. Although, the study is focused on biomass production as a result of diversity, it will hopefully be used to analyze potential energy production from restored prairies once the plots support stable plant communities.

Ben Thompson and Nathan Schaefle (Advisor). THE KETO-ENOL TAUTOMERISM OF ß-DIKETONES.

Using NMR spectroscopy and computational modeling, the tautomerism of acetylacetone and its 3-substituted analogues were studied in solution. The enol form of most ketones is unstable, but it is stabilized by a six-membered ring in ß-Diketones. Due to electron withdrawing effects, 3-chloro and 3-phenyl acetylacetone stabilize the enol relative to acetyleacetone whereas 3-methyl and 3-ethyl acetylacetone are electron donating and destabilize the six-membered ring relative to acetylacetone. The increasing dielectric constant of different solvents destabilizes the enol. Optimization and energy calculations of the studied molecules have been done in the gas phase using ab inito, DFT and semi empirical methods. Energies and molecular orbitals will eventually be calculated in solvents and will be compared to the solvent and substituent trends.

Kate Tummers and Steve McKelvey (Advisor). SUDDEN OAK DEATH.

Phytopthora ramorum is a fungus-like organism that is spread by host plants that provide a platform for *P. ramorum* to sporulate. Upon infecting a susceptible oak tree, cankers are formed on the trunk and eventually the infected tree is killed. Current infestations in natural environments are located in the west coast of the United States. Mountains and deserts seem to act as a natural barrier and the major method of infection is through nursery shipments. To assist with the inspection efforts to find the most likely locations of new eastern outbreaks and help prevent the onset of Sudden Oak death in the forests of eastern North America, we built a model that describes the movement of host plants through a bipartite shipment network. We used Bayes' rule and other probabilistic methods to create this model.

Aimee Weinlander, Eric Cole (Advisor), and Erica Zweifel (Advisor). EVALUATING METHODS OF DELIVERING DNA INTO LIVE *TETRAHYMENA* CELLS: BIOLISTICS VS ELECTROPORATION.

Two methods are currently being exploited for genetic transformation (DNA delivery) of living *Tetrahymena* cells: electroporation and biolistics. With electroporation, mating cells are collected at 10hrs into conjugation (a time when the cell's own genetic material is being amplified) and they are subjected to

a programmed pulse of electricity in the presence of foreign DNA. Electroporation has been useful, but has limited application. With biolistics, tiny particles of gold are coated with DNA, and these particles are blasted into live cells using compressed Helium and a particle bombardment chamber (the biolistic gun). Our lab has recently acquired a biolistic gun, and we wish to a) optimize conditions for biolistic cell transformation, b) compare efficiencies between biolistics and electroporation, and c) develop protocols for transforming three types of *Tetrahymena* nuclei: germline nuclei, developing macronuclear anlagen, and mature somatic macronuclei. Finally, we hope to pioneer transformation using a mating pathway that generates whole genome homozygotes.

Daniel White and Eric Cole (Advisor). HURRICANE OYSTER PROJECT (2007)

This summer, I continued ongoing work on the Hurricane Oyster Project. The aim of the project is to investigate the sexual development phenomena occurring on San Salvador Island, Bahamas in the species *Longisquamosa pinctada*. In some of the brackish inland ponds that *L. pinctada* inhabits, the species has been undergoing the protandrous hermaphroditism typical of related species. That is to say, juveniles generally begin their life as male and then become female later in life. In other ponds, however, female oysters are very common among the smaller size classes, which are made up of younger oysters. We are investigating the hypothesis that the hurricanes that regularly strike the island exert selection pressures favoring early feminization in the ponds where the phenomenon is occurring, based on the fact that they are more prone to disturbance by environmental factors, because they generally lack the Red Mangrove cover typical of such inland ponds, and are generally relatively shallow and fairly large, with relatively fragile substrate, allowing hurricane-force winds to eject oysters from the ponds themselves. I contributed through data collection, processing, and analysis, by collecting and analyzing several hundred oyster specimens, processing into slides several hundred specimens that had been collected by others, and analyzing the gender data evident from those slides.