

STUDENT TITLES AND ABSTRACTS BASED ON SUMMER RESEARCH 2004

Alyssa Anderson. EFFECTS OF PREDATORIAL THREATS ON THE PARENTAL BEHAVIOR OF HOUSE WRENS (*TROGLODYTES AEDON*)

Predation may be one of the most important factors relating to survivorship and fitness of birds. To deal with this constant threat, birds have had to develop various survivorship strategies to avoid predation while maximizing foraging efficiency and upholding other daily activities. The purpose of this study was to determine how the parental behavior of the House Wren (*Troglodytes aedon*) is affected by predatorial threats. During the summer of 2004, playback replicates of both a female wren alarm or scolding call and a raccoon call were conducted for a total of 18 wren pairs. Playback tapes consisted of 30 minutes of blank tape followed by 30 minutes of the selected playback. Of primary interest were the following events: number of feeding trips to the nest box, amount of time spent scanning the area from the nest box, number of times the male sang, amount of time the female spent scolding, amount of time spent brooding chicks, and the number of trips made to the box in which the wren did not feed the chicks. Data were analyzed using an ANOVA. Results for the raccoon playback recordings support the null hypothesis that parental behavior is not influenced by auditory predatorial threats. However, significant differences were found for the scolding playback data, suggesting a lower number of successful feeding trips and a higher number of trips to the box without feeding, as well as a significant increase in scanning time during the scolding playback, thus suggesting an increase in territorial alertness.

Brian Andersen, Ida Jensen, Sara Champlin. COUNTING WATERS: THE INFLUENCE OF BETAINE AND GLYCINE ON DNA HYDRATION AND HELIX STABILITY

To understand the chemical and physical properties of DNA, information about the extent of DNA hydration and the changes in hydration when DNA undergoes a physical or chemical change is needed. The DNA double helix can possess on average almost sixty water molecules per nucleotide unit when optimally hydrated. These waters of hydration are essential for DNA helix stability; removal of these hydrating water molecules reduces the energetic requirement for DNA denaturation.

We have chosen the cosolvents ethylene glycol, betaine, and glycine to probe the hydration of mononucleosomal calf-thymus (ct) DNA. Using high precision density measurements to extract the partial specific volume of DNA before and after dialysis, we have determined the preferential interaction parameter ν_4 for these cosolvents. ν_4 indicates the extent to which cosolvents and water are accumulated near the DNA surface relative to bulk solution. At concentrations of 1 molal or less, all cosolvents studied had a higher concentration near the DNA surface than in bulk, reaching a maximum value of approximately one cosolvent molecule per nucleotide. We found that ctDNA was almost fully hydrated in ethylene glycol solutions (55 ± 4 waters/nucleotide), while only half as hydrated in glycine (31 ± 5 waters/nucleotide) and betaine solutions (28 ± 6 waters/nucleotide). The reduction in the number of hydrating waters with specific cosolvent agrees favorably with ctDNA helix denaturation temperatures. Our results suggest that DNA solvation by water and cosolvent rather than dielectric constant is the major environmental determinant of DNA helix stability.

Isaac Arnquist. DESIGN AND OPTIMIZATION OF BIOANALYTICAL CHEMISTRY EXPERIMENTS

The goal for this summer research project was to create and optimize several different bioanalytical chemistry experiments for the new curriculum being offered for the first time in January of 2005. The objective of the course is to introduce the fundamentals of bioanalytical chemistry through lectures and integrated laboratory experiments. Using techniques like mass spectrometry (MS), 1-D and 2-D gel electrophoresis, high performance liquid chromatography (HPLC), size-exclusion chromatography (SEC), and several others, I was able to develop 8 experiments. Also, at least two others are close to being completed. The completed labs include: (1) molecular weight identification of peptides using MS, (2) peptide sequencing using tandem mass spectrometry (MS/MS), (3) determination of the molecular weight of a protein (>6.0 kDa) by analyzing charge states using MS, (4) separation and analysis of protein mixtures using 1-D gel electrophoresis, (5) analysis of proteins using western blots and dot blotting, (6) molecular weight determination using size-exclusion chromatography for comparison with MS and gel electrophoresis methods, (7) analysis of a directly infused protein mixture using MS, (8) analysis and identification of digested proteins using liquid chromatography-mass spectrometry (LC-MS), and (9) 2-D gel electrophoresis of *E. coli* samples. These experiments will form the core of the bioanalytical chemistry lab curriculum, which will introduce students to state-of-the-art analytical techniques used to study biological processes.

Beth Assell, Christopher Klaus, Milena Klimek and Kate Schindler. EASTERN BLUEBIRD POPULATION DYNAMICS AND BOX PREFERENCE ON THE ST. OLAF NEST BOX TRAIL

The St. Olaf College nest box trail was established in 1992 to encourage the nesting of the Eastern Bluebird (*Sialia sialis*), whose populations have diminished significantly over the past century. Since then, the nest box trail has been consistently monitored and the species of nesting birds and their reproductive success has been recorded. The species of birds found nesting on the trail include: eastern bluebird (*Sialia sialis*), tree swallow (*Tachycineta bicolor*), house wren (*Troglodytes aedon*), house sparrow (*Passer domesticus*) and black-capped chickadee (*Parus atricapillus*). We found that the eastern bluebird tends to be the first species to nest on the trail, has a varying degree of fledging success and is the third most successful nester on the trail. In addition, we determined that bluebirds prefer the Gilwood style nest box to the Peterson style nest box.

Joel Beard. DATABASE MANAGEMENT OF MICROARRAY GENE EXPRESSION FOR *MYCOBACTERIUM TUBERCULOSIS*.

Tuberculosis has made a surprising comeback in recent years and currently infects 1/3 of humans worldwide in its latent form. With the rise of bioinformatics as the fusion of biology, computer science, and mathematics, new tools have been developed to better understand life at the genetic level. One of these tools is the microarray. In microarray experiments, the levels of gene expression across an entire genome can be measured under a variety of conditions. In one experiment, tens of thousands of data points are produced. Biologists performing microarray experiments are thus inundated with information and need efficient ways of giving meaning to the mountains of data. We have used the open source microarray database AMAD (Another MicroArray Database) to provide a home for ~500 microarray experiments performed on the tuberculosis genome by our collaborators. With all the expression data collected together in an efficient and easy to use database (accessible via the web to any researcher with appropriate authentication), more extensive and comprehensive analysis of the data is possible than ever before. This analysis should lead to the discovery of regulatory patterns that may point to regulons, operons, metabolic pathways, or other significant biological phenomena that will further our understanding of one of the world's deadliest diseases.

Anna Bite. EXPLORING THE *TETRAHYMENA* VASA ORTHOLOG

Vasa is a gene involved with germline/somatic cell distinction in multicellular organisms. The vasa gene codes for a DEAD-family protein and was first identified in *Drosophila*. Homologs have been found in diverse species such as mice, oysters, frogs, and recently *Tetrahymena*. This study was undertaken to study the expression of a potential vasa ortholog in *Tetrahymena thermophila*. In order to induce and view the expression of Vasa in conjugating cells, we isolated a potential vasa ortholog in *Tetrahymena* cells and inserted the DNA segment into two plasmid vectors. The vectors used were pIGF-1, a rDNA vector, and pUC118 ;; B-MGL, a vector designed for insertion into the *Tetrahymena* β -tubulin locus. Both vectors contain a metallothionein promoter and a GFP tag. Gene expression may be induced with cadmium and viewed under fluorescent microscopy. Expression of the vasa ortholog in the conjusome, a transient organelle present at the time of nuclear determination, would suggest that *Tetrahymena* possess a mechanism for germline/soma determination similar to that used by multicellular organisms.

Jessica Burtness and Graeme McAlister. UNDERSTANDING THE ROLE OF ACTIN IN TRANSLATION BY STUDYING THE BUNDLING OF MUTANT ACTIN BY eEF1A

Previous research demonstrates that proteins involved in translation co-localize with actin, suggesting a role for actin in translation. Of all the proteins involved in translation, evidence is strongest for an interaction between eukaryotic elongation factor 1A (eEF1A) and actin. Previously it has been shown that eEF1A binds and bundles filamentous actin *in vitro*. Additionally genetic evidence has demonstrated an *in vivo* relationship between actin and eEF1A. We sought to further explore the interaction between these two proteins. We procured a set of yeast with actin mutations that had previously been studied for defects in translation. We purified the mutant actin from the yeast cells, and mixed it with eEF1A. We then examined the bundling and binding of the mutant actin by eEF1A to determine if a change in the interaction between the proteins correlated with the defects in translation observed in the yeast with the mutant actin. We used two different techniques to examine the bundling and binding of actin by eEF1A. We used an immuno-dot blot test that detects the proteins using antibodies specific for actin or eEF1A. We also used an atomic force microscope (AFM) to visually examine bundle formation. Together these techniques allowed us to qualitatively and quantitatively assess the bundling and binding of the mutant actin samples. Interestingly one of the mutant actin proteins, act 1-3, showed decreased bundling and binding efficiency with simultaneous defects in translation. All the other mutant actin was bundled and bound to eEF1A similar to wild type, while still exhibiting varying translation defects.

Ian Cambell and Allison Hagen. ANALYSIS OF SUBGLACIAL BEDROCK MORPHOLOGY IN MODERN AND PALEO ICE SHEET ENVIRONMENTS

The CEGSIC research group maps bedrock beneath the West Antarctic Ice Sheet by transmitting ice penetrating radar signals and recording the returned reflections. We use numerical models and existing high-resolution elevation datasets from North America to test the accuracy of our processing and interpretation procedures. In addition, the models can help to understand the 3-dimensional nature of the topography seen in the 2-dimensional radar profiles recorded in Antarctica during US-ITASE. In our model we assume that the radar wavefronts are hemispheric in shape, picking up reflections in all directions; however, by convention all reflections are plotted as though directly below the system receiver. Reflections from bedrock topography along the vertical plane defined by the profile line can be geometrically corrected through a process known as migration, but the same is not true for reflections from topography to either side of the vertical profile plane. It is these side reflections that we have attempted to recreate, modeling synthetic radar paths over various types of known topography in order to identify and categorize these side reflections.

It is crucial to understand the interactions between ice and bedrock if we are to characterize the response of ice sheets to climate change. At present it is unknown whether there is ongoing bedrock erosion beneath the West Antarctic Ice Sheet, although it is implied by high nutrient transport to the Southern Ocean. We compared the morphology of previously glaciated and unglaciated bedrock in North America with the morphology of West Antarctic bedrock topography interpreted by the St. Olaf College portion of US-ITASE. Glacially eroded bedrock should have a different shape than bedrock where no ice sliding has occurred and erosion has been dominated by surface water. Frequency spectral analyses via wavelets and Fourier analysis have provided little discernment between different types of topology, so we have begun analysis of the topographic curvature (second derivative). We present preliminary results of these studies.

Dean Charles. ETHANOL INDUCED CONDITIONED PLACE PREFERENCE IN ADULT AND ADOLESCENT MICE

Two experiments were conducted using the place conditioning paradigm comparing ethanol-induced place preference between adult (experiment 1) and adolescent (experiment 2) mice. Mice were injected with ethanol (2g/kg) or saline immediately before being placed on a grid or hole floor. Mice spent 5 min on the floor per trial. After four trials of each type a preference test was performed where all mice received a saline injection immediately before being placed on a half grid, half hole floor for 30 min. Conditioned place preference was demonstrated in both the adult and adolescent mice such that on the test day mice spent more time in contact with the floor that had been paired with ethanol during the conditioning trials. The adolescent mice spent fewer seconds per minute on the ethanol-paired floor near the end of the trial than did adult mice. Ethanol injections normally cause an increase in activity and this increase gets bigger over conditioning trails. In the present experiments this held true for the adult mice with conditioned activity increasing overall from the first ethanol trial to the fourth ethanol trial, however conditioned activity for the adolescent mice decreased from the first to fourth ethanol trial. Additional experiments using different doses of ethanol and a different number of conditioning trials need to be performed to determine the reason for these differences between adult and adolescent mice.

Bunkhuon Chhun. CENTRAL EXCITATORY STATE IN DRONE FLIES

The drone fly (*Eristalis tenax*) Is an important pollinator with a direct impact on its environment. The drone fly also exhibits a phenomenon called the Central Excitatory State (CES) when stimulated with sucrose. After stimulation, the flies' movement, flying, and landing behavior increase in intensity. Dethier (1976) outlined four different criteria in distinguishing the CES from other phenomena: 1) Decay of excitation over time 2) Influence of stimulus intensity on the rate of decay 3) Effect of food and water deprivation and 4) Influence of inhibiting stimuli. My experiments verified that the CES of the drone fly meets these criteria. Also, other experiments involving visual stimuli, age of the flies, and sensory properties were conducted.

Knut Christianson. A REVIEW OF 4 YEARS OF ST. OLAF DEEP PENETRATING RADAR DATA AS PART OF US-ITASE

The United States Trans-Antarctica Scientific Expedition (US-ITASE) is a consortium of 11 research institutions that investigates the last 200+ years of change in climate and atmospheric chemistry over the West Antarctic Ice Sheet (WAIS). US-ITASE recently completed 4 traverses of WAIS from 1999-2002. St. Olaf's contribution to US-ITASE is a deep penetrating radar system that can record internal features in the ice and subglacial bedrock topography along the traverses. The St. Olaf deep radar system recorded local profiles during the 1999 and 2000 traverses and recorded over 2000 kilometers of data along the complete 2001 and 2002 traverses. Processing and interpretation of this data is now complete and ready for public distribution by the National Snow and Ice Data Center (NSIDC). This talk will review the goals of deep penetrating radar as part of US-ITASE, highlight the improvements in data seen between each year, review glaciological features seen in the ice, discuss case studies of glaciological features, and discuss the completed results.

Kieran Cofell-Dwyer. A COMPARISON OF CONSUMER VS. SURVEY-GRADE GPS SYSTEMS: PRECISION, ACCURACY AND REPEATABILITY

While GPS offers a simple way to obtain position information in field science programs, the expense of precision survey-grade systems can be prohibitive. Handheld units are more affordable, but manufacturer documentation often lists accuracy levels on the order of 10 m. Such inaccuracy may not meet the needs of even general location requirements. However, these published specifications often predate the elimination of Selective Availability in the GPS system and may also suffer from liability concerns of the manufacturer. Past experience has indicated that the accuracy and precision of handheld GPS units may be better than the published values and may be serviceable in a broader range of fieldwork applications. Trials were performed with Garmin handheld GPS units and a Trimble precision GPS system to test this hypothesis. These trials indicate that the Garmin systems have a horizontal precision of ± 1 m when real-time WAAS differential corrections are available. The horizontal accuracy is dependent upon the view of the sky and the satellite constellation, but with good conditions (and an external antenna) the accuracy is ± 1 m. Vertical accuracy provided by GPS is usually three times worse than the horizontal accuracy. For this reason it is preferable to use an altimeter to record elevation. The altimeter used by the Garmin units has a precision of $\pm .5$ m. However, transient changes in barometric pressure adversely affect repeatability of elevation measurements. Pressure changes due to weather fronts can be effectively removed by employing a second altimeter as a stationary reference station. Barometric trends in the reference station are removed from the roving altimeter data to obtain repeatable precision on the order of ± 1.5 m. Absolute accuracy of the altimeter is then determined by the accuracy of the elevation calibration. In practice we find that the reliable accuracy of the handheld GPS units is generally on the order of 2 m in the horizontal and 3 m in the vertical.

Leigh A. Cooper and AmberBeth VanNingen. EARLY TREE GROWTH PATTERNS IN A CONIFER RESTORATION

As part of the St. Olaf College natural habitat restoration program, two conifer sites were planted with two-year old seedlings in 1993 and 1999 to establish areas similar in species composition to coniferous forests in northern Minnesota. The purpose of this project was to examine early conifer growth patterns and reproductive output with the goal of making recommendations for future restoration projects. Some trees were initially grown with plastic tree shelters or fabric mats to reduce competition. For each tree, we measured height, diameter, and male and female cone production. We also took GPS positions of the trees to produce maps with locations of individual trees and measured soil nutrients. Soil tests for nutrients and moisture showed few significant differences among the conifer sites and nearby prairie and agricultural plots. Tree results showed significant differences in tree heights among species after 10 years of growth, but no significant differences in tree heights between those grown in plastic tree shelters or with fabric mats and those with no initial growth treatment. Jack pines had the tallest and balsam firs had the shortest mean heights. Few viable seeds were produced in the cones found on the 12-year old trees. Unless deer herbivory is high, this study suggests that the benefits do not justify the cost of using tree shelters for young conifers. In the future, cone production is expected to increase and red and white pines are expected to dominate the canopy. Continual maintenance will be required to decrease the hardwood seedlings that naturally grow in the area.

Mehdi Dastrange. INDOLES AND INDOLINES AS LIGANDS IN EARLY TRANSITION METAL COMPLEXES

The development of new ligands to support inorganic and organometallic chemistry has been a cornerstone of research in chemistry for many years. In this context we have decided to examine the synthesis and reactivity of complexes containing indole/indoline ligation. This is a class of ligands that has so far been underutilized. Once prepared and purified, these organic molecules will be reacted with early transition metals titanium, zirconium and tantalum. These compounds we propose synthesizing could be viewed as a homogeneous models for hydrodenitrogenation catalysis.

Sara Fortman, John Nichol, and Jimmy Randolph. MOLECULAR BEAM SPECTROSCOPY.

Using St. Olaf's Molecular Beam Electric Resonance Spectrometer, we study hyperfine interactions, which are interactions between the nuclei of molecules and their surrounding molecular electric and magnetic fields. By finding the energies associated with hyperfine transitions, we can model the electric and magnetic characteristics of the nuclei, as well as the fields that act on them. This summer we completed the fine-tuning of a new data analysis program that is more efficient than the software we used previously. We also continued previous years' work on lithium iodide, rubidium chloride and rubidium fluoride. Additionally we began and nearly completed our investigation of potassium bromide. We expect to publish papers on these four molecules in the near future.

Haley Hedlin. STATISTICS' ROLE IN THE ANALYSIS OF LINGUISTIC VARIATION

Variationist linguistics examines the variation in the speech of individuals or between groups of people. In order to adequately analyze the data and arrive at conclusions about linguistic patterns, the linguists transform speech into quantitative form. This is often done using a computer program called VARBRUL, which derives its name from "variable rules". The variables are characteristics of speech, such as lexical items, that impact the speaker's choice of words or linguistic pattern. VARBRUL then transforms these variables into output, which consists of factor weights, probabilities, and contingency tables. The goal of my research project is to understand how VARBRUL carries out these actions from a statistical point of view.

Casey Johnson. COMPLETION OF THE POSITRONIUM-GAS SCATTERING APPARATUS AND DATA ACQUISITION SYSTEM.

A positron and electron can form an exotic atom called positronium. The interaction of positronium and a gas can be analyzed by measuring positronium lifetimes and annihilation energies. This summer I worked on finishing and optimizing the apparatus, electronics, and software for our positronium-gas scattering experiment. My work constitutes a unique data acquisition system that can correlate the energy and lifetime of positronium. We are currently taking data with this acquisition system, and we hope to soon obtain the most precise measurements of positronium-gas interactions to date.

Elizabeth R. Johnson. MONGOLIAN MUD: A LOOK AT THE CORRELATIONS BETWEEN CHARCOAL, FIRE AND CLIMATE IN CENTRAL ASIA

Fire greatly influences the grasslands of North America (Umbanhowar 2004) and possibly Mongolia. Sediment charcoal was analyzed from Lake Dood and Lake Telmen in central Mongolia. Generally, Telmen had more charcoal than Dood, reflecting a greater abundance of grasses. Median charcoal fluxes (Telmen-0.0024, Dood-0.0087) were less than fluxes for similar sites in North America (Clark et.al. 2001). The charcoal data indicates more burning associated with transitions from forest to grasslands (Fowell et.al. 2002).

Brent A. Kudak. EVALUATING THE UTILITY OF THE MITOCHONDRIAL CONTROL REGION IN PHYLOGENETIC ANALYSIS OF MINNESOTA FISH POPULATIONS

After the Wisconsin glaciation of the late Pleistocene, Johnny darters (*Etheostoma nigrum*) recolonized the streams and lakes of Minnesota/Wisconsin. In order to learn more about the dispersal routes and subsequent gene flow radiating darters may have used, this study utilized phylogeography. Phylogeography uses intraspecific genetic variation to construct phylogenies that help explain current organismal distributions. Johnny darters were collected from eight sites, and the NADH dehydrogenase subunit 2 (ND2) gene was sequenced and analyzed. In general, Minnesota and Wisconsin fish possessed very similar haplotypes. However, individuals from the Otter Tail River (MN, Red River drainage) grouped together, as did individuals from the Pike River (MN, Rainy River drainage) and the Swan River (MN, Laurentian drainage).

Benjamin Landsteiner. SOFTWARE FOR AUTOMATING PROTEIN DOMAIN AND SEQUENCE SEARCHES FOR BENCH SCIENTISTS.

Biological data is continually being updated. This constant flood of information can become overwhelming and hinder scientific progress for bench scientists. Current Comparative Table (CCT) solves this problem by automating information retrieval and analysis. Biological sequences, databases, and analysis searches of interest are put into CCT and the computer does the rest. Updates to biological databases are automatically retrieved and the analysis searches are rerun. Any updates that are found are saved and stored in a table that is color-coded by age. Each individual analysis report shows what and where results changed, allowing for the bench scientist to focus on analyzing the new data rather than rehashing the old data

Maureen McDonald and Jenell Stewart. H9c2 CELLS AS A MODEL OF CARDIOPROTECTION

Myocardial ischemia, the underlying cause of a heart attack, results in cell death due to lack of oxygen. When exposed to simulated ischemia, H9c2 cells, a non-differentiating rat heart cell line, can provide a model of cell death. Ischemia is simulated by exposing cells to a buffer which contains chemicals that inhibit metabolic pathways. A principle ingredient in the buffer is sodium hydrosulfite, a strong reducer that targets the electron transport chain. The purpose of this research was to develop cell survival curves in relation to varied concentrations of sodium hydrosulfite and to correlate this to the production of metabolic byproducts. To accomplish this, H9c2 cells were exposed to an "ischemic buffer" for 30, 60, or 120 minutes. Five concentrations of sodium hydrosulfite in the buffer were tested using the published 7.47×10^{-4} M concentration of $\text{Na}_2\text{S}_2\text{O}_4$ (1X) and 0.1X, 5X, 10X, and 20X. Increased concentrations of $\text{Na}_2\text{S}_2\text{O}_4$ led to a decrease in cell survival at 30 and 60 minutes; cell survival was low at all concentrations at 120 minutes. As assessed by HPLC, increased concentrations of $\text{Na}_2\text{S}_2\text{O}_4$ corresponded with increased levels of adenosine and AMP and decreased levels of inosine. These data will help establish H9c2 cells as a model for the study of myocardial ischemia.

Megan McWhirter. ETHANOL-INDUCED CONDITIONED PLACE AVERSION IN ADOLESCENT AND ADULT MICE

Two experiments were conducted using 40 male DBA/2J mice each. One experiment used adolescent mice and the other used adult mice. Subjects were given access to a distinctive environmental stimulus (type of floor: grid, hole) and ethanol (20%, 2 g/kg dose) in a place conditioning paradigm. A different type of floor was given with saline. Adult mice that were injected with ethanol immediately after being removed from the floor of the conditioning chamber showed a conditioned place aversion to the drug-paired floor. Saline injections did not produce a conditioned place aversion in the mice. These results suggest that the intraperitoneal injections of ethanol elicited an unwelcome transition from sobriety to drunkenness and this transition was associated with the drug-paired floor. In the same procedure, adolescent mice did not display a conditioned place aversion to the drug-paired floor, which suggests that perhaps adolescents are not as sensitive to the aversive effects of ethanol.

Christopher Mueller. CPET STAGE 1: BACKGROUND RESEARCH AND PROTOTYPE

CPET, the Co-Process Extension Tool, is a software "glue" that binds external applications, or co-processes, to a Web page. CPET's co-processes provide services that enhance an existing course management system (CMS) without altering it directly. CPET helps to deliver Just-in-Time Teaching (JiTT) services to a wide audience. CPET can, for example, check computer code that students type into a JiTT-style online quiz in computer science--something no existing CMS can do. CPET operates using a client/server model. The CPET client, a Web browser plug-in, modifies the HTML code of Web pages served by a CMS in order to provide access to CPET co-processes, and sends requests for these services to the CPET server. The CPET server is a hub with various co-processes attached capable of processing CPET client requests and returning the results to that client.

Kristen Mueller. USING PHYLOGEOGRAPHY TO STUDY THE EFFECTS OF PLEISTOCENE GLACIATION ON DARTER FISH

During the Pleistocene, glaciers covered much of North America, driving fauna into refugia such as the Wisconsin Driftless Area. Phylogeography was used to investigate the role of the Driftless Area as a potential refugium for the broadly distributed darters *E. caeruleum*, *E. flabellare*, and *E. zonale*. The mitochondrial ND2 gene was sequenced for specimens obtained from the unglaciated Driftless Area, and combined with past data sets for these species. The phylogenies constructed grouped Minnesota and Driftless Area populations together strongly, with populations from southern refugia falling outside of the midwestern fish. There was little genetic variation among Midwest populations, especially when compared to populations from Kentucky, consistent with the fact that the Midwest populations are relatively recent arrivals. Based on these analyses, it seems unlikely that *E. caeruleum*, *E. flabellare*, or *E. zonale* used the Driftless Area as a refugium during Pleistocene glaciation.

Matt Nyflot. PROBING MICROSCOPIC STRUCTURE USING POSITRONIUM LIFETIME AND ENERGY ANALYSIS

The unique characteristics of positrons make them useful for detecting changes in microscopic structure in materials. Goals for the summer were to develop two new experiments based on Doppler-broadening and lifetime spectroscopy techniques. My work, specifically, was to construct the necessary apparatuses, tune the electronics, and design software for interfacing and analysis. At the end of the summer, both experiments have been completed and preliminary structural data has been taken on the melting of calf-thymus DNA and phase transitions in actin.

Joey Paulsen. POSITRONIUM ENERGY ANALYSIS FOR THE POSITRONIUM-GAS SCATTERING EXPERIMENT

Positronium (Ps), the bound state of a positron and an electron, is a unique and useful tool for studying collisions with gases on the molecular level, because of its size and mass. These attributes have been harnessed in a project to study the scattering of Ps from gas atoms. We now have the capability of collecting Ps annihilation radiation energy data as a function of the time spent by Ps in the gas. My work has been focused on writing a computer program to automate data analysis. Currently, the program can separate the desired signal from background noise and fit a number of energy peaks, while correcting for the resolution of the gamma ray detector. These fits are then used to measure the energy of the Ps through its annihilation radiation. From this we can measure the interaction between Ps and gas atoms. We have processed and fit some preliminary data, and more data acquisition and analysis will take place this fall.

Anton (Tony) Peterson. IDENTIFICATION OF FENESTRIN AND OTHER *TETRAHYMENA* PROTEINS

The goal for this research project was to determine the sequence of an approximately 64 kDa protein called Fenestrin, which is found in the unicellular organism *Tetrahymena thermophila*. In the experiment, proteins obtained from *Tetrahymena thermophila* were first separated by mass using 1D-gel electrophoresis. Although the 64 kDa protein was not isolated, an approximately 20 kDa protein that appears to be related was isolated. The 20 kDa band was excised and digested in-gel using sequence grade trypsin. The digest was analyzed using Liquid Chromatography Mass Spectroscopy, with electrospray ionization on an ion trap instrument. Upon analysis, a series of twenty-three signals were observed in the digest and not in the background, and thus are candidates for peptide fragments produced from the digest of the isolated protein. The masses of the identified peptides were submitted to the Rutherford lab to determine the identity of the isolated protein using bioinformatic techniques.

Kirsten Rittenbach. ANALYSIS OF CAFFEINE TRACERS IN THE CANNON RIVER WATERSHED.

Anthropogenic (human produced) compounds pass unscreened through wastewater treatment facilities (WWTF), or as agricultural runoff, into natural waters. The United States Geological Survey (USGS) recently conducted a nationwide study in attempt to analyze the presence of anthropogenic pollutants in natural waters. Such a study has only just begun at the local level. Our research goal was to design and apply analytical methods to determine the identity and quantity of contaminants in the Cannon River Watershed. River water samples were collected, centrifuged, and filtered using standard procedures. Solid Phase Extraction (SPE) was conducted using 3M Empore poly-styrenedivinylbenzene (SDB) cartridges. Caffeine and other anthropogenic compounds were analyzed using Gas Chromatography/Mass Spectrometry detection (GC/MS). Standard calibration curves were used as a basis for comparison and evaluation. The limit of detection for caffeine was $50 \text{ ng} \pm x \text{ ng}$. We want to continue expounding on previous research and use our findings to inform the local community of pollution problems and their possible environmental impacts.

Johanna Savage. THE NUCLEAR EXCHANGE JUNCTION OF TETRAHYMENA THERMOPHILA: THE DEVELOPMENT OF AN ISOLATION PROTOCOL FOR FUTURE MOLECULAR AND MORPHOLOGICAL CHARACTERIZATION.

The understanding of membrane fusion represents one of the great biological enigmas of our time. Membranes are defined by their definitive function to isolate one structure or organism from another. Hence, the occurrence of membrane fusion presents a unique and mystifying paradox. The study presented here focuses on the membrane fusion event of conjugation (sexual reproduction) in *Tetrahymena thermophila*. In particular, our research sought to develop a working protocol for the isolation of the nuclear exchange junction (conjugation junction). Using a 50% ethanol fixative followed by ultrasonication, we effectively isolated the nuclear exchange junction with modest purity from the surrounding cellular context. Further purification by density gradient centrifugation is currently being developed. Proteins from these exchange junctions were solubilized by employing a Triton High Salt (THS) extraction and are being prepared to serve in the manufacture of monoclonal antibodies. Future studies will explore the appearance of particular exchange junction proteins during conjugal development.

Lisa Schaus and Laura Taylor. MODELING ENZYME ACTIVE SITES: GROUP 6 METAL CHEMISTRY.

Molybdenum (Mo) and tungsten (W) are Group 6 metals often found in the active sites of enzymes that catalyze oxidation-reduction reactions in a wide variety of organisms. These active sites share a common structure, with the metal bonded to a dithiolene ligand complex called molybdopterin. An effective way to study the metal environment of the active site is to synthesize a simpler molecule that can mimic the bonding at the active site. The dithiolene ligand *tfd* is used as a model for molybdopterin in our compounds. Laura's project involves the synthesis of model compounds containing *tfd* and a dithiocarbamate ligand, a ligand similar to dithiolenes. Some Mo- and W-containing enzymes have two dithiolene ligands at the active site, and the dithiocarbamate ligand can be used to represent this second dithiolene. Two model compounds have been synthesized containing both a dithiolene and a dithiocarbamate ligand bonded to a central metal. The compounds are analogous but contain different metals. Lisa's project involves the synthesis of a heterobimetallic compound containing a Mo-W bond as well as bridging *tfd* ligands. The use of chemical tags on the metals helps identify the presence of each metal through ¹H-NMR. Several compounds have been isolated that have potential for being the target compound. In the process, a new compound has been synthesized that contains two tungsten atoms, *tfd*, and other ligands.

Keisha Sedlacek. DETERMINING THE LETHAL DOSE OF DIMILIN IN TOBACCO HORNWORMS.

Diflubenzuron (Dimilin) is a pesticide that affects molting by interfering with chitin synthesis. It must be ingested to be toxic. It has typically been used to control Gypsy Moth populations. However, it can also affect other non-target arthropod species. I studied the effects of Dimilin on the larvae of *Manduca sexta* (tobacco hornworm). The purpose of this study was to determine the lethal dose of Dimilin in tobacco hornworm larvae on a per mass basis. I fed the larvae food containing different concentrations of Dimilin. The higher the concentration fed to the larvae the higher the mortality rate. I was able to extract Dimilin from the food and tobacco hornworm larvae. The next step will be to quantify the concentration of Dimilin in each larvae.

Jared Walker Smith. SEARCHING FOR THE VANISHING PRAIRIE VOLE

When determining the quality of prairies, the small mammal populations within them are often overlooked. While prairie plants can survive as small remnant patches for lengthy periods of time, small mammal populations are more restricted and need larger areas of land to live in. Prairie voles (*Microtus ochrogaster*) are one such remnant population and are listed as species of special concern in Minnesota and deserve careful monitoring. This study surveys some of the most likely habitats for prairie voles to be found in around Rice, Goodhue, and Dakota counties in Minnesota and conducted a standard small mammal trapping session of both remnant and reconstructed prairies. Two prairie voles were captured in only two of the seven sites surveyed in five prairies. Remnant populations are especially at risk for local extinction when lack of corridors between prairies inhibits movement. Knowledge of small mammal species present in prairies can help determine the best ways to preserve, conserve, and restore native dry grass prairie.

Logan Smith and Mike Helgen. OVERVIEW OF ICE AND CLIMATE STUDIES IN ANTARCTICA

Glaciers and ice sheets play a major role in the earth's climate, affecting the absorption of solar radiation as well as atmospheric and oceanic heat flow. The U.S. International Trans Antarctic Scientific Expedition (US-ITASE) has completed four traverses across portions of the West and East Antarctic Ice Sheets to help understand the relationship between Antarctica and the earth's climate and changes over time. Along these traverses St. Olaf has recorded deep penetrating ice radar data that provides information on subglacial bedrock topography and internal ice. The internal ice stratigraphy is affected both from above by wind scour and below by bedrock topology. We have compared trends in the 2002-03 traverse data and other data including shallow radar, reflectivity, and ice flow velocities to better understand these effects.