SPECIAL ISSUE
SUMMER RESEARCH 2007
IN THE ST. OLAF FNSM

Application Deadline is Feb 16

BIOLOGY DEPARTMENT

Diane Angell – Small Mammals in Prairies

Next summer we will continue projects trapping small mammals in remnant prairies in and around Northfield. Small mammals play crucial roles as predators, prey, seed dispersers and grazers. We know little about the distribution of prairie small mammals in southern Minnesota. We will have two goals this summer. First, we will continue to monitor the presence of prairie voles by re-trapping in areas where they were found in previous summers. The prairie vole is currently a species of "special concern" in Minnesota. Despite being historically abundant, it has declined in numbers as prairies have been replaced by agricultural lands. Second, we will expand trapping in order to formally compare species diversity in remnant prairies with prairies that have been reconstructed on agricultural lands. As local colleges and nature preserves replant prairies we need to evaluate the utility of these reconstructed prairies in the preservation of declining prairie mammals such as the prairie vole. Access to a car is an advantage and research students need to be independent and motivated! Evenings setting traps and early morning trap checks are required.

Eric Cole and Doug Beussman – *Tetrahymena* gene stream project. Doug Beussman and Eric Cole are collaborating again on research related to the biology of nuclear exchange during mating in the ciliate *Tetrahymena thermophila*. More specifically, we are attempting to identify and characterize all the proteins that constitute the nuclear exchange junction between mating cells. This work involves two projects this summer. First, one student will work to develop 2-dimensional SDS PAGE (electrophoresis), in order to separate and purify proteins based on molecular weight and pH characteristics (Cole Lab). Meanwhile, two students will use mass spectrometry to determine precise molecular weights for these proteins and bio-informatics in order to identify, and characterize the relevant genes from the published *Tetrahymena* genome.

Eric Cole – Sex determination in the scaly pearl oyster.

Learn classic light microscopy and paraffin histology in order to study sex determination in the Scaly Pearl Oyster. We are studying two discrete populations of oysters on the Island of San Salvador in the Bahamas. These bivalves are sequential hermaphrodites, beginning life as males and becoming females as they grow older. We want to determine the sex of individuals as a function of size/age, and compare a colony that has been subjected to extreme population decimation due to hurricane activity with a colony that has not been severely effected. We are testing a prediction that the hurricane-decimated population should be quicker to mature, and quicker to change sexes as a consequence of their severe and repeated population bottlenecks, and size-dependent mortality. The work consists of examing fixed oyster gonads under the microscope in order to evaluate sexual maturity and gender.

Kevin Crisp – Cellular mechanisms of dopamine-induced fictive crawling activity in isolated ganglia of the leech CNS.

Many rhythmic animal behaviors are produced by oscillator circuits, neural networks that are capable of generating patterned motor activity in the absence of patterned are capable of generating patterned motor activity in the absence of patterned sensory inputs. The actions of dopamine on ganglia isolated from the leech central nervous system (CNS) produce rhythmic oscillations similar to those recorded from semi-intact, crawling animals. The crawling circuit is composed of a chain of more than 20 oscillator circuits, and intersegmental coordination between these oscillators organizes the expression of crawling behavior. This project aims to characterize the intracellular signaling mechanisms leading to activation of the crawling circuit.

Kevin Crisp and Doug Beussman – Neuromodulators of hormones

Neuromodulators are hormones that cause long-lasting changes in the ways neurons and neural networks function. They exert their effects on neurons by activating intracellular signaling pathways leading to the phosphorylation of diverse proteins that regulate cellular excitability. In the medicinal leech, the neuromodulator serotonin regulates behavior (e.g., swimming and biting) and neurodevelopment (e.g., synaptogenesis), in part through tyrosine phosphorylation. This project aims to identify proteins that exhibit serotonin-regulated phosphorylation in the medicinal leech using a variety of proteomic methods. Proteins will be extracted from leeches, and separated using affinity chromatography and/or gel electrophoresis. The resulting proteins will be digested and analyzed using LC-MS and tandem mass spectrometry techniques, and the results used to attempt to identify the original proteins.

Steve Freedberg – Sex-ratio evolution in reptiles.

I am interested in the evolutionary dynamics of sex ratios and sex determining systems. For instance, species with environmental sex determination (ESD) may be subject to large sex ratio fluctuations over time due to periodic climatic shifts. Because sex ratio fluctuations are predicted to lower the effective population size, and consequently, genetic diversity, there is an expectation of lower genetic variation in ESD populations. Reptiles provide an ideal system to examine this issue because there are several species with ESD that are closely related to species with genetic sex determination. In order to address this question, we can analyze genetic sequence data from three sources: 1) "mining" genetic data banks, 2) analysis of preserved museum specimens, and 3) tissue collection from turtles housed here at St. Olaf and collected from the wild in Northfield. I am looking for 1-2 students who would be interested in laboratory molecular analysis and/or writing code for sorting through genetic sequence databases.

Jean Porterfield – Freshwater fish phylogenetics.

In general, I study the evolutionary biology of freshwater fishes. Specifically, my work with St. Olaf students has focused mainly on phylogeography, or the use of phylogenetic (genetic relationship) data to interpret geographic (distribution) data. Last summer, two students and I, along with Dr. Patrick Ceas, began a project on the longear sunfish (it really does have long "ears" - check out the poster outside SC 142!). This species is of special concern in Minnesota because of its spotty distribution within and among various groups of lakes throughout the state. This summer we plan to go on three or four longear sunfish reconnaissance missions, which each consist of three to five days sampling lakes (mostly in the northern half of the state) with seine nets, usually using boats to search for appropriate sampling habitat. The purpose of these trips is to check on historical localities, find new records of the longear sunfish in the state, and collect tissue samples of the fish for DNA analysis. Our work also contains a significant genetic component, and about two-thirds of the ten weeks will be devoted to laboratory work on the genetic diversity of the longear sunfish that we collect. We use two methods to assess genetic diversity: sequencing of mitochondrial DNA, and fingerprinting of nuclear microsatellite loci (microsatellites are sequences of repetitive DNA like "CACA…CA" that are usually quite variable in repeat size, even within populations). Our field sampling and our genetic analyses will eventually be used in recommendations to the Minnesota Department of Natural Resources about potential management of this fish. Dr. Ceas and I would like to work with two students this summer, and I'd like at least one of the students to be able to continue the genetics work in Fall 2007 by registering for an Independent Research course (Biology 398). If you think you would enjoy both rigorous fish sampling field work, and detailed molecular genetics techniques, please come talk to me and find out more about the research!

John Schade – Nutrient cycles and consumer-resource interactions.

My current research interests center on studying feedbacks between multiple nutrient cycles and consumer-resource interactions. I am currently involved in a project in which we ask where and when are biotic interactions and biological stoichiometry important determinants of nutrient transport and retention in river networks, and what are the consequences for downstream communities? I am looking for 1 or 2 students to participate in a project studying these processes in a network of streams at the Angelo Coast Range Reserve in Northern California. Students would be responsible for developing a research project and assisting in the lab and field. They will also gain valuable experience in fieldwork involving collection of water, algae and stream invertebrate samples, as well as exposure to standard and novel approaches to studying stream ecosystems. In addition, this project will provide opportunities to interact with collaborators at the University or California-Berkeley and from the University of Minnesota.

Kathy Shea – Forest ecology/Population structure.

My research will focus on forest ecology through studies of forest restoration, population genetics, and tree-ring analysis. There has been increased interest in how to restore natural systems as more landowners see the benefits of having adjacent natural habitat. With students over the last 16 years I have conducted studies on the growth and survival of trees in the forest restoration areas that are part of the natural lands surrounding the campus. Trees in the forest restoration areas were mapped using a GPS system and then map location and tree/site characteristics were transferred to a GIS database. New data, including tree size and soil characteristics, will be collected and added to the existing database on the St. Olaf Natural Lands. Because part of the emphasis will be on data analysis, I am looking for someone with interests/background in statistics.

Other areas of research include an analysis of balsam fir population level genetic variation and tree ring variation. For the population genetics project DNA from previously collected samples from large and small populations will be compared using microsatellites. Population genetic data provide information on the genetic health and past history of populations. Loss of genetic diversity is a concern for conservation, especially in small isolated populations. For the tree-ring project ring-width variation patterns in balsam fir tree cores will be analyzed and compared with tree size and climatic variation. Students working during the summer will be encouraged to use some of this research as the basis for an independent research project during the academic year.

Mike Swift - Aquatic biology in northern Minnesota.

WANTED – one-two students interested in summer research in a semi-wilderness setting in northern Minnesota! Must be willing to study aquatic biology by canoe, live and work in an atmosphere of intensive teaching and research, and work independently and cooperatively. My students will begin their research on campus (~ 2 weeks), conduct their field sampling at Coe College's Wilderness Field Station where I'll be teaching aquatic ecology (~ 4 weeks) and complete their project on campus (~ 4 weeks). A broad range of research projects (e.g., vertical migration, predation), habitats (e.g., lakes, ponds, streams, wetlands), and organisms (zooplankton, fish, insects, plants) are possible . A ~ $700 fee covers room, board, use of equipment, and insurance.

Charles Umbanhowar, Paul Jackson, and Meg Ojala – Imaging and imagining changes in the landscape of southern Minnesota described by the J.N. Nicollet expedition of 1838.

Joseph Nicollet was a French astronomer and was hired by the U.S. Gov. to survey the Upper Mississippi drainage, and he is noted for his detailed (and sympathetic) descriptions of the landscape and its people. In the Fall of 1838, he and the others in his expedition traveled from Fort Snelling south to present-day Northfield (crossing the Cannon at Waterford), then on to the current location of Faribault and eventually on to Spirit Lake in Iowa.

We will be working with six students (8 weeks only) to document the path of Nicollet's travels by reconstructing the landscape and 1838 and today. Students will be engaged in activities ranging from photographing the modern landscape, exploring documents related to the expedition at the Library of Congress and Smithsonian in Washington, D.C. sampling water from the various lakes visited by the expedition as well as extracting lake sediments that were deposited in the 1830s and 1840s. Students working with Umbanhowar will have primary responsibility for lake sediment coring and analysis of sediments for charcoal, P, and biogenic silica. Students working with Jackson will be focused on caffeine and pharmaceuticals in lake water and students working with Ojala will be responsible for landscape photography and photographing and/or scanning historical documents.

Anne Walter and Doug Beussman – The lipid and protein signatures of plant membranes.

We will be continuing our efforts to isolate and assess the purity of particular beetroot sub-cellular membrane components. Our primary focus will be the tonoplast membrane which will be isolated from a beet homogenate by differential and sucrose density gradient centrifugation techniques and tested for purity using a combination of classic enzyme based assays and LC-Mass Spec analysis of the total lipid and protein components. The latter will be initially separated by polyacrylamide gel electrophoresis and the former by reverse phase liquid chromatography and/or thin layer chromatography. The motivation for this project is ultimately to understand how a plant toxin, dihydrowyrone, is able to increase the proton permeability of tonoplast membrane. Knowing the components with which it is interacting is a critical step in this process.

Anne Walter – Introducing MathCad and some new experiences in the physiology laboratory.

Animal Physiology and Cell Physiology labs and assignments are due for a make over and the goal of this project is to effectively introduce an appropriate level of physiological modeling into both courses. I propose to use MathCad as the "tool" and intend to develop exercises related to "fluxes" – heat flux, gas flux and ion fluxes between two and more compartments under a variety of well defined conditions. Clearly, we need to make sure the measurements we make in the lab are as exciting as the models. In addition, we'll be testing some new lab equipment and writing protocols. The student working with me on this project will have the opportunity to pick and choose among the projects, to do the necessary background research on the science and on the pedagogy. As the goal is to be interdisciplinary in our approach, the research will also involve identifying links to other courses and coming up with an assessment plan to see if the new course exercise actually helps students learn to see the links among the disciplines.

BIOLOGY AND CHEMISTRY DEPTS

Laboratory development for ID125/126/127: Integration of Chemistry and Biology.

The chemistry and biology departments are developing a sequence of courses, ID125/126/127, that will be offered beginning fall 2007. These courses will take an interdisciplinary approach to cover topics equivalent to those in Chemistry 125 and 126 and Biology 125. The committee for the integration of chemistry and biology has identified potential integrated topics for which laboratory exercises must be developed and tested. Two students will be hired to develop, create, and test new laboratories that will be used in these courses. Students will learn a wide variety of laboratory skills and have a wonderful opportunity for affecting development of these new courses in a way that will have lasting impact on the chemistry and biology curriculum. Interested students must have completed both Biology 125 and Chemistry 125 and 126. For more information see Professors Gary Miessler, Jeff Schwinefus, Beth Abdella or Kim Kandl.

CHEMISTRY DEPARTMENT

Doug Beussman – Summer 2007 research opportunities.

There will be several opportunities for students to engage in research with me during the summer of 2007. All projects will rely to a large extent on the use of mass spectrometry, as well as on various separation methods.

One project includes collaborating with Dr. Cole in the Biology Department and a research group at Drake University on the identification of proteins isolated from *Tetrahymena thermophila*, using proteomic methods. These proteins will be digested and analyzed using mass spectrometry techniques with the LC-MS instrument (and possibly a new MALDI instrument) and screened against a database. Peptides from potentially identified proteins will be reintroduced into the mass spectrometer and tandem mass spectrometry will be performed in order to sequence the peptides for confirmation of protein identification.

A second opportunity for summer research involves developing sensitive and selective forensic science methods for the analysis of date rape drugs in beverage residues, using mass spectrometry. The residues may be the final few drops of liquid in the bottom of a glass, or the dried remains of these drops. This project will use the LC-MS to attempt to identify and quantitate different drug residues from a variety of beverage samples.

My lab will also be involved in a variety of other collaborative projects. If interested in these, please take a look at the descriptions listed, in the Biology Department section, with Dr. Anne Walter or Dr. Kevin Crisp.

<u>Paul Jackson</u>, Charles Umbanhowar, and Meg Ojala – Imaging and imagining changes in the landscape of southern Minnesota described by the J.N. Nicollet expedition of 1838.

Joseph Nicollet was a French astronomer and was hired by the U.S. Gov. to survey the Upper Mississippi drainage, and he is noted for his detailed (and sympathetic) descriptions of the landscape and its people. In the Fall of 1838, he and the others in his expedition traveled from Fort Snelling south to present-day Northfield (crossing the Cannon at Waterford), then on to the current location of Faribault and eventually on to Spirit Lake in Iowa.

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Paul Jackson – Additional research opportunities

In addition to the J.N. Nicollet project, there are other opportunities for students may work with me. <u>Green Chemistry in Upper Level Labs</u>: This project seeks a student willing to continue the development of new experiments in green chemistry. Building on work done this past year the researcher will work with Dr. Jackson and consult with other faculty on experiments suitable for analytical and physical chemistry lab courses. The work will range from identify aspects of green chemistry that apply to these laboratory settings, applying appropriate green chemistry metrics, adapting green experiments already developed elsewhere, and inventing new experiments utilizing green chemistry. Use of Raman spectroscopy in real-time analysis of organic reactions, such as those done in synthesis lab will also be included. Students interested in this work should have completed either physical chemistry lab or analytical chemistry lab by the summer of 2007. <u>Blood Alcohol Testing</u>: Working in cooperation with Dr. Shelly Dickinson's lab this project will focus on developing and implementing the necessary analytical scheme to determine blood alcohol levels in mice that have been dosed with ethanol. The researcher will need to learn the appropriate neurochemistry, analytical methods and animal handling. (For additional details, see Dr. Dickinson).

Kris Keuseman – Paladium

Palladium belongs to the "platinum group" of metals, which also includes ruthenium, rhodium, osmium, iridium and platinum. Of the platinum metals, palladium is one of the most important in organic synthesis. Cyclopalladated complexes (CPCs) are a class of organometallic compounds with a variety of applications. Enantiopure CPCs have many important properties; however, until recently, most studies had been conducted using complexes derived from optically active α-methylbenzyl amines and related compounds. This summer, I plan to initiate study of cyclocarbo- and cyclooxypalladation of enantiopure 2-oxazolines to provide a new type of CPC. Carbo- and oxypalladation is often used in organic synthesis, but there has been little investigation of *cyclo*carbo- and *cyclo*oxypalladation reactions, which yield CPCs. This study will involve the investigation of potential asymmetric induction of a chiral oxazoline moiety on incipient formation of C–C or C–O bonds at a new stereogenic center.

Another opportunity in my lab will also involve palladium, but this time in an application as the catalyst for coupling reactions. A number of palladium catalyzed coupling reactions have been developed, including: Heck, Stille, Suzuki, Sonogashira and others. In many instances these reactions use fairly toxic materials, such as organostannanes. In light of St. Olaf's commitment to "Green Chemistry" I will pursue a project with the aim of coupling relatively non-toxic organoboron compounds and organobismuth compounds using Pd-catalysts. Organoboron compounds often hydrolyze readily to simple inorganic salts, similar to those in Borax laundry additive. Bismuth compounds are fairly non-toxic, bismuth subsalicylate being the active ingredient in the stomachache remedy Pepto-Bismol®.

These research projects will involve the specialized equipment and techniques used in organometallic and organic synthesis. In addition, important separation (chromatography) and characterization techniques (NMR) will be critical. The goals of this research are to study cyclocarbo- and cyclooxypalladation of chiral 2-oxazolines and hopefully observe asymmetric induction associated with formation of a new stereogenic center. We also hope to extend the repertoire of organoboron coupling reactions to organobismuthanes using palladium catalysis.

Greg Muth – Biochemistry and Bio-Organic summer research opportunities

My group is currently working on two projects, each centered on the structure and function of ribonucleic acids (RNA).

Gene Regulation by mRNA-Thiamin Recognition

Recent advances in genomics, the mapping of genes and their functions, have provided a wealth of information for researchers. One of the areas that has benefited is the study of gene regulation, the ability of an organism to selectively turn off and on certain genes in response to environmental conditions or at specific times during its lifecycle. To better understand the details of these genetic switches, we are comparing the regulatory regions of the thiamin (vitamin B1) biosynthesis gene from *E. Coli*, *R. Etli* and *B. Subtilis* using a variety of biochemical and biophysical techniques.

The project utilizes interdisciplinary techniques from biochemistry, microbiology, genetics, cell biology and bioinformatics. We will be working jointly with members of Prof. Schwinefus's team.

Design and Synthesis of Conformationally Constrained RNA Oligonucleotides

Small, highly structured fragments of RNA have been shown to play important roles in numerous biological processes. For example, specific genes can be turned off by the presence of small interfering RNA, and the presence of small RNA molecules has also been shown to disrupt the binding of the nucleocapsid protein to HIV-1 RNA or the binding of the Rex fusion protein to its target in human T-cell leukemia virus type 1. While the sequence of these RNA fragments plays a role in their binding, we hypothesize that the overall structural architecture of these RNA fragments is also a vital component. To address this, we are chemically synthesizing a series of RNA nucleotides with varying degrees of bend and then incorporating them into short RNA oligonucleotides. We will test for the presence of unique structural attributes using nuclear magnetic resonance spectroscopy, gel-shift and various protein binding assays.

The project utilizes interdisciplinary techniques from biochemistry, physical chemistry and organic chemistry.

Nat Schaefle – Summer 2007 Research Description

I have several potential research projects for students; funds, materials, and interest will determine which ones are actively pursued this summer. To be successful, students working on these projects should have completed organic chemistry and calculus. Anyone who found the topics from chemistry 126 interesting will enjoy these research subjects. We will cover any necessary and/or interesting background concepts for the research as we do the work.

1. Kinetics study by NMR. A series of NMR spectra collected during the course of a chemical reaction can be used to study the rate at which the reaction occurs. I will be studying series of related compounds reacting under identical conditions in order to study how the structural differences affect reactivity.
2. Statistical Thermodynamic studies by NMR. After a reaction has reached equilibrium, the equilibrium (the "system") itself can be studied. While many spectroscopic techniques are capable of these types of studies, NMR's unique sensitivity to the sample's environment (the "surroundings") can be used to provide a better description of the conditions in order to more fully describe the underlying thermodynamics.
3. Molecular Modeling. Theoretical descriptions of the electronic structure of molecules will be applied to a variety of trends in observed chemical phenomena (e.g. 1 and 2 above) in order to describe the structural characteristics that lead to the observed phenomena.

Jeff Schwinefus – Summer 2007 Research Opportunities.

Functionally important RNAs (ribonucleic acids) contain a set of interactions that precisely defines a three-dimensional shape for the RNA. While RNA double-helical elements (often termed secondary structure) have been studied extensively, it is this three-dimensional structure (tertiary structure) that remains poorly understood. In our group, we attempt to thermodynamically distinguish between secondary and tertiary structure interactions of RNA using ultraviolet spectroscopy and differential scanning calorimetry. Our goal is to understand how chemical interactions differ between secondary and tertiary interactions and what effects environmental factors have on these interactions. All of our RNA projects are done in collaboration with Greg Muth.

In one project, our group uses neutral organic molecules termed cosolutes to lower or raise the temperature required to unfold RNA structures (often referred to as melting). Cosolutes such as alcohols, amino acids, and sugars influence the stability of RNA molecules by preferentially accumulating at or excluding from the chemical moieties exposed when RNA is unfolded. Using thermodynamic techniques, we can predict the amount of cosolute at this newly exposed surface area of unfolded RNA relative to the folded structure. Recently, we have demonstrated that certain cosolutes prefer either guanine-cytosine base pair- or adenine-uridine base pair-rich RNA double-helices. To further investigate this observation, we will study the interaction of short RNAs with varying guanine-cytosine content with cosolutes and correlate cosolute-RNA interactions with calculations of the surface area and chemical moieties newly exposed in the unfolding process.

In another project, we seek to elucidate the folding of RNA riboswitches in the presence of binding metabolites, such as thymine or diaminopurine. These metabolites change the tertiary structure of their respective riboswitches as they bind, often enhancing the extent of folding or the stability of the riboswitch. Our goal is to identify the strength of the binding event between the riboswitch and its target metabolite and how this binding event can be perturbed by RNA riboswitch mutations.

MATHEMATICS, STATISTICS, AND COMPUTER SCIENCE DEPARTMENT

Dick Brown – Beowulf cluster computing.

Beowulf cluster consists of numerous commodity computers that are networked together in order to perform high-performance computations. In 2006, students assembled St. Olaf's first Beowulf clusters and began to apply them to scientific computing problems from Physics, Biology, Mathematics, Statistics, and other fields. During Summer 2006 we developed a system of two clusters, one consisting of over 30 computers for research and development in cluster technology, and a high-performance cluster consisting of 16 Sun servers on a Gigabit network, for production runs see http://www.cs.stolaf.edu/projects/beowulf

We seek students to continue this work during Summer 2007. Goals include: development of interdisciplinary applications and software libraries to support such applications; installation and testing of software systems that take advantage of cluster technology, and creation of user interfaces for accessing those systems; and development/deployment of system management procedures for the two clusters. Students with Software Design backgrounds are encouraged to apply; "core" CS courses and background in natural science are assets.

Tina Garrett – Enumerative combinatorics .

Enumerative Combinatorics is an area of study that uses advanced counting techniques to understand the properties of a wide variety of combinatorial objects used in Mathematics, Statistics and Computer Science. These objects include permutations, tableaux, tilings and partitions. I am looking for 1-2 students to work on one (or both) of the following projects.

Project #1 Investigate permutation statistics that are preserved by the insertion algorithm for certain Young tableau developed by Killpatrick and Cameron. No experience in Combinatorics is necessary, but successful completion of Abstract Algebra is preferred.

Project #2 Recent work by Benjamin and Quinn has detailed the strength of using combinatorial methods (tilings) for proving identities involving Fibonacci numbers. Past student researchers have adapted their methods to give combinatorial proofs of q-Fibonacci identities using weighted tilings. Several interesting theorems remain unproved. No experience in Combinatorics is required, but an aptitude for problem solving and a willingness to work with Mathematica (computer algebra package) is necessary.

Olaf Hall-Holt – The Palantir project.

Are you interested in graphics, 3D visualization, and measurement sensors? Do you have some familiarity with the C++ programming language? The Palantir project is an on going team effort that is currently focused on extracting 3D information from video sequences. Given digital video clips taken with two synchronized cameras, our challenge is to find patterns in the data that allow us to infer information about the shape and position of objects in the scene. We will build on work from last summer on image analysis, and begin using stereo robotic cameras. This is a joint project with Gary Muir in psychology, who will be applying the new tools to study the way that rats navigate through space.

Urmila Malvadkar – Mechanistic models of seed dispersal & optimal reserve size.

The goal of the first project is to link meteorological and landscape topography to seed dispersal in plants, using numerical models. Ultimately, this will help us understand community dynamics in tropical forests. We will develop and apply mechanistic models of seed dispersal by wind to several tropical tree and liana species across local and regional scales in Panama. Then we will analyze the resulting wind fields and predicted seed trajectories to assess what particular atmospheric features are most critical for seed dispersal, especially long-distance seed dispersal. This analysis will allow us to quantify the relationships between these features and dispersal patterns on local and regional scales.

The second project relates to how fish movement affects the success of marine protected areas. The fact that fish move has two primary effects: it decreases the probability that the fish will survive, because some of the fish will leave the protected area and are likely to get caught; it increases the benefit of extra fishing yield in adjacent areas that are open to fishing, because when fish leave the reserve they can be caught. This study will attempt to reconcile these two apparently conflicting goals (ecological persistence and economic benefits). We will be investigating species of fish that move both as juveniles and adults, and hope to determine what size of reserve will maximize fishing yield. Students will find both numerical simulations and analytic solutions to equations which describe this system to determine optimal reserve size.

Steve McKelvey – Mathematical modeling of disease.

The project would involve the mathematical modeling of disease spread throughout North American forests. The specific pathogens of interest are exotic species introduced into North America via international trade or commerce.

Paul Roback – Statistical Modeling and the Tuberculosis Genome

The prediction of operons (sets of genes that function together) in *Mycobacterium tuberculosis* (MTB) is a first step toward understanding the regulatory network of this pathogen. Along with researchers from the University of Seattle, we are developing statistical models to predict operons in MTB, using information such as intergenic distance and the correlation of gene expression for adjacent gene pairs from nearly 500 microarray experiments with MTB RNA. Our goal is to build an improved genome map for this human pathogen. Funding is available for two students to work on statistical aspects of this project this summer; ideal candidates would have taken Statistical Modeling (Stats 272), be working toward a statistics concentration, and have interest in genetics (and potentially even relevant coursework in biology).

Paul Roback – Computer Science/Bioinformatics and the Tuberculosis Genome

Related to the tuberculosis genome project described above, there is an opportunity for 1 or 2 students to travel to Seattle University for the summer to work on programming/bioinformatics aspects of the project. The primary contact for this aspect of the project is Dr. Rob Rutherford, formerly of St. Olaf, now at Seattle University. We are looking for 1-2 students with programming skills who are interested in making the data from this map viewable over the web. The right student(s) would be supported to work with Dr. Rutherford in Seattle for one or more summers, participating in Seattle University's undergraduate research program. Interested parties can email robertr@seatteu.edu for more specific details and/or to set up a time to chat about the project.

PHYSICS DEPARTMENT

Brian Borovsky – A new apparatus for microscopic studies of friction / Physics curriculum development.

In the summer of 2007, I plan to work with one student, preferably a physics major who has taken Physics 228. The position will be split equally between modifying research equipment and developing curricular materials for Physics 228 and 125. On the research side, it will be a summer dedicated mostly to equipment improvements for more precise measurements of friction in microscopic systems. If you are a student interested in a mix of hands-on tinkering and creation of classroom-ready teaching materials, please come talk to me. Broadly, my research program asks the question what gives rise to the force of friction at the molecular level? 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 goal is to determine how the length of the lubricant molecules affects the levels of friction and to compare these results with recent theoretical predictions.

James Cederberg & David Nitz – Molecular beam spectroscopy.

The molecular beam spectrometer in SC150-152 was obtained from Harvard University in 1981, and has been in use here at St. Olaf ever since. The project involves using the spectrometer to record data on the molecules, and developing and using software for the analysis of the data. The purpose is to measure molecular properties that quantify the interactions between the molecular and external electric and magnetic fields and the nuclear spins.

During the summer of 2006 two students, Ben McDonald and Charlie McEachern, both new to the project, explored the spectrum of KI, obtaining precise new values for the hyperfine parameters that added five significant figures to values based on previous measurements elsewhere. The summer saw the publication of articles reporting on the spectra of RbF and RbCl as observed and analyzed by previous St. Olaf students. Recent graduates Sara Fortman and Jimmy Randolph also presented papers on these molecules at the International Symposium on Molecular Spectroscopy at Ohio State University in June of 2006.

Still in the works are the molecules RbBr, KBr, and RbOH that have been examined by other students. The KBr is essentially complete, and may be included with the KI when that is completed and written up for publication. The RbBr and RbOH both need considerably more work. These, or other molecules, could be researched by students during the summer of 2007. Students are colleagues in the whole process, helping to decide what molecules to examine and what data to take, analyzing the data, maintaining the apparatus, writing software, and writing the papers for publication.

Jason Engbrecht – St. Olaf positron research group.

The Positron Research Group focuses on properties of and applications for the positron, an antiparticle, and the atom Positronium. Positronium (Ps) is the exotic atom formed by the electron and the positron. This summer we will be pursuing three projects. The first will be the interaction of Ps scattering off ordinary gas atoms and molecules. The second will investigate the possibility of using Ps to study biological systems. Our third project involves the development of a positron beam for materials studies. Students will be exposed to apparatus design, computer laboratory interfacing techniques, and data analysis methodology. I would encourage any interested students to apply. More information can be found at http://www.stolaf.edu/academics/positron/. Feel free to contact Jason Engbrecht with any questions.

Robert Jacobel and Brian Welch – Summer research with the Center for Geophysical Studies of Ice & Climate (CEGSIC).

CEGSIC

Changes now underway with the world's glaciers and ice sheets make the cryosphere (the earth's icy surfaces) a critical element in the global climate system. Our group uses ice-penetrating radar and satellite imagery to examine the surface, interior and base of ice sheets and glaciers. The characteristics of internal ice layers and basal geology that we measure with the radar lead to understandings of the relationship between ice flow and climate change.

Currently we are working with recently acquired data from two projects in Antarctica and will be making preparations for the second season of an Antarctic traverse that is taking place during the International Polar Year (IPY), 2006-2008. Summer research in 2007 will focus on preparations for the IPY traverse and data analysis and interpretation from the first season plus our ongoing project on Kamb Ice Stream in West Antarctica. It is also possible that we may be able to send someone to Sweden for part of the summer to do research on one of the large Swedish glaciers with our colleague Rickard Pettersson.

Students involved in our group will use existing software to analyze ice-penetrating radar data and satellite imagery as well as learn to write new code in Matlab. We also work with GPS, GIS, and remote sensing software/data to establish a spatial context for our radar results. Our work is supported grants from the Office of Polar Programs, National Science Foundation.

PSYCHOLOGY DEPARTMENT

Gary Muir – The neural basis of navigation.

My research program is guided primarily by questions about the neural mechanisms of spatial cognition and navigation. The firing activity of certain neurons is thought to represent the animal's perceived location ("place" cells) and head direction ("head direction" cells), but how is information contained in the firing activity of these cells used by the animal when solving a spatial task? I am also particularly interested in how learning a spatial task may alter the firing activity of these cells to represent the animal's newly acquired knowledge. To answer these questions, students will have the opportunity to observe a "behaving" brain in action by recording the activity of single neurons while freely-moving rats perform spatial tasks. How does this neural activity relate to the animal's navigational behavior? Students will be involved in all stages of the project: designing the experiment, small animal handling and training, single-unit electrophysiology, data collection and analysis, and public presentation of the results. Students interested in continuing the project into the academic year as independent research are especially encouraged to apply. *Applicants should note that this 10 week research program will commence one week later than usual (i.e., June 4th) and therefore finish one week later (i.e., August 10th).*

Shelly Dickinson – Drugs, alcohol and adolescents (mice, that is)

Previous work in the lab has found that adolescent mice do not show a preference for environments associated with alcohol, although adult animals do. There are several possible reasons for this age difference and projects this summer will be directed at two of these possibilities. First, it is possible that adolescent mice just can't learn about the rewarding effects of drugs using the place conditioning procedure. To answer this question, we'll be testing cocaine place conditioning in adolescent mice. Cocaine-induced place preference is a very robust experimental finding in rats and adult mice, so if it's not a learning/procedure problem we should see place preference for cocaine-associated environments with adolescent mice. Second, it is possible that adolescent mice are metabolizing the alcohol at a much higher rate than adults and would therefore need a higher dose to get the same effect. This possibility will be addressed in conjunction with Dr. Paul Jackson in the Chemistry Department using gas chromatography to assess blood alcohol levels in mice of different ages at various time points after alcohol injection. An interest in analytical chemistry and/or forensics would be advantageous for the second project. Students will start at the beginning with experimental design and will learn animal handling and injection techniques, and will gain experience analyzing the data. Participation beyond the summer is expected with regard to manuscript preparation, and continued work during the academic year doing independent research is possible and encouraged.