Special Issue
SUMMER RESEARCH** 2004
IN THE NATURAL SCIENCES AND MATHEMATICS AT ST. OLAF

Applications available from the Biology, Chemistry & Physics Department Offices
Due FEBRUARY 20. Decisions made by March 5.
Please talk to the research director if you have questions about project.
We reserve the right to make any necessary changes in projects.
An on-line version may be found at http://www.stolaf.edu/people/ceumb/research.html

** Available only to St. Olaf undergraduates. Not all summer research projects in the sciences and mathematics are covered by this application form. If you planning to work with someone not listed here please check with them directly for application process.

BIOLOGY DEPARTMENT

Diane Angell – Small Mammals and Prairies

Small mammals are important to prairie communities. They feed on large quantities of vegetation, may affect plant diversity, and are food for many mammals and birds. Last summer Jared Smith continued a project by trapping in parts of the prairie that have slightly different burn histories. There is some evidence that meadow voles prefer unburned areas and deer mice more recently burned prairie. Jared also investigated the role of paths in fragmenting small mammal populations. He set up temporary enclosures and then created artificial paths to evaluate how reluctant small mammals are to cross paths of different widths. This summer we hope to expand and continue this research, trapping on the natural lands at St. Olaf, but also possibly at Carleton. We hope to catch fewer weasels this year! Research students may require a car, and need to be independent and motivated. Beautiful evenings setting traps and early morning trap checks are required. I would prefer students that have had Bio 125, 126 and either Ecology, Genetics or Conservation Bio.

Eric Cole –(Team Tetrahymena) From Genes to Proteins to Cellular Function!

Our laboratory is interested in identifying genes involved in mitosis, meiosis, and intracellular patterning. We are employing molecular genetics and bioinformatics to search for genes, clone and sequence them, and then perform targeted gene knock-outs, as well as GFP fluorescence and immunofluorescence to visualize where and when in a cell's life these proteins are expressed. We are also isolating proteins involved in nuclear exchange, by 2-D Gel Electrophoresis, and are developing methods of analyzing both proteins and genes through Mass Spectrometry and Proteomics. Students willing to make a long-term commitment are encouraged to apply for research opportunities.

Mary Caroline Henry – Can Insects Learn?

We will continue our study of simple learning abilities of syrphid flies. The drone fly, believed to be a Batesian mimic of the honey bee, is widely reported as an important pollinator of plants. In order to be an effective pollinator, it must be able to remember and identify the species of flower on which it is feeding. This implies learning. Last summer we (Bun Chhun and I) were successful in raising naive flies in the lab from eggs laid by captured wild flies. This year we hope to repeat that feat and continue observations of conditioned responses of flies to different colors.

Kim Kandl – The Role of Actin in Translation

I am interested in using the budding yeast, *Saccharomyces cerevisiae*, as a model organism to look at the role of the actin cytoskeleton in translation. Why would the actin cytoskeleton be involved in translation? One idea is that this is a mechanism to localize protein synthesis, so that proteins are made where they are used in the cell. One link between the actin cytoskeleton and translation is through the eukaryotic Elongation Factor 1A (eEF1A) protein, which plays a central role in protein synthesis by delivering aminoacyl-tRNAs to the elongating polypeptide at the ribosome. eEF1A has been shown to bind and bundle actin *in vitro*. Although yeast with actin mutations do not show a global decrease in translation rates, they do exhibit more subtle translation defects. This past year, I have become interested in the role of actin bundling by eEF1A, and we began a study to look specifically at the role of actin bundling by eEF1A. In this study, we examined several actin mutant proteins for their ability to be bundled by eEF1A. From this work we have identified actin mutants that have translation defects, yet are bundled by eEF1A, suggesting that the translation defects are not due to a lack of bundling. We have also identified two actin mutants that are not bundled by eEF1A. Interestingly, one of these actin mutants has translation defects, and the other does not. This may suggest that bundling of actin by eEF1A is not essential for translation, and further work is being done to examine this.

Stop by my office, SC 144, if you have any questions. My research is open to students of all levels, but I prefer students who have had Intermediate Genetics. Students who are willing to make a long-term commitment are encouraged to apply.

Henry Kermott - Behavioral Ecology

This summer I will continue my ongoing project on the mating system of the house wren, a project that will be in its 20th year and has resulted in some eighteen publications and about eight papers given at scientific meetings. This research falls under the area of animal behavior, or more specifically behavioral ecology. Currently I work with Tom Guy, a public school science teacher from Faribault and member of the Rice County Bird Club. We will have room for up to two students for the summer of 2004. Our study area is near Big Woods State Park, just 12 miles from Northfield, and consists of some 35 acres of woods. In past years we have concentrated on general mating behavior, testing of various hypotheses for the evolution of polygyny in birds, and differences in reproductive success among individual wrens. For the coming summer we will concentrate on whether male help in caring for the young results in increased reproductive success, and we are planning to put small radio transmit-ters on the young to see how fast and how far they disperse after fledging. Please see me for more information and procedures for applying.

Jean Porterfield – Something Fishy About Population Genetics

My research uses population genetics as a tool for addressing a range of evolutionary questions about Minnesota fish. My students and I focus on non-game fish species, especially darters – little bottom-dwelling fish that can exhibit beautiful colors and patterns seasonally. By sequencing the DNA of numerous individuals from multiple populations of a species, information about the species' history can be obtained. These DNA sequences can tell you how much the fish migrate, what past migration patterns have been, where populations were founded from, and many other interesting things.

For the past two summers my students and I have gathered DNA sequences from many fish representing three species, and have found some interesting patterns of genetic diversity. Minnesota populations exhibit very low genetic variation, especially when compared to populations from southern states; this is consistent with a recent colonization of Minnesota (since the glaciers left about 10,000 years ago). This summer we will continue to collect specimens and gather sequence data to add not only individuals but also new species to our growing comparative data set. The project involves field work (collection of fish with a seine) as well as laboratory work (DNA isolations, PCR) and data analysis (building phylogenetic trees).

I am interested in working with students who preferably have taken Biology 125, 126, and 233 (Intermediate Genetics). Please feel free to come find out more – my office is SC 142.

Rob Rutherford - Bioinformatics of Tuberculosis Latency

Approximately one third of the human population (~2 billion persons worldwide) have viable, but nonreplicating tubercle bacilli in their lungs. Together with HIV, it is the worlds number one killer. Using a combination of computer science and statistical thinking, we build a "whole genome" view of the causative bacterium *M. tuberculosis*. Over the past few years, we have provided bioinformatic support for several major labs, helping them store and manage the data on the expression all of this bacterium's genes under several hundred different growth conditions, helping discover the roles of each gene. We also build and distribute new open source software to help biologists discover new things. Lovers of Genetics/Molecular Bio and/or Statistics (and/or UNIX/Linux) are especially encouraged to apply. For more information see Dr. Rutherford in SC226.

Kathy Shea - Forest Ecology

Student research will involve studying various aspects of forest ecology. Possible projects include dendrochronological (tree-ring) analyses of local forests. Dendrochronology enables us to study the age structure of a particular tree species, examine past variation in growth patterns and make predictions about future of a species. Another project will focus on the study of earthworms, soils and their relationship to forest vegetation. Earthworms are invasive species in Minnesota and have changed the litter layer and soil, making it more difficult for certain plant species to become established. Plots have been set up at Nerstrand Big Woods State Park and additional study sites will be determined. Students will learn a variety of techniques in terrestrial ecological sampling and data analysis. I am looking for students interested in continuing to work on the project as independent research during the academic year.

Mike Swift – Aquatic Biology in Northern Minnesota

WANTED -- 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 (1-2 days), conduct their field sampling at Coe College's Wilderness Field Station where I'll be teaching aquatic ecology (~35 days) and complete their project on campus (2+ weeks). Research projects will focus on zooplankton ecology (e.g., diel vertical migration, predation, swarming, etc.), but other projects are possible. A $700 fee covers room, board, use of equipment, and insurance.

Charles Umbanhowar – Linkages of fire and climate in Manitoba

Does climate change more directly affect vegetation or fire? How do changes in vegetation and fire feedback on each other? I am looking for a student to work with me on a continuing project that addresses these questions. This summer our research will focus on lake sediment cores that are 7000-8000 years old and were located in the aspen parkland or tundra of central and northern Manitoba. Students will learn how to extract charcoal from sediment cores and how to quantify charcoal abundance using a dissecting microscope mounted with a CCD camera and connected to a computer running NIH image capture software. I am especially interested in a student who might be available for a trip to western Mongolia in August and who would be able to continue their charcoal work into the Fall semester.

CHEMISTRY DEPARTMENT

Douglas Beussman – Mass Spectrometry/Course Development Research Opportunities

There will be several opportunities for students to engage in my research during the summer of 2004. One project might include collaborating with researchers in the Biology Department on the identification of isolated proteins, using mass spectrometry techniques with the new LC-MS instrument. This may also involve developing methods to reduce the amount of sample required for protein identification. A second research area might include development of LC-MS techniques for the analysis of dietary supplements or performance enhancing drugs. There may also be opportunities to help develop laboratory experiments for two new courses to be offered at St. Olaf in 2005.

Bob Hanson -- Web-Based Chemical Informatics

Current plans for research in the Hanson group this summer are in the area of chemical informatics, particularly as it relates to chemical education. "Chemical Informatics" is the "computer-assisted storage, retrieval and analysis of chemical information, from data to chemical knowledge." This is a reviving of a project we started some years ago that culminated in a student co-authored paper, "Data-Driven Chemistry: Making Molecular Models (Literally) from Electron Diffraction Data," a book, "Molecular Origami," and an extensive website (http://www.stolaf.edu/people/hansonr/mo). Our interest now is in using the latest web-based technology to allow immediate student on-line access to extensive and detailed structural information relating to molecular geometry and bonding. The project is based on the idea that learning from real data more closely resembles actual science than typical book learning, but learning from real data is only possible when real data are readily available. In collaboration with Scot Wherland at Washington State University, we will be developing a chemical structure database (see http://www.stolaf.edu/people/hansonr/mo/struc for its preliminary form) and associated educational lessons. Plans are to submit this work for publication by the end of the summer and also present this work at the Biennial Conference on Chemical Education in July. Additional projects will be developed that are consistent with the particular interests of group members. Student coworkers should have an interest in molecular structure and bonding and be able to work and learn independently (with guidance, of course). Students with an interest in web programming (HTML, JavaScript) but not necessarily any background in such are encouraged to apply. Course background should include Chemistry 125 and 126.

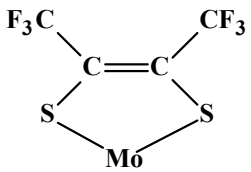
Paul T. Jackson – Investigating Environmental Contamination in the Cannon River Watershed: Caffeine and the Other Actors"

During the summer of 2004 there are opportunities for interested students to work with me on projects related to separation science and environmental analysis. Pharmaceuticals and personal-care products contain numerous chemicals designed to illicit specific biological responses. What happens to these unmetabolized or unreacted materials after we "flush" them down the drain? The focus of this project is to extend the chemical assessment of surface waters to include largely rural, agriculturally-dominated river watersheds. Specifically, my research group is interested in identifying and quantifying therapeutics and personal care products in wastewater output from rural communities with populations between 10,000 and 25,000. Therapeutic agents, metabolites, and a suite of chemicals related to personal care products have been traced to effluents emanating from wastewater treatment works, and the exact impact of such chemicals on the river ecosystem is not well understood. Our initial hypothesis is that rivers flowing through rural communities are at a similar risk of contamination as compared to their larger urban cousins, such as Minneapolis-St. Paul.

I hope to have students apply gas and liquid chromatography, mass spectrometry, and sampling/ extraction techniques to answer two questions. In the past we have found levels of caffeine in the Cannon River. Since caffeine is an excellent indicator of anthro-pogenic (human) influence on the water system, what can it tell us? More specifically, what is the temporal and spatial concen-tration of caffeine in the Cannon River around Northfield? Secondly, the USGS found a significant number of surface water systems contaminated with steroidal chemicals (including hor-mones) and non-prescription medications. Which of these chemicals exist in the surface waters of the Cannon River and at what concentration level?

Gary Miessler – Dithiolene Complexes of Molybdenum and Tungsten

My main research interests are in the organometallic chemistry of molybdenum and tungsten. Primarily I hope to develop syntheses of new compounds of these metals that contain dithiolene ligands in addition to organic ligands such as CO and η^5-C_5H_5. Some important molybdenum- and tungsten-containing enzymes have dithiolene ligands (the structure of one dithiolene is shown below), and I hope to prepare compounds that might serve as models for the metal sites in such enzymes.



A dithiolene ligand bonded to Mo

In the laboratory, students participating in this work will gain experience in vacuum line synthesis and purification techniques and in photochemical procedures. Students will also use a variety of spectroscopic methods, especially NMR, IR, and UV-vis, and

will perform web-based searches of the chemical literature. The department's new mass spectrometer should also be a valuable tool in this project.

Greg Muth – Gene Regulation by mRNA-Thiamin Recognition

Gene regulation in bacteria often occurs by protein factors binding to DNA near the site of the start of transcription. It is also clear that regulation can occur by direct interactions of small molecule co-factors (vitamins) with the mRNA after it has been transcribed. What has not been well established is a detailed biochemical model of the RNA structures that form in the presence of co-factors and a mechanism of discrimination used by these RNA structures to differentiate between potentially very similar co-factors. The goal of this project is to study the mRNA regulatory region and effector molecules in the biosynthesis of the vitamin cofactor thiamin from bacteria *Rhizobium etli*.

The project is a hybrid between molecular biology, biochemistry and synthetic organic chemistry utilizing skills and techniques from each of these disciplines.

Patrick Riley – Ligand Synthesis and the Preparation of Transition Metal Complexes:

My research interests are developing new ligands to support inorganic and organometallic chemistry. Ligand synthesis 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 hydroxyindole ligation. Once these ligands have been prepared and purified, we will conduct reactivity studies with early transition metal halides and metallocene halides. The resulting complexes may be useful as olefin polymerization catalysts or as homogeneous models for hydrodenitrogenation catalysis.

Students working on this project will learn techniques and use instrumentation commonly employed in organic synthesis, organometallic, and inorganic chemistry.

Jeff Schwinefus – The Mechanism of DNA Destabilization in Cosolvent-Water Solutions: Is DNA Preferentially Hydrated?

Why are proteins thermally stabilized in most cosolvent-water mixtures while the DNA double helix is destabilized? As an example, glycerol thermally stabilizes protein structure while decreasing the melting temperature of double-stranded (ds) DNA. Since dsDNA and proteins are both polyelectrolytes with hydrophobic cores, why is there such a difference in cosolvent influence on dsDNA and protein structures? Interestingly, cosolvents that stabilize protein structure are generally excluded from the protein surface. Are cosolvents then accumulated near the DNA surface, disrupting hydration of the DNA helix? As of yet, the answer is unknown. This is rather surprising considering the understanding of dsDNA physical chemistry in cosolvent-water mixtures has potential meaning for cosolvent mediated protein-DNA interactions and the polymer coil-globule transition.

Students involved in my research during the summer of 2004 will measure cosolvent accumulation or exclusion near the surface of calf-thymus (ct) DNA using high precision density measurements. Our ultimate goal is the determination of dsDNA water-cosolvent transfer free energies to piece together the thermodynamic cycle of dsDNA thermal destabilization. Students involved in this research will gain exposure to biophysical chemistry concepts, thermodynamics, and analytical techniques for the study of biopolymers.

PHYSICS DEPARTMENT

James Cederberg and 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 nuclei. For example, during the summer of '99 the students completed a study of the molecule CsF which was published (Journal of Chemical Physics, 8 November, 1999).

For the past 3 summers we have concentrated on RbF, RbCl, and RbBr. The RbF and RbCl are in good shape. We have observed many transitions and have been able to fit them all into a model based on values of the parameters that quantify the different interactions between the nucleus and the rest of the molecule – to a precision of 8-9 sig figs! We just need to refine the data analysis a bit to get the best possible results before we submit the work for publication. The RbBr still has a long way to go. We have many transitions, but do not yet know how to assign them. The process is much like putting together a complicated jigsaw puzzle. We have some pieces out of the box, including some that we can recognize as edge pieces, but have not yet succeeded in fitting any of them together. That should begin happening soon, and once the picture starts to take shape, the others will fall into place much more easily.

For the future, we will continue to observe hyperfine spectra in sequences of vibrational and rotational states in small molecules, such as alkali halides or hydroxides, using this high-resolution molecular beam electric resonance spectrometer. Students are colleagues in the process, helping to decide what molecules to examine, what data to take, analyzing the data, maintaining the apparatus, writing software, etc. One student will be continuing from the summer of 2003 (John Nichol). One additional student will be selected to join the group for the summer of 2004.

David Dahl – Nanomagnetics

This research uses both experimental (Magnetic Force Microscopy-- MFM) and theoretical (micromagnetic simulators) tools to study permanent magnetism in nanometer-sized particles made with electron-beam lithography and metal deposition. I collaborate with Professors E.Dan Dahlberg (expt) and Charles Campbell (theorist) and am currently at UMN on sabbatical. We are interested in both the fundamental physics of these small magnets as well as the device applications, e.g., higher density hard drive storage plus non-volatile memory (MRAM).

Work last summer (Doug Stone) used MFM to examine the pulsed magnetic field switching of elliptical permalloy dots between magnetic states along or against the axis (0 or 1). This work continues with one of our current graduate students.

Next summer I'll work with one student (sophomore or junior). This student has choices depending upon interest: 1. Continue the work on the elliptical dots; 2. Join our new work exploring magnetic soliton propagation in chains of dots (a limiting factor in the processing speed of MRAM); 3. Participate in upcoming work using superconductors and magnets; or 4. Cycle through all of the ongoing experiments, including ones studying spin glasses, to learn more techniques (AC susceptibility, Vibrating Sample Magnetometry).

Please note that UMN has an application deadline of Feb. 16 for the Faculty-Student Teams.

Jason Engbrecht - Positronium Research

The Positron Research Group focuses on properties of and applications for the exotic atom Positronium. Positronium (Ps) is an exotic atom formed by the electron and it's antiparticle the positron. This summer we will be pursuing two 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 structural changes in DNA.

This will be the second summer for these projects at St. Olaf. Though much has already been accomplished, there is much left to do. Students on this project will play an important role in the design and construction of an apparatus. Additionally, they will be exposed to 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/ or feel free to contact me with any questions.

Robert Jacobel and Brian Welch – Radar and Satellite Remote Sensing for Ice and Climate Studies (Physics & Environmental Studies)

Our Research involves the use of geophysical remote sensing techniques in studies of the role played by ice in the global climate system. Our summer work in 2004 will have several areas of focus. We are involved in a collaborative project in West Antarctica called ITASE (International Trans Antarctic Scientific Expedition) using our radar to image the ice along an overland traverse route. We have collected radar data during recent field seasons that needs to be processed and analyzed. This will involve working with commercial software packages, and some programming. The goal of these studies is to answer questions about recent climate-related changes in the flow of ice from the interior of Antarctica to the ocean.

In support of the ITASE project we will also be working with recently acquired satellite imagery from RADARSAT, MODIS and LANDSAT-7. This work involves using commercial soft-ware packages to combine individual scenes into a mosaic, and to geolocate the images spatially and enhance them to identify features.

We also have a second project in Alaska where we have been deploying high-frequency ground-penetrating radar (GPR) in studies of ice in the summit caldera of Mt. Veniaminof Volcano. This project could involve field work for one or two students.

I anticipate openings for one to two new people in the group this summer, probably from the class of 2006 or 2007 - (first-year and sophomore students please apply!). Interest and expertise in working with computers is an essential criteria for applicants, along with a strong background in physical sciences and mathematics. A desire to do field work is an obvious qualification, and expertise in programming for at least one of the positions is desirable. I encourage you to visit our web site for more information and to contact me or any of the group members whose names appear there. See us at http://www.stolaf.edu/other/cegsic

PSYCHOLOGY DEPARTMENT

Shelly Dickinson – Behavioral Neuropharmacology

My primary research interest is the understanding of the neuropharmacological mechanisms underlying the effects of drugs of abuse. One specific summer project in the lab will be looking at the role of dopamine systems in the conditioned effects of alcohol in mice. Why should we look at drunk mice? Well, the processes of conditioning (association of environmental cues and drug effects) are thought to be extremely important in craving and relapse in humans, and while alcohol is used by a large proportion of people in our society, the neural effects of alcohol are quite complex and not fully understood. In another project, I am investigating genetically determined differences in dopamine transporter function and in response of the transporter to drug exposure (this work will also be done in mice). This project stems from the importance of the dopamine system in the reinforcing effects of abused drugs, and will hopefully lead to a better understanding of individual differences in drug response. Students involved will start at the beginning with experimental design, will learn animal handling and injection techniques, and in vivo voltammetry techniques, including stereotaxic surgery.