SPECIAL ISSUE
SUMMER RESEARCH 2005 IN BIOLOGY, CHEMISTRY, MATHEMATICS, PHYSICS & PSYCHOLOGY

Applications available from the Biology, Chemistry, Math, Physics & Psychology Department Offices
Due Friday, FEBRUARY 18. Decisions made by Friday, March 4.
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

BIOLOGY DEPARTMENT

Diane Angell – Small Mammals and Prairies

During the coming summer I am looking for a student to continue projects trapping small mammals. Small mammals play crucial roles as predators, prey, seed dispersers and grazers. We know little about the distribution and abundance of prairie small mammals in southern Minnesota. Last summer Jared Smith surveyed prairies in and around Rice County focusing on prairie voles, a species classified as a "species of special concern". I would like to repeat and expand upon this work by increasing the numbers of prairie remnants surveyed. Research students may need a car, and need to be independent and motivated! Evenings setting traps and early morning trap checks are required. I would prefer students that have had 125, 126 and either Ecology, Genetics or Conservation Biology.

Mary Caroline Henry – Can Insects Learn?

In my lab we are continuing our study of the "central excitatory state" (CES) in flies and how it contributes to their foraging success. If given a very small amount of a concentrated sugar solution, hungry flies are kicked into an "excited" state, in which they move faster, fly more, and land more often on artificial flowers. We are exploring various parameters of this phenomenon and trying to determine if it relates to the drone fly's alleged

role in pollination. Students who have worked on this project, if you want to talk with them, are Bun Chhun and Ben Terpstra. Interest in insects, tolerance of strange odors, and patience make good qualifications.

Kim Kandl – The Bundling of Actin by Eukarytotic Elongation Factor 1A

I am interested in using the budding yeast, *Saccharomyces cerevisiae*, as a model organism to examine the role of the actin cytoskeleton in protein synthesis. Why would the actin cytoskeleton be involved in protein synthesis? 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 protein synthesis 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*. Recent work has focused on the role of actin bundling by eEF1A. We have examined several actin mutant proteins for their ability to be bundled by eEF1A. From this work we have identified actin mutants that have defects in protein synthesis, yet are bundled by eEF1A, suggesting that the defects are not due to a lack of bundling. We have also identified an actin mutant that does not appear to be bundled by eEF1A. Interestingly, this actin mutant has only subtle defects in protein synthesis. This may suggest that bundling of actin by eEF1A is not essential for protein synthesis, and further work is being done to examine this. The assay used to assess bundling is relatively crude, and we will develop techniques to fine-tune the characterization of the actin-eEF1A bundles this summer.

Rob Rutherford –Two Collaborative Projects for 2005

Project #1 (collaborative with Paul Roback): Using bioinformatic and functional genomic methods to understand a cluster of related bacterial species, including the human mega-pathogen *Mycobacterium tuberculosis*. Fighting this pathogen means understanding its biology, something we are in an especially strong position to do at St. Olaf because of the large amount of gene expression data we have from DNA microarray. Currently we are using a statistical approach to predict operon structure from examining co-expression of adjacent genes. During the summer of 2005, we hope to extend our work with DNA microarray data and test predictions about operon structure in the laboratory.

Project #2 (collaborative with Eric Cole and Doug Beussman): Software creation for working research biologists. Dr. Rutherford and his students design and build customizable data mining tools to help lab biologists exploit the data overload of post genome biology.

Because computational and molecular biology are interdisciplinary fields, few if any students will have "a perfect background". This makes it more fun, because we learn as we go. I'll be looking for students with a strong work ethic and some background in lab biology OR statistics OR computer science.

Kathy Shea – Forest Ecology on the St. Olaf Natural Lands

Student research will involve mapping and measuring trees planted as part of the forest restoration projects on the St. Olaf Natural Lands. Trees in the forest restoration areas have been or will be mapped using a GPS system. Data will be transferred to an existing GIS database on the St. Olaf Natural Lands. Field data will be collected to compare the growth and survival of trees planted from seeds and seedlings. Other parts of the project may vary depending on student interest and will involve soil chemistry analyses and documentation of the flora of the Natural Lands. Applicants should have taken the GIS course. Parts of these projects may form the basis for taking 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.

Dave Van Wylen - Strategies of Myocardial Protection

My research this summer will continue to focus on mechanisms by which the heart can be protected from periods of oxidative stress such as that encountered during a heart attack. The research will either use a cell culture model to simulate the oxidative stress associated with a heart attack or a rat model to mimic the cardiac events that ensue from blockage of a coronary artery.

Anne Walter – Membrane Lipids and Their Properties

Anne Walter is looking forward to working a student interested in membrane lipids and their properties. One project involves isolating plant tonoplasts in order to study the properties of their lipids in the absence of proteins. A second step is to determine the specific lipid composition of these membranes. The studies will involve organelle isolation using several centrifugation techniques, enzyme analysis for purity, dissolution and reconstitution assays along with fluorscent assays of fluidity and permeability

CHEMISTRY DEPARTMENT

Douglas Beussman - Research Opportunities for 2005

There will be several opportunities for students to engage in research with me during the summer of 2005. All projects will rely to some extent on using mass spectrometry, as well as on various separation methods.

One project includes collaborating with Dr. Cole in the Biology Department on the identification of proteins isolated from *Tetrahymena thermophila*. These proteins will be digested and analyzed using mass spectrometry techniques with the new LC-MS instrument and screened against a database in collaboration with Dr. Ruther-ford's group. A second, similar collaboration with a research group at Drake University might also be available. Several other collaborations with researchers in the St. Olaf Biology Department are also being discussed and may be of interest to summer researchers.

Another research area would involve screening a library of small peptides to extract and identify those compounds that have an affinity for a target of interest. One of the targets I am interested in is the VEGF receptor, which has been shown to be involved in an important tumor-progression pathway in many cancers. This work is aimed at better understanding the VEGF receptor as well as trying to find lead candidates for anti-cancer agents.

A third opportunity for summer research involves developing sensitive and selective forensic methods of analysis using mass spectrometry. This might include the analysis of inks, fibers, or performance enhancing drugs.

Paul Jackson - Research Opportunities

During the summer of 2005 there are opportunities for interested students to work with me on projects related to separation science and environmental analysis.

Project 1: Pharmaceuticals and personal-care products contain numerous chemicals designed to illicit specific biological responses. What happens to these unmetabo-lized or unreacted materials after we "flush" them down the drain? Our biggest question right now is "What substances are present in the Cannon River?" Secondary, is "What is the source of the contamination?" This project will go "fishing" for these chemical species throughout the Cannon River Watershed – we will apply method development work by previous students to finish the story of caffeine as an anthropogenic marker in the river. We might delve into future work on steroids, hormonal mimics (plasticizers) or nonprescription drugs.

Project 2: Analytical chemistry provides tools used to develop an understanding of the fate of chemicals and their degradation products as the materials cycle through or occupy various compartments in the world's ecosystems. Over time a paradox has developed. A vast majority of the analytical approaches employed to investigate environmental problems contribute to other environmental problems because the processes and procedures use and/or generate hazardous substances. This project will explore how to apply green chemistry principles to the collection and analysis of surface water samples in support of project 1.

Greg Muth - Biochemistry and Bio-Organic 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.

Design and Synthesis of Conformationally Constrained RNA Oligonucleotides: Small, highly structur-ed 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 nucleo-tides 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.

Jeff Schwinefus - Research Opportunities 2005

Water plays an integral role in the structure and function of nucleic acids. In the case of the DNA double helix, water molecules hydrate the helix and aid in its overall stability. Lowering the concentration of water destabilizes DNA making it easier to pull apart the two complementary strands that comprise the double helix. To understand how hydration affects the chemical and physical properties of DNA, we need information about the extent of DNA hydration and the changes in hydration when DNA undergoes a physical or chemical change.

As a probe of DNA hydration, our group uses neutral organic molecules termed cosolvents to reduce the water concentration and lower the temperature required for DNA helix strand separation (often referred to as DNA melting). Cosolvents such as alcohols, amino acids, and sugars influence the number of water molecules released in this transition by binding to DNA directly or modifying the overall hydration pattern on the DNA helix. How these cosolvents influence DNA structure in living organisms is unclear. Cosolvents are just one component of a complex mixture of salts, organic solutes, and macromolecules that modify DNA helix structure and stability.

Our focus this summer is the dependence of DNA hydration on DNA base-pair composition. Using ultraviolet spectroscopy, vapor pressure osmometry, and thermodynamics, students involved in my research will "count" the number of water or cosolvent molecules released or bound to the DNA surface during the melting transition. Our ultimate goal is to correlate DNA hydration with DNA composition and DNA helix stability.

Bob Hanson and Gary Spessard – Developing Green Chemistry Experiments

We seek two students to develop new experiments in green chemistry. These experiments would be used in first- and second-year chemistry courses at St. Olaf, both extending the work that has already occurred in organic laboratory and exploring new territory for the first-year courses. One student would work with Professor Hanson on experiments suitable for first-year courses and the other with Professor Spessard on organic experiments. The work could range from adapting green experiments already developed elsewhere all the way to inventing new chemistry (basic research) that would be suitable for use in our laboratory courses. Students interested in this work should have completed at least first-year and organic chemistry by the summer of 2005.

Developing new green chemistry experiments is an exciting opportunity for you to both do research and see the fruits of your work applied directly in the teaching laboratory. Your work will play an integral role in our current program, supported generously by the W. M. Keck Foundation, to adopt the principles of green chemistry throughout our chemistry laboratory courses. We anticipate the outcome of your work will be disseminated outside the college, and thus students who do green chemistry development will not only have opportunities to attend regional and national scientific meetings and report their work, but also see their results appear in articles published in the *Journal of Chemical Education* or *The Chemical Educator*.

MATHEMATICS DEPARTMENT

Dick Brown - CPET: A Plug-In to Make Browsers Smarter

CPET, the Co-Process Extension Tool, is a browser plug-in that adds capabilities to existing web pages, *after* those pages have been received from a web server. For example, CPET can add the power to evaluate C++ or Scheme programming language expressions to a course's Moodle page, delivering the results of that computation to Moodle. For Summer 2005, we seek students with strong backgrounds in CS and programming (Javascript, C# desirable but not required) to extend CPET toward new applications: providing mathematical computation (e.g., performing Maple computation for Moodle responses); automatically adding reference links to pages such as online science research articles; integrating applets, video, etc., into pages that don't originally have them; and connecting web pages with spreadsheets.

Urmilla Malvadkar – Ecological Quantitative Problems Research

This is an opportunity for either a math student interested in applications to biology or a biology student to focus on quantitative problems, particularly in ecology. We will develop a project which draws on on your mathematical skills and biological interest. Please contact me malvadka@stolaf.edu for details.

PHYSICS DEPARTMENT

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 nuclei. For example, during the summer of '99 the students completed a study of the molecule CsF which was published in the *Journal of Chemical Physics*, 8 November, 1999.

The summer of 2004 was devoted to the analysis of past data on several molecules (^{6}LiI, RbF, RbCl) as well as a new investigation of KBr. In the process of fitting the data for ^{6}LiI (taken mostly during 2000), John Nichol recognized that there was an effect we could not account for using the expected interactions and their dependence on the vibration and rotation of the molecule. The interaction between the iodine nucleus and the electric field created by the rest of the molecule changed with the substitution of the Li isotope (replacing ^{7}Li by ^{6}Li) by an amount that we still cannot explain.

The analysis of KBr, RbF, and RbCl went smoothly, leading to a determination of all the expected interactions. The puzzle in the case of LiI, however, raises questions about similar but smaller shifts in these molecules that we need to understand more fully before submitting them for publication. Part of our task for the coming summer will be to examine these molecules more closely to see whether they show the effect.

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. Three students will be continuing from the summer of 2004 (John Nichol, Jimmy Randolph, and Sara Fortman), so we do not expect to support any new collaborators in the project.

David Dahl – Research at U of Minnesota-Minneapolis

Next summer I will be working with one St.Olaf student at UMN-Minneapolis on a nanomagnetism project funded by NSF through UMN's MRSEC program (Materials Research Science and Engineering Center), an interdisciplinary collaboration among Chemistry,Physics,Biology, Materials Science and various engineering departments. A sophomore or junior student will receive a stipend and housing at UMN for the 10 week program.

We will work in Professor Dan Dahlberg's lab (Magnetic Microscopy Research Group) in the Physics Department, interacting with graduate students and post-docs, with Magnetic Force Microscopy (MFM) the main research tool (we have two of these at St. Olaf,too). The goal of the research is to look at the fundamentals of magnetism in tiny particles (10's of nanometers) and examine their potential use in higher-density hard drive memory as well as "spintronics"--devices that make use of electron spin rather than charge. Work the last two summers examined the dynamics of magnetic reversal in isolated ellipsoidal dots and closely-spaced dots. Next summer we anticipate work to see how effective a magnetically polarized current (e.g. in iron) is in flipping the magnetism of another thin layer in contact with the first.

Jason Engbrecht - Positronium Research

The Positron Research Group focuses on properties of and applications for the exotic atom Positronium. Positronium (Ps) is the 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 biological systems.

Students on this project will play an important role in the design and construction of scientific 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 (Physics) & Rickard Pettersson (Environmental Studies) - Summer Research with the Center for Geophysical Studies of Ice & Climate (CEGSIC)

Glaciers and ice sheets make the cryosphere, an important feedback mechanism in the global climate system. Our group uses commercial and in-house radar systems to examine the interior and base of glaciers and ice sheets. The characteristics of internal ice layers and basal geology we measure with the radar lead better understanding of the relationship between ice flow and climate change.

Currently we are working on existing data from two past projects (one in Sweden, one in Antarctica), and are continuing fieldwork on two new projects (one in Antarctica, the other in Alaska). Summer research in 2005 will focus on finishing up the details of the older projects, analyzing new data from our current Antarctic project on Ice Stream C, and collecting data from an icefield atop Mt Veniaminof, a volcano in Alaska.

Students involved in our group will use existing software to analyze the data 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 data.

Laboratory Development for Physics 124/125: Incorporation of Chemistry and Biology

The physics department is working on incorporating examples of Chemistry and Biology into the Physics 124/125 sequence for non-majors. The committee on Biology and Chemistry in Introductory Physics has identified potential laboratories and demonstrations to be developed. Ranging from the electrochemistry of batteries to thermodynamic treatments of living organisms. Two students will be hired to develop materials and test these new laboratories. Physics majors as well as Biology and Chemistry majors who have had Physics 124/125 are encouraged to apply. Students will learn a wide variety of laboratory skills and have a wonderful opportunity for affecting significant change in these courses in a way that will have lasting impact.

PSYCHOLOGY DEPARTMENT

Donna McMillan – Environmental Psychology

My research explores the multifaceted nature of the human relationship with the natural world, asking both how nature affects us, as well as how we affect nature.

How does the natural environment affect us psychologically? In today's technological Western world, one might question what place nature has in our lives. I plan to continue to expand on our research from the past few years exploring the effects that interaction (or lack of interaction) with the natural world can have on a wide range of affective, cognitive, and behavioral variables, from sensory and physical engagement to spiritual contemplation.

And how do we affect the natural environment? How do our behaviors, values, attitudes, beliefs, and cultural practices affect the natural world? In addressing this question, my research focuses on the effects of consumer culture on the natural environment, in particular examining what effects a materialistic value orientation has on the natural world and on our lives.

I am interested in working with students who are intrigued by any of these questions and who have a strong background in psychology including Research Methods.

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.

Bonnie Sherman - Imagery and Number-Forms

I work with spatial (cognitive) layouts of abstract concepts such as numbers, months of the year, the alphabet, etc. These layouts are the mental landscapes some people use to represent concepts. Because the first descriptions of these were concerned with numbers, they are generally called number-forms, or sometimes simply forms. With several students I am currently examining reaction time to a simple arithmetic task involving (1) comparing numbers (up to 14) and (2) addition of small numbers (up to 14). We are searching for differences in time to add and compare between those people who use a number-form and those of us who do not use one. Our hypothesis is (from a pilot study) that people who use a number-form perform arithmetic tasks more slowly. I plan to continue with this work in the summer. Some background in psychology and good statistics background (concentration perhaps) is important.