SPECIAL ISSUE
SUMMER RESEARCH 2003 IN THE BIOLOGY, CHEMISTRY & PHYSICS DEPARTMENTS

______NOTE THAT THESE OPPORTUNITIES ARE ONLY AVAILABLE TO ST. OLAF STUDENTS______________

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Applications available from the Biology, Chemistry & Physics Department Offices
Due FEBRUARY 21. Decisions made by March 1.
Please talk to the research director if you have questions about project.
We reserve the right to make any necessary changes in projects.

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BIOLOGY DEPARTMENT

Diane Angell –Small Mammals in Prairie Communities, & Fluctuating Asymmetry Data

During the coming summer I am looking for students to continue projects on small mammals initiated by students last summer. Small mammals are important to prairie communities. They feed on large quantities of vegetation, sometimes affecting prairie diversity, and are food for many carnivorous mammals and birds. Last summer Craig Nelson found throughout his summer trapping, that he consistently trapped meadow voles in unburned areas and deer mice in recently burned prairie. It is not clear why such a pattern might exist. This summer we hope to expand and continue this research, trapping on the natural lands both at St. Olaf but also possibly Carleton. Research students may need a car, and need to be independent and motivated! Evenings setting traps and early morning trap checks may be required.

My other goal is to sort out the statistical approaches to analyzing data gathered on something called fluctuating asymmetry. Populations that are either environmentally stressed or "genetically stressed" often have higher levels of asymmetry than populations not under such stress. Fluctuating asymmetry data are currently being explored for use in the conservation of

projects, I would prefer students that have had 125, 126 and either Ecology, Genetics or Conservation Biology.

Eric Cole – Molecular Genetics, Protein Biochemistry and Cell Biology

There are three projects I'd like to hire researchers for. These involve Molecular Genetics, Protein Biochemistry, and Cell Biology. I hope to attract students willing to consider a 2-year commitment.

Molecular Biology: The student would start with a novel cell division mutant created by antisense mutatgenesis. Their task could involve:

- PCR amplify the antisense DNA responsible for the mutant phenotype, and clone it into our rDNA plasmid
- transform cells with the antisense construct to see if they recover the same phenotype.
- do photomicroscopy to characterize the phenotype.
- sequence the DNA (with the U.M. facility)
- extend sequence info in both 3' and 5' directions.
- run a "blast" search of the resulting gene.
- GFP tag the resulting gene and visualize its cellular location.

- run PAGE gels to visualize proteins from these for both wildtype and mutant cell lines.
- harvest proteins
- send to monoclonal facility for antibody production
- screen antibodies using immunofluorescence micsroscopy.

OR

- use antibody to protein Fenestrin to characterize nuclear exchange junctions in wild type nad mutant cell lines.
- this would involve training on confocal fluorescence microscope or use of deconvoultion microcsopy..

Cell Biology (2 possiblities)

- construct cell lines with broken chromosomes in their nuclei and assess conjugal success (test model that chromosome fragments create a checkpoint arrest during meiosis).

OR

- apply DNA synthesis inhibitor to mating cells and dissect developmental responses. (Does inhibition of DNA synthesis uncouple meiotic checkpoint mechanisms in our cells?)

Mary Caroline Henry – Learning Ability of Flies

Although flies traditionally have not been considered particularly "intelligent," there are some species which appear to exhibit simple learning. Jerry Hirsch, for example, has published reports of conditioning in fruit flies. Drone flies (a type of hover fly which resembles the honeybee male, or drone) are pollinators of flowers, which implies an ability to visit and feed from a single species of flower during one feeding period. How do the flies stick to one species of flower? Or do they? This project involves a little field work capturing and observing flies, and a lot of laboratory time raising, training, and testing them. It is a continuation of the study done by Ben Thwaits and Adrienne Schwartz last summer, but has the possibility of creative design of further experiments. Patience and a love of, or at least tolerance for, insects are good qualifications.

Kim Kandl – A Role for Actin in Protein Synthesis

I am interested in using the budding yeast, *Saccharomyces cerevisiae*, as a model organism to look at 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 establish localized protein synthesis, so that proteins are made where they are interested in the observation that some of our actin mutants show defects in the fidelity of protein synthesis. One mutant in particular shows a very high rate of nonsense suppression and reads through stop codons at a very high rate. Why would an actin mutant show an increase in nonsense suppression? Does this mutant actin have a defective interaction with some component of the translation machinery? Last summer Esther Lee made great progress on this question. She started a genetic screen to look for proteins that when overexpressed would suppress the translation defects of an actin mutant. Esther has great preliminary work and she may have identified a transla-tion factor that interacts with actin in a novel fashion! There is still much work to be done on this project - the result needs to be verified and experiments to look at interactions between this protein and actin need to be done. My research is open to students of all levels, but you must have a strong interest in genetics, biochemistry, cell and/or molecular biology, and you must be interested in following up on this work (preferably in the Fall) through an Independent Research project.

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 19th 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 2002. 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 the song of male wrens, how they communicate with each other and with females, and the function of the song. We may also look at the begging sounds of young in the nest. This will involve tape recording and computer analysis of vocalizations. Please see me for more information and procedures for applying.

Jean Porterfield – Population Genetics of Minnesota Fish Species

In Summer 2003 we will continue our work on the population genetics of Minnesota fish species. So far

similarity among populations of the banded darter (a colorful 2-inch stream fish) in Minnesota when we sequenced about 550 nucleotides of a protein-coding mitochondrial gene. While this was a fascinating result, our lab will be searching for other genetic markers that exhibit more population-level variation. We want to be able to address historical questions concerning post-glaciation colonization, as well as questions about migration and gene flow among Minnesota fish populations. I am interested in students who want experience in aquatic field work (we collect our own fish specimens from around the state), molecular genetics lab work (we isolate, purify, and PCR amplify DNA for DNA sequencing), and some computer analysis of genetic data. If you are interested, come on by SC 142 and learn more about this project!

Kathy Shea - Forest/Restoration Ecology

Student research will involve studying various aspects of forest ecology. A primary focus will be to continue a study on the growth and survival of tree seedlings planted as part of the forest restoration projects on the St. Olaf campus. This summer we will focus on the conifer plantings. Other possible projects include a dendroecological (tree-ring) analysis of stands in Minnesota and a study of earthworms and their relationship to forest vegetation. Students will learn a variety of techniques in terrestrial ecological sampling and data analysis. I am looking for students interested in continued work on some aspect of these projects as an independent research project during the school year.

Mike Swift – From Ecology to DNA!

Chaoborus larvae are important plankton predators in lakes, biomonitors of metal pollution, and nuisances to people outdoors. They are found worldwide, but their taxonomy and phylogeny is not well understood. Research in my lab will focus on using DNA sequences and morph-ological characteristics to determine the relatedness of several species of *Chaoborus*. From field collection to raising adults to sequencing DNA and estimating phylo-genies, students in my lab will be able to satisfy their curiosity about these wonderful insects at several levels of organization. 2 students.

Charles Umbanhowar – Effects of Climate Change on Lake and Terrestrial Ecosystems over the Past 12,000 Years

This summer we will be working to further document the impacts of climate change on lake productivity as measured by concentrations of biogenic silica and sediment phosphorus. This work will involve timed digestion of sediment samples and finally colorametric analysis of dissolved silica using a Flow Injection Analyzer. Students working on this project will learn about the basic ecology of lakes, climate history and the basic techniques of paleoecology and we will be contrasting the rates at which lakes and terrestrial systems respond to climate change. I am looking for 1-2 students.

Dave Van Wylen – Adenosine Receptor Overexpression and Cardioprotection

The goal of my research program is to enhance our understanding of mechanisms by which the heart can be protected against periods of oxidative stress such as that encountered during heart attacks or open heart surgery. This summer we will continue to use a cell culture system for studying such strategies. Using cultured cardiac myocytes, we hope to establish a cell model of adenosine receptor overexpression in order to determine if an abundance of adenosine receptors confers protection against oxidative stress in these cells.

Anne Walter – Lipid Organization in Membranes

I hope to work with 2 students this summer supported by HHMI or Merck. The projects are all lipid related--and could address questions such as: Are lipids randomly organized in membranes? Will that organization change with the addition of a protein or other lipid factor such as a phytoalexin? What are the fluidities of membranes and do these change with proteins or lipidic molecules? These studies will be done using a combination of tools includ-ing fluorescence spectroscopy, scanning calorimetry, lipid analysis, thin layer chromatography and gel electrophoresis.

CHEMISTRY DEPARTMENT

Research Opportunities with Bob Hanson

Probably you have seen the new nuclear magnetic resonance (NMR) spectrometer in what used to be our stockroom on the third floor of the Science Center. This coming summer will be an opportunity for one or two students with a computer science/instrumental analysis interest to work in my group designing a totally new way of carrying out NMR experiments. This is work started last summer by Gregg Sydow, Stephanie Skladzien, and Mike Purnell. The idea is to build a web interface that will allow student "experimentalist teams" to design and run NMR experiments using a robotic interface from a simple web browser. Sound interesting? We've done enough development to prove this possible, and now the job will be to really make it happen. Optimally, if you have some computer programming experience (JavaScript or HTML, for example), you will be ahead of the game, but I'd be happy getting you going from scratch if that interests you. There will be plenty to do that does not involve programming, like designing and testing the interface, writing web-based materials that describe experiments and show how to do things, and basically just discovering all of the amazing things that this new instrument will do. Feel free to stop by and let me give you a demo. Or visit http://www.stolaf.edu/people/hansonr/nmr/24-7 for an idea of what we're up to. I guarantee that by the end of the summer you will have learned much about the "behind-the-scenes" workings of the web as well as one of the most advanced NMR spectrometers in the world. (If you have an interest in this as an independent study project during second semester, that could be arranged as well.)

Research Opportunities with Dr. Paul Jackson

During the summer of 2003 there are numerous opportunities for interested students to work with me on projects related to separation science, environmental analysis, and synthesis.

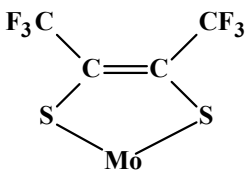
Project 1: Pharmaceuticals and personal-care products contain numerous chemicals designed to illicit specific biological responses. What happens to these unmetaboliz-ed or unreacted materials after we "flush" them down the drain? This project will go "fishing" for these chemical species in an area of the Cannon River downstream from the Northfield Wastewater Treatment facility – building on method development work of the previous students. Our biggest question right now is "What substances are present in the Cannon River?" Secondary, is "What is the source of the contamination?"

Project 2: Wetlands play a vital role in the natural world; they provide an excellent water filtration system and a bridging habitat for both aquatic and terrestrial species. Work on this project focuses on the development of analysis methods in which organic components in wetland waters may be surveyed and quantitated. Complexities abound when analyzing natural samples; the sampling protocol as well as the sample matrix provide challenges to be overcome. Samples will be taken from the Skog-lund wetland, the city of Northfield, and throughout Rice County.

Project 3: Reversed-phase liquid chromatography (RPLC) is used in over 2/3 of all liquid chromatographic separation protocols. The chemical and physical pro-cesses that result in a RPLC separation are not completely understood. Using previous experiment results from stationary phases containing embedded polar groups, we will design experiments to study the behavior of these stationary phases in purely aqueous mobile phase systems. Additionally, we may chemically graft a stationary phase ligand onto porous silica particles to create a different type of stationary phase material for study.

Gary Miessler - Organometallic Chemistry of Molybdenum

My main research interests are in organometallic chemistry. Primarily I would like to develop syntheses of new compounds of molybdenum 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, and I hope to synthesize compounds that might serve as models for the metal sites in such enzymes. In addition, I am interested in testing new ways to prepare transition metal complexes of the now well-known buckminsterfullerene (C_{60}, alias "buckyball") using both thermal and photochemical methods.



A dithiolene ligand bonded to Mo

In the laboratory, students participating in this work will gain experience in vacuum line synthesis and purification techniques beyond the scope of our regular synthesis laboratory courses. Students will also use a variety of

will perform web-based searches of the chemical literature. Opportunities to use our CAChe workstations for chemical calculations on the molecular orbitals of these types of metal complexes will also be included in this project.

Biochemistry Research Opportunities with Greg Muth

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 co-factor 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.

Summer Research with Jeff Schwinefus

Why are proteins thermally stabilized in most cosolvent-water mixtures while the DNA double helix is destabilized? As an example, the cosolvent 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 elucidation of dsDNA physical chemistry in cosolvent-water mixtures has potential meaning for cosolvent mediated protein-DNA interactions and the polymer coil-globule transition.

My research during the summer of 2003 will attempt to ascertain why the DNA double helix is destabilized in cosolvent-water mixtures. Students involved in research will measure the accumulation or exclusion of cosolvent near the DNA surface using high precision densimetry, a technique not normally encountered in the undergraduate curriculum. Students will have the opportunity to determine dsDNA water-cosolvent transfer free energies using densitometry measurements as well as dsDNA melting free energies using uv-absorbance measurements. These free energies can be used 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).

The molecule investigated during the summer of 2000, lithium-6 iodide, gave good data and is still being analyz-ed. The purpose was to see whether it would show a value for the iodine hexadecapole interaction (a subtle effect related to the shape of the nuclear electric charge distribution) consistent with what we had earlier observed in lithium-7 iodide.

During the spring semester and summer of 2002 Evan Frodermann and Katie Huber worked on the analysis of the RbF molecule. The main goal was to use the spectra determine to 9 significant figures the ratio (for the two Rb isotopes) of the amount by which the rubidium nuclei differ from spherical shape--compared to only 5 sig figs known previously. The work is essentially done, and just

is also going well, with more data coming through the year. Lee Langer was mainly responsible for organizing the RbCl investigation. It should also yield information about the comparative shapes of the nuclei of the two Rb isotopes. That will let us determine whether other effects contribute significantly to the spectrum. Mike Bongard worked mainly on rewriting the software that runs the spectrometer, while Heather Tollerud wrote several software subprograms that greatly speed up the analysis.

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, writ-ing software, etc. Three students will be continuing from the summer of 2002 (Katie Huber, and Mike Bongard and Lee Langer). One additional student will be selected to join the group for the summer of 2003.

David Dahl – Magnetic Force Microscopy

This research uses both experimental and theoretical tools to investigate magnetic nanostructures, multilayered spin transport, and the statistical mechanics and dynamics of magnetic materials. It's in collaboration with the Magnetic Microscopy Research Group at UMN. The main experimental probe is Magnetic Force Microscopy (MFM), a variant of the Scanning Probe Microscopes (SPM) we currently have at St.Olaf. MFM operates by using a microscopically sharp tip with a single magnetic atom at the end to sense the attraction/repulsion from a surface underneath. A laser beam reflected from the cantilever where the tip is mounted is used with computer software to give a visual image at atomic scale of the surface. Theoretical simulation of the magnetism expected from nanostructures is compared with experiment.

During summer 2003, I'll be participating along with 1 student (sophomore or junior) in the MRSEC (Materials Research Science and Engineering Center) program at UMN. This 10-week program will run from June 2-Aug 8. The student will receive a stipend and housing will be provided at UMN. Our goal will be to work with researchers in Professor Dan Dahlberg's MFM group, and to make use of that information next year to upgrade the St. Olaf microscopes in anticipation of on-campus research.

Jason Engbrecht – Positronium Thermalization

Positronium (Ps) is exotic atom formed by the

and slows down is called thermalization. Though the proper-ties of Ps are in many ways like those of Hydrogen, its mass is a factor of 1000 less than that of Hydrogen. This fact has many interesting implications in the physical process of Ps colliding with gas molecules at low energies.

Most recently this process was studied at the University of Michigan (M. Skalsey, J. J. Engbrecht, et al., Phys. Rev. Lett. **80**, 3727 (1998)). A new apparatus will be built at St. Olaf this summer that will improve the efficiency of data acquisition for this experiment by more than a factor of ten compared to the previous studies at Michigan. This will enable us to study the thermalization process in new gases as well as previously studied gases with improved precision. This research will have important implications in experiments that use Ps to test Quantum Electrodynamics, the most fundamental theory of electricity and magnetism at the atomic scale. It could also lay the groundwork for future material studies similar to that which is now done with Ps in condensed matter.

This summer will mark the beginning of this project at St. Olaf. It will therefore provide students the opportunity to work on an experiment from its very beginnings and play an important role in the design and construction of a new apparatus. Students will also 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/people/engbrech/research.htm 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 2003 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

past four seasons that now 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 software 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 Arctic Sweden where we have been deploying a new high-frequency ground penetrating radar (GPR) in studies of englacial water conduits. This project has just completed two summers of field work and is now in the data analysis phase.

We have a possible third project involving preparations for more field work in West Antarctica, but as of this writing we are still awaiting word about the funding from the National Science Foundation.

I anticipate openings for one to three new people in the group this summer, probably from the class of 2005 or 2006 - (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.