

Sigma Xi Research Symposium
Abstracts of Papers
May 4, 2007
Gustavus Adolphus College

Abstracts are listed in the order in which they appear in the symposium schedule.

Session 1a (1:45-3:15)

Decreased Viability and Fertility in Drosophila melanogaster Females Following Copulatory Bacterial Exposure

Fertility and immunity are concurrently upregulated in *Drosophila melanogaster* females after normal mating, potentially requiring physiological trade-offs. Using a novel bacterial introduction method, I observed female copulatory *Serratia marcescens* receipt and infection. Immuno-competent females surviving copulatory *S. marcescens* exposure had significantly reduced progeny production during the second week after mating, a reduction not observed in immuno-compromised females. These findings suggest early-life immunity introduces late-life trade-offs in fertility for females receiving copulatory bacterial exposure.

Tanner S. Miest Advisor: Margaret Bloch-Qazi

Computational and Spectroscopic Investigation of 7-Azaindole: Solvation and Intermolecular Interactions, Part I

We report results of an experimental study of 7-azaindole (7AI). This system has been studied extensively by others due to its role as a simplified model for hydrogen bonding interactions in DNA base pairs. In this study we use laser resonance Raman spectroscopy to investigate excited state dynamics of 7AI, its dimer, and the possibility of excited state double proton transfer (ESDPT). We selectively probe the monomer and dimer by varying concentration and excitation wavelengths. UV-visible concentration study investigate the presence of monomer and dimer species in solution.

Michael Z. Kamrath, Krista M. Cruse, Nathan R. Erickson, Molly B. Beernink
Advisor: Jonathan Smith

Computational and Spectroscopic Investigation of 7-Azaindole: Solvation and Intermolecular Interactions Part II

We report results of a computational study of 7-azaindole (7AI). This system has been studied extensively due to its role as a simplified model for hydrogen bonding interactions in DNA base pairs. We simulated Resonance Raman spectroscopy to investigate the excited state dynamics of 7AI and its dimer, particularly, the possibility of excited state double proton transfer (ESDPT). The trend in stability of the dimer is quantified in various solvents using ab initio and DFT calculations with implicit and explicit solvation models.

Michael Z. Kamrath, Krista M. Cruse, Nathan R. Erickson, Molly B. Beernink
Advisor: Jonathan Smith

Effects of Larval Density on Adult Fertility and Size in Female *Drosophila melanogaster*

Juvenile environments with limited resources, such as food or space, have a lasting effect on adult life due to a forced allocation of resources between reproduction and growth/survival. In this study, *Drosophila melanogaster* females were reared at three different larval densities and their fertility, size, and relative reproductive organ size were measured. The results suggest that adult fertility and size, but not relative reproductive organ size is influenced by larval density.

Heidi Bulfur Advisor: Margaret Bloch-Qazi

Caged Molecules and the Preparation of [1.1.1]Propellane

Cubane and similar highly strained hydrocarbons have garnered a great deal of interest in recent years. They have been nitrated to form explosives 30% more powerful than HMX, and added to pharmaceutical compounds, increasing the lipophilicity and degradation time of drugs. We report our initial efforts in the preparation of [1.1.1]propellane, a grotesquely strained, yet kinetically stable molecule. The general synthesis involves a carbene addition to 3-chloro-2-(chloromethyl)-1-propene, followed by a metal-halogen exchange with methyllithium, with characterization by reaction with thiophenol, followed by ^1H NMR and ^{13}C NMR. Additional reactions aimed at polymerization or attachment to drugs may lead to advances in materials science and drug design.

Alex Burum Advisor: Brian O'Brien

Frequency-Dependent Auditory Adaptation in Anura

Anuran auditory nerve fibers are unusual in that they reveal frequency-dependent adaptation. A model was created in which auditory nerve fibers, dorsal medullary nucleus neurons and toral cells were simulated and connected in three ascending layers. Changing the adaptation profiles of the periphery is reflected by similar changes at the torus maintaining the frequency-dependent profile. More dramatic changes in toral output can be observed when the synaptic input weights of excitation and inhibition patterns are altered.

Asitha Jayawardena Advisor: Michael Ferragamo

Subterranean Longevity of Botrychium Sporophytes

The genus *Botrychium* (moonworts) is a unique group of small ferns which is often rare and difficult to find due to their ability to persist, belowground, in a dormant state for one to several years without photosynthesis. This infrequency of aboveground leaves has led to difficulty in assessing populations. This study analyzed soil samples from one to ten years old to develop a conservative estimate on how long individual plants can remain healthy belowground

Michael P. Lynch Advisor: Cindy Johnson-Groh

Determination of the Structural Characteristics of the Inhibitor Binding Site in beta-Glutamylcysteine Synthetase

E. coli γ -Glutamylcysteine Synthetase, the rate limiting enzyme in glutathione synthesis, was purified using a three-step chromatographic separation to 42.3% yield and 4.19-fold purity. Kinetic studies were performed with substrate analogues of varying structure to probe the 3-D structure and constraints of the enzyme binding site. Preliminary results with D-Threonine proved to be the most interesting and this analogue became subject to further analysis due to its unusual ability to both enhance and inhibit enzyme activity in a concentration dependent manner.

Audrey Schenewerk Advisor: Brenda Kelly

Climate During the Last Glacial Maximum in the Wasatch Mountains Inferred from Glacier Mass-Balance and Ice-Flow Modeling

The timing and extent of the last glaciation in the Wasatch Mountains is becoming increasingly well understood, but comparatively little is known about its climate. To address this issue, ice extent in the American Fork Canyon was simulated using numerical models of glacier mass balance and ice-flow. The models link climatic parameters, such as temperature, precipitation and solar radiation ice extent, which can be used to set limits on the climate of the last glaciation.

Eleanor A. R. Bash Advisor: Benjamin J. C. Laabs

Effects of Reverberation, Age, Noise, and Sentence Context on Vowel Recognition

Sentences were played to 66 students and 18 older adults through headphones that created different room reverberations and noise. Subjects listened for a target word of a vowel pair (gem/jam, net/knot) that was presented in one of three sentence types. Some sentences gave little context, some suggested the incorrect word, and some were context correct. Results showed main effects for vowel sound, sentence context, and a 3-way interaction between vowel, reverberant condition, and sentence context.

Rachel Elvebak Advisor: Janine Wotton

Poster Session - 3:15-3:45 (Posters will be on display for the duration of the Symposium).

Computational and Spectroscopic Investigation of 7-Azaindole

We report results of an experimental and computational study of 7-azaindole (7AI). This system has been studied extensively due to its role as a simplified model for hydrogen bonding interactions in DNA base pairs. In this study we use laser resonance Raman spectroscopy to investigate excited state dynamics of 7AI, its dimer, and the possibility of excited state double proton transfer(ESDPT). We selectively probe the monomer and dimer by varying concentration and excitation wavelengths. UV-visible concentration study investigate the presence of monomer and dimer species in solution. The trend in stability of the dimer is quantified in various solvents using ab initio and DFT calculations with implicit and explicit solvation models.

Michael Z. Kamrath, Krista M. Cruse, Nathan R. Erickson, Molly B. Beernink
Advisor: Jonathan Smith

Till Genesis and Moraine Deposition during Pleistocene Glaciations in the Uinta Mountains, Utah

Although much is known about the history of glaciations in the Uinta Mountains of northern Utah, processes of sediment deposition by glacier ice during the Pleistocene are poorly understood. I examined three outcrops of moraine sediments in the Blacks Fork, Lake Fork, and Hades Creek valleys, and inferred the genesis of glacial till exposed in each moraine from pebble fabrics, grain-size analysis, sedimentary structures and stratigraphic relations. Most tills were classified as supraglacial sediment, deposited by saturated debris sliding off the surface of glacier ice at its margin.

Todd Kohorst Advisor: Benjamin Laabs

Synthesis of Uranyl Mesoporous Materials

Since their discovery in 1992, mesoporous materials have aroused interest for their unique absorbing and catalytic properties. Mesoporous materials, which have pore sizes slightly larger than those of zeolites, were originally silicates and aluminosilicates, but have been expanded to include various rare earth metals such as yttrium and gallium. The development of uranium-based mesoporous materials has generated particular interest due to its potential as a filter for the collection of ^{137}Cs and ^{90}Sr in nuclear waste and its ability to catalyze the degradation of organic molecules. The uranyl ion, consisting of uranium in the +6 oxidation state double bonded to two oxygen atoms in the axial positions, can be coordinated to four, five, or six ligands giving tetragonal, pentagonal and hexagonal bipyramids. The bipyramids can bond to each other forming single clusters, chains, sheets, and frameworks. We are planning to use these clusters to form a zeolitic framework, with uranium in powder similar to what is found in crystal structures.

Alex Burum Advisor: Peter Burns

Inflorescence of the *Gustavus Amorphophallus titanum* (Corpse Flower or Titan Arum)

Amorphophallus titanum, commonly known as the Titan Arum or Corpse Flower, is native to the tropical rainforests of Sumatra. It produces the largest unbranched inflorescence in the world, and is well-known for its fragrance, which is reminiscent of the odor of a decomposing mammal. The first stage of the growth cycle consists of production of a large single leaf, which grows from a corm, or food storage unit. This stage is followed by a period of dormancy. The cycle is repeated until flowering size is attained. We present observations of the rate of development for the inflorescence of the first plant of *Amorphophallus titanum* to flower in cultivation in Minnesota.

Alex Burum, Emily Pelton, Britt Forsberg, Emily Hoefs Advisor: Brian O'Brien

Reaction Initiation by Blue Light

The Thrasher research group from the University of Alabama, Tuscaloosa has shown that CF_3NO_2 and SF_5NO can be synthesized much more easily using 420 nm blue light rather than UV light. Dr. O'Brien has shown that blue light can initiate $\text{S}_{\text{RN}}1$ reactions in phthaloyphosphide systems. Using blue light initiation, the reactions of phthaloyphosphide with 2,3,4-trifluoriodobenzene, chloropentafluorobenzene, and perfluorohexyl iodide were investigated to define the limits of reactivity of phthaloyphosphide under these conditions.

Kevin Oberg Advisor: Brian O'Brien

Characterization of Fumarase by UV Resonance Raman Spectroscopy

Fumarase, an enzyme in the TCA cycle responsible for the conversion of fumarate to L-malate, has been studied using UV resonance Raman spectroscopy to probe the structural characteristics of the enzyme's histidine residues. Histidine-tagged-yeast fumarase was purified using a Ni-NTA affinity column. A broad signal associated with imidazole, the aromatic moiety in histidine, was observed at Raman shift 1450-1500 cm^{-1} for commercial porcine fumarase and purified Histidine-tagged yeast fumarase. These data suggest that UV Resonance Raman spectroscopy, which can enhance signal intensities one million-fold by comparison to traditional Raman spectroscopy, is a technique useful in the characterization of macromolecular structures.

Alex Burum, Brandon Burum, Lindsay Eastman Advisors: Brenda Kelly and Jonathan Smith

Vibro-Acoustography: The Birth of a Scanning Vibrometer

Modal testing of objects is an important industry related science. Through the use of ultrasound excitation, more precise measurements can be made. In order to do modal testing here at Gustavus, a fully functional scanning vibrometer was built from "bargain basement" parts.

Scott Hagemeyer, Eric Ofstad Advisor: Thomas Huber

Session 2b (3:45-5:00)

Anatomical Characterization of Putative Ischemic Pain Transduction Molecules: Immunohistochemical Localization of ASIC3 and P2X5

Ischemic pain results when muscle does not receive enough oxygen to support the work it is carrying out. Recent research has suggested that two different ion channels, ASIC3 and P2X5, work together to trigger the pain signal. In this experiment, muscle tissue was immunohistochemically labeled to determine the presence of ASIC3 and P2X5. P2X5 was found in the muscle fascia. Additional studies using 1,1-dioctadecyl-3,3,3,3-tetramethyl-indocarbocyanine perchlorate (Di-I), a retrograde tracer, are currently underway.

Bethany Thicke Advisor: Heather Wenk

ASIC3 and P2X Involvement in Ischemic Pain Sensation

Ischemia in skeletal muscle occurs when muscle cells are deprived of sufficient oxygen to support metabolic needs. Pain sensations likely occur due to metabolites acting on the sensory neurons that innervate the muscle. Here, we show that sensory receptors ASIC₃ (acid-sensing ion channel #3) and P₂X₅ are involved in producing the nociceptive signal from ischemic muscle contractions. A novel *in vitro* muscle-nerve preparation of rat hind foot muscle and nerve was used to record sensory response from induced muscle contractions in an oxygen-controlled environment. Sensory signals that were measured during contractions in simulated ischemic conditions were reversibly inhibited by concurrent bath application of ASIC₃ and P₂X receptor antagonists (ASIC₃ receptor antagonist APETx2 at 10μM, P₂X receptor antagonist PPADs at 100μM). Further testing will be done to quantify the role that each of these receptors plays in the transduction of ischemic muscle pain.

Brandon Baartman Advisor: Heather Wenk

From Farmland to Prairie: Tallgrass Prairie Restoration in the Linnaeus Arboretum

Gustavus Adolphus College owns an 80-acre field, located adjacent to the Linnaeus Arboretum designated as a future restored prairie. A restored prairie should have a sustainable community of native species, resistance to invasion, and healthy habitat characteristics. My research has resulted in a comprehensive plan, timeline, budget, and species list for this restoration site. My plan is based on professional literature, the historical land-use of St. Peter, the soil characteristics of the site and interviews.

Althea Archer Advisor: Cindy Johnson-Groh

Energy Storage Systems for Peak Shaving as a Complement to Wind Power at Gustavus Adolphus College

As Gustavus Adolphus College prepares to install two wind turbines on campus, we are faced with the question of what to do with the excess electricity that is generated. Since the college pays a substantial demand charge, it would seem fiscally responsible to store the energy and use it for peak shaving, instead of selling it to the power company at their avoided cost. We analyzed six currently available systems: hydrogen energy storage, flywheels, pumped hydroelectric storage, battery storage, compressed air storage, and superconducting magnetic energy storage, for energy and financial suitability. Potential wind turbine production is compared to consumption to determine the energy deficit or excess, which is fed into a model for each of the storage systems. We will discuss the advantages and disadvantages of each of the storage systems and their suitability for energy storage and peak shaving in this situation.

Jared Sieling

Advisor: Charles Niederriter

Electrophysiological Recordings of Temperature Sensitive Neurons Innervating Glabrous Rat Skin

re and by chemical agonists. We are studying two members of this family, TRPV8 and TRPA1. We used

Transient receptor potential channels are ion channels that are gated by both temperature and in vitro rat skin nerve preparation to record the activity of single sensory neurons while applying either temperature or chemical stimuli to the skin receptive field. The goal for this experiment was to categorize cold receptive neurons and to determine whether they express these receptors.

Nick Murray

Advisor: Heather Wenk