Faculty-Student Research

Student-faculty collaborative research is a strength of the department. Research projects are ongoing in the areas of analytical, physical, organic, inorganic, and biochemistry. The research experience may be as short as a single semester or it may last for a year and even culminate to a published paper. All students who are pursuing an American Chemical Society approved major must complete one year of undergraduate research. Please take a few minutes to check out the exciting research opportunities available.

**Dr. Michael Dvorak – Analytical Chemistry**

http://web.stcloudstate.edu/madvorak

My research interests are based on the practical application of fluorescence and luminescence techniques for the detection and quantification of select species in mixtures. This can take on either a theoretical or experimental application. On the theoretical side, our goal is to develop simple, matrix based algorithms that can model the spectroscopic response from the components of a mixture. The results of these models are compared with experimental results to determine the validity of the model. On the experimental side, we are interested in using pulsed (laser based) and non-pulsed (traditional lamp) techniques aimed at generating either fluorescence lifetimes (pulsed mode) or fluorescence signatures (lamp) from species on surfaces, species separated via chromatographic techniques, or species intrinsic to a mixture.

Other projects include establishing a Resonance Enhanced Multiphoton Ionization (REMPI) workstation for ultratrace detection of aromatic species in the gas phase. I am also involved in understanding the nature of dative bonding via several techniques including IR grazing angle and possibly Surface Enhanced Raman Spectroscopy (SERS) on self assembled monolayers, gas phase IR in a supersonic slit expansion (in collaboration with the U of MN), and fluorescence signatures of select B-N species in solution phase.

The interested student should note that my work requires a “hands-on” aptitude to work with chemical instrumentation and to trouble-shoot experimental methodology. Although programming skills are not necessary, students desiring to develop programming skills are especially welcome. I believe that students ultimately interested in graduate or post-SCSU activities in a physical/analytical laboratory are a good fit for my lab.

**Dr. Daniel Gregory – Organic Chemistry**

http://web.stcloudstate.edu/ddgregory

As a physical organic chemist, I am interested in the physical aspect of organic chemistry. In particular, I am interested in the mechanistic elucidation of photo-organic reactions. Currently, I have four different projects that I am working on. The first involves investigating the photochemistry of aromatic compounds that contain the isothiocyanate functional group.
Isothiocyanates of interest

This functional group plays a very important role in industrial chemistry as it is used to make a very wide range of compounds. The second project is using computational chemistry to investigate the excited states of these isothiocyanates. We use a wide range of computer techniques to gain valuable information about how these molecules look when they absorb light. The third project is a collaborative study with Dr. Mahroof-Tahir pertaining to the computational investigation of vanadium complexes. It has been shown that these complexes can serve as insulin mimics for the treatment of diabetes. Again we use a wide range of computational techniques to establish the geometries and energetics of these complexes. Photochemistry is not a topic that is discussed in great detail in your classes. Therefore, we also spend a lot of time talking about photochemistry and discussing the research project. Students are not required to have a strong understanding of the subject to begin research in my lab.

Dr. Michael Jeannot – Analytical Chemistry
http://web.stcloudstate.edu/majeannot

We are investigating simple microextraction techniques capable of performing trace analysis on environmental samples. In particular, we have developed a novel technique called headspace solvent microextraction in which a microliter of extracting solvent is suspended from the tip of a syringe needle in the headspace above an aqueous sample. Volatile organic compounds (pollutants such as chloroform and benzene) are preconcentrated in the microdrop, which is then analyzed by gas chromatography - mass spectrometry or other techniques. Current and future research in this area includes: analysis of disinfection byproducts and odor compounds in St. Cloud drinking water, and adapting the microextraction technique to analysis of mixtures by time-resolved fluorescence spectroscopy. The above research is done in collaboration with Dr. Dvorak's group.

We are also exploring the quantitative capabilities and other applications of matrix-assisted laser desorption/ionization (MALDI) mass spectrometry using our new Bruker Autoflex MALDI-MS which was acquired recently through a National Science Foundation grant. Research activities include: using room-temperature ionic liquids as matrices for quantitative MALDI, exploring the feasibility of MALDI analysis of natural organic matter and disinfection byproducts, and proteomic studies of human breast cancer cells. The above research is done in collaboration with Dr. Sreerama's group.

Dr. Tamara Leenay – Organic Chemistry
http://web.stcloudstate.edu/tleenay

Research projects involve developing science outreach modules to incorporate in our Husky Volunteers for Science program. Students will develop modules by first researching ideas, creating all handouts and procedures, presenting to SCSU student volunteers and then implementing the modules at a local elementary school.

Dr. Mohammad Mahroof-Tahir – Inorganic Chemistry
http://web.stcloudstate.edu/mmahroof

My group is involved in synthesis and characterization of vanadium complexes with promising antidiabetic properties. These complexes are characterized by using instrumental techniques like NMR, IR, UV-vis, and GC-MS. We characterize these complexes in a solution state to get an insight into the active species with antidiabetic properties. We are also working on understanding the mechanistic and structure activity relationship (SAR) studies in which complexes are synthesized with systematic variations in their structures. These complexes are tested for their enzyme inhibition properties with
three key enzymes, protein tyrosine phosphatase, alpha glucosidase and phosphodiesterase, which play an important role in diabetes.

My research group is also involved in synthesis and characterization of anticancer complexes of titanium and germanium. The studies of the interaction of these complexes with DNA are carried out by using NMR spectroscopy and other instrumental techniques to understand the mechanism and action of these complexes. The anticancer properties and enzyme inhibition studies of these complexes are carried out in my collaborators’ laboratories.

Dr. Jack McKenna – Physical Chemistry
http://web.stcloudstate.edu/jfmckenna

Current research topics include:

1. Analysis of codeine in poppy seed muffins by GC-MS.
3. Growth of "large" crystals for a macro-crystallography demonstration.
5. Analysis of the fire hazard in the copper-to-silver-to-gold demonstration.
6. A modification of the "glowing pickle" demonstration.
7. Development of an NMR equilibrium/kinetics laboratory for pchem.
8. Development of an NMR experiment on the hydration of aspirin.
9. Modification of general chemistry experiments to be more "discovery-based."

Dr. Mark Mechelke – Organic Chemistry
http://web.stcloudstate.edu/mmechelke

A major goal in cancer research has been the development of chemotherapeutic agents that are more specific and less toxic than those in current use. While traditional approaches to cancer management have involved cytotoxic compounds of limited selectivity, new ideas are focusing more on the primary disease mechanisms that underlie the development and maintenance of human cancer. One such target is a guanosine triphosphate-binding protein known as RAS that plays an essential role in the signal transduction pathways which regulate cell proliferation. Mutations in RAS proteins are associated with approximately 50% of all human cancers. The demonstration that RAS farnesylation is essential for RAS-induced cellular transformations has aroused an intense interest in farnesyl pyrophosphate analogues as potential chemotherapeutic agents.

Farnesyl pyrophosphate, the natural substrate for RAS farnesylation, is composed of two structural units, a hydrophobic farnesyl “tail” and a polar diphosphate “head.” My research focuses on incorporating modified farnesyl “tails” on natural product “heads”. The initial objective of my research group will be to synthesize farnesyl “tails” which incorporate aromatic rings in the terpenoid chain. It is anticipated that these modified “tails” will bind tighter to the enzyme active site due to intermolecular interactions with the aromatic amino acid residues that have been shown to line the hydrophobic cleft that accepts the farnesyl chain. Initially, the polar “head” of a natural product, chaetomellic acid A, will be placed on these modified “tails”. It is anticipated that compounds modified in this manner will illustrate for the first time the importance of nonbonding interactions in the binding of farnesyl pyrophosphate analogues to the enzyme active site.

Dr. Lakshmaiah Sreerama - Biochemistry
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We are conducting research in the areas of cancer chemotherapy (drug resistance and drug metabolism), toxicology of ethylene glycol ethers and forensic toxicology. Our research is divided into three areas.
Area 1: Understanding the role of aldehyde dehydrogenases in toxification of ethylene glycol ether aldehydes (toxicological and forensic interest) and detoxification of aldehyde intermediates of anticancer drugs, e.g., cyclophosphamide and its analogues.

Area 2: Identifying the molecular basis for the resistance to selective anticancer drugs, e.g., cyclophosphamide, mafosfamide, flavopiridol, UCN-01 and Otteliones via proteomic [matrix-assisted laser desorption/ionization (MALDI) mass spectrometry-based analysis] and genomic analysis.

Area 3: Genetic polymorphisms in aldehyde dehydrogenases and their relevance to cancer chemotherapy, carcinogenesis and cancer chemoprevention.

Research Model Systems: We utilize cell-free systems (purified enzymes), cultured human cell (normal and tumor) models, animal-tumor models and human tissues for our research.
Dr. Nathan Winter - Biochemistry

I am interested in protein structure. More specifically, determining the three dimensional structures of proteins through X-ray crystallography. The proteins that I am studying are aldehyde dehydrogenase and creatine kinase. I am also interested in designing, synthesizing and evaluating a cross-linking reagent which could potentially increase the ease of crystallization of proteins containing a histidine leader sequence.