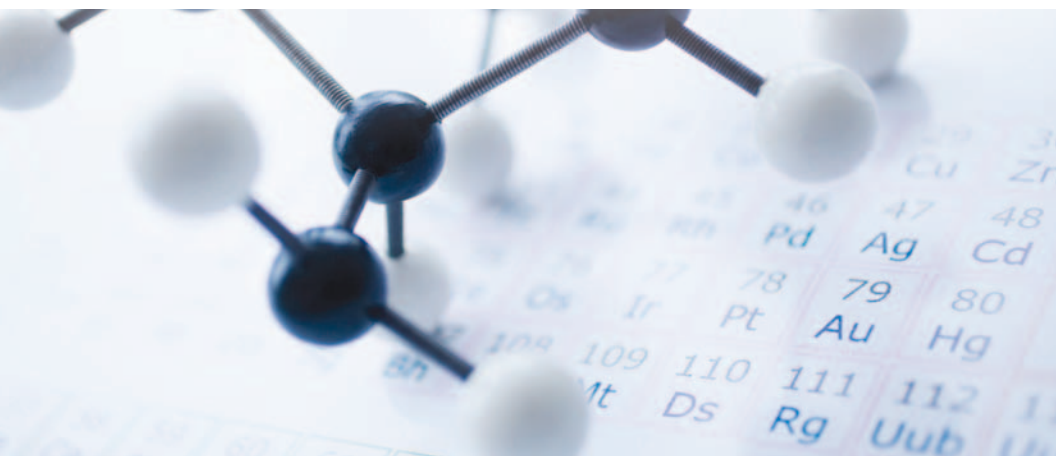




**Northeastern**

U N I V E R S I T Y

# Department of Chemistry and Chemical Biology



**Undergraduate  
Research  
Opportunities**

# Introduction

The promise of excitement and personal satisfaction associated with discovery of something new has drawn generations of students like yourself to chemistry, biochemistry and related scientific disciplines. Like many other undergraduate students, a desire to participate in scientific research developed during your secondary school years and affected your decision to pursue science in college.

At Northeastern University all students pursuing a BS or BS/MS degree in Chemistry are required to participate in one semester of undergraduate research in an academic laboratory independent of any co-op experiences. This research is usually undertaken in the senior year. An increasing number of undergraduates express an interest in working in a research laboratory prior to their senior year. This brochure describes a variety of opportunities available to you in the research laboratories in the Department of Chemistry and Chemical Biology. All of the programs listed here are open to all students in the University, regardless of major, provided they have completed the necessary prerequisites and have secured the permission of the instructor or principal investigator.

## Research for academic credit

### Senior research (CHM U750)

All chemistry majors participate in a minimum of one semester of research in one of the academic laboratories on campus by registering for CHM U750, Senior Research. The course carries 4 semester hours of credit and is a graduation requirement for the BS and BS/MS degree programs. This requirement is typically fulfilled during the senior year, currently the final semester you will spend as an undergraduate student in the BS degree program. For students in the BS/MS program, you will enroll in CHM U750 earlier, probably in your junior year.

Once you have enrolled in CHM U750, the most important decision is finding a research group in which to work. Many, but not all, faculty will accept undergraduate students into their research groups. You should peruse the list of faculty and the corresponding research descriptions at the back of this brochure for guidance. The list is not comprehensive, but simply mentions those who have supervised senior research in the last five years. You will notice that faculty with a wide variety of interests, including chemical education, are represented.

After deciding on a couple of potential advisers (you may also wish to speak with an academic adviser in the department), you should arrange an appointment with the faculty member to discuss a project. It is useful to have a second choice in mind, as some faculty will not have space in their research laboratories for another student or they may be on sabbatical. Typically, an undergraduate research student will join an ongoing project rather than setting out on their

own ideas. The project should allow you to actively participate in the scientific enterprise, not just act as a technician or do menial labor. Make sure to clarify the requirements for the course. You should plan to work 10-12 hours per week based on the typical formula, 3 hours of laboratory equals one semester hour of credit. Since you are receiving academic credit, you may not be paid. Once you have reached agreement with a faculty member, please inform the academic adviser of your decision. This will make it easier to transfer the grade to your record at the end of the semester. CHM U750 also satisfies the university experiential education requirement.

## **Undergraduate research (CHM U901)**

In addition to CHM U750, there are additional undergraduate research courses in which an enterprising student may enroll. The procedure is first to speak with the academic adviser and then follow the procedure described above for CHM U750. Some faculty will be reluctant to take students whose training has not reached the necessary standard for successful research in their area. Don't be discouraged. As for CHM U750, you are not allowed to accept compensation for your work since you are getting academic credit. CHM U901 may be substituted for CHM U750.

## **Directed Study (CHM U921-924)**

Students who wish to participate in less than 4 semester hours of research, either independently of or in addition to CHM U750, may enroll in CHM U921-924, a directed study course with variable credit ranging from one to four semester hours. As with other academic research courses, students are required to reach an agreement with a faculty member regarding supervision of the research. As for CHM U750, you are not allowed to accept compensation for your work since you are getting academic credit. CHM U924 may not be substituted for CHM U750.

## **Paid Research Positions**

### **Internal Co-op**

From time to time, students and faculty may find it mutually attractive for a student to accept a co-op position in the department. The arrangements for such positions will involve the co-op adviser and the Co-op Department but may not be advertised extensively. It is useful to consult with the academic adviser about the availability of co-op positions.

As a co-op student, you will be paid for your work and will bear all of the responsibilities of a co-op student in terms of scheduled work hours. The details of wage scales, hours, etc. are resolved by negotiation between the faculty member

and the co-op adviser. You can not receive academic credit for a co-op position nor does such an “internal” co-op position fulfill the experiential education requirement. An internal co-op does not substitute for CHM U750.

## Shapazian Research Scholarships

Students who qualify for the BS-MS degree option with premedical focus, and who wish to pursue an internship at Harvard Medical School affiliated teaching hospitals, may be eligible for Shapazian research scholarships. Contact the academic advisers in the Chemistry & Chemical Biology Department for more information.

## Summer Research

Certain federal grants carry provisions that allow the principal investigator (faculty member with the grant) access to additional funds to support summer undergraduate research students. While the department will make efforts to publicize the availability of paid research positions, the best information will be available from the academic adviser, who can inquire about positions among the faculty. When available, these positions are typically restricted to the summer sessions, as it is difficult to be an effective research student while carrying a full academic load.

## Merck Undergraduate Research Fellowship

Funded by Merck Research Laboratories-Boston, the objective of this fellowship is to prepare students for their first co-op assignment and to introduce them to original research by placing them in a research atmosphere for the Summer 1 (May-June) semester.

**Eligibility:** Full-time undergraduate chemistry major; completion of organic chemistry (CHM U311/313 or CHM U315/317) by Summer 1.

**Funding:** Stipend adequate to cover living expenses for two months, and a limited amount of funds to the research advisor for supplies.

**Expectations:** Students are expected to work 32 hours per week over the six-week summer session which will leave them with limited opportunities for coursework. The students participating in the Merck Scholars Program will be, for the most part, sophomores who do not have any regularly scheduled classes during summer 1, however, students should be allowed to take one academic course if they wish. Students will be required to make a presentation (10-15 minutes) on their research to Merck representatives during the late summer or early fall.

**Application Procedure:** Requires a proposal from a faculty adviser.

**Deadline:** Late February.

## Astra-Zeneca Undergraduate Research and Travel Scholarship

Funded by Astra-Zeneca, a limited number of undergraduate research and travel scholarships are available to students with prior undergraduate research experience whose work is likely to produce publishable/presentable research by the end of a six-month period (January 1 to June 30). Students are expected to travel to a regional or national meeting and present the results of their efforts.

**Eligibility:** Full-time undergraduate chemistry major; completion of organic chemistry (CHM U311/313 or CHM U315/317) by January 1; prior involvement in undergraduate research in the department.

**Funding:** Funds will be provided to fully or partially cover registration, housing and travel costs to a regional or national meeting together with a contribution to research expenses.

**Expectations:** It is anticipated that any student enrolled in the program will be taking a full load of courses during the Spring and Summer 1 semesters. A commitment of 6 hours per week is expected of the students, or a total of 120 hours between January and June.

**Application Procedure:** Requires a proposal from a faculty adviser.

**Deadline:** Proposals will be considered on a rolling basis.

## Work-Study

Students eligible for work-study support can apply for appointment as professor's assistants. An undergraduate student can work in the research laboratory at the hourly work-study rate up to their maximum eligibility. As usual, a mutually acceptable match between student and research supervisor must be agreed upon. No faculty member is required to take a work-study student even though their own research funds are not being taxed. It is mostly a case of matching skills and time a student can commit to such a position each week.

The department also has several laboratory assistant positions available each semester for work-study eligible students to help the staff in the undergraduate laboratories. While these positions do not typically involve research, they will hone your laboratory skills and allow you to participate in the chemical education enterprise. These positions are arranged through the department business manager, Mr. Richard Pumphrey, in 102 Hurtig Hall.

## Externally Funded Research Fellowships and Internships

Every year the department receives applications and information about summer research opportunities for undergraduates through fellowships, internships and scholarships of various kinds. These programs are typically during the summer months (June through August) which may conflict with the Northeastern University split summer session. These opportunities may allow you to work in the department or may require you to take residence in another city. The fellow-

ships and internships are always competitive and open to students from many universities nation-wide. A strong academic record and advanced standing (typically juniors, which in the case of NU students may mean middlers as well) are typically required of all applicants. Listed below is an opportunity that was sent to the department this year. Further information is available from the academic advisers.

### Norris/Richards Undergraduate Research Scholarship

This competitive scholarship is funded by the Northeast Section of the American Chemical Society.

**Eligibility:** Student must be a chemistry, biochemistry, chemical engineering, or molecular biology major in good standing, and have completed at least two full years of college-level chemistry by Summer 1.

**Funding:** Stipend of \$2,750 to the student and \$500 in supplies for the research adviser.

**Expectations:** 10 weeks of work in a department research laboratory. Award winners are required to submit a report (5-7 double-spaced pages including figures, tables, and bibliography) of their summer projects to the NESACS Education Committee by early November for publication in *The Nucleus*. They are also required to participate in the Northeast Student Chemistry Research Conference (NSCRC) in April of the following year.

**Application Procedure:** Requires a proposal from a faculty adviser.

**Deadline:** early April.

## University Sponsored Fellowships

### Faculty Undergraduate Research Institute (FURI)

The Faculty Undergraduate Research Institute (FURI) program, sponsored by the Center for Experiential Education and Academic Advising (CEA), is designed to support undergraduate research through a variety of means, including assisting students in finding faculty to work with, providing some funding for undergraduate research, and tracking participation in undergraduate research throughout the college. The goal is to provide students with meaningful intellectual and practical research in their chosen academic disciplines while aiding faculty in their research and scholarship.

Students can provide research support to faculty in a variety of ways, including, but not limited to, conducting literature reviews, analyzing and categorizing information, analyzing statistical data, assisting in running laboratory experiments, developing computer programs, and drafting written analyses.

Students may participate in faculty research in three different time allotments. For one unit of academic credit or hourly compensation, a student typically works five hours per week. For four units of academic credit or hourly compensation, a student works 12-15 hours per week, and for co-op credit and hourly compensation, a student works 35 hours per week.

Financial compensation may come from work-study funding for part or full-time positions, grant funding for any position, or Faculty Undergraduate Research Institute (FURI) grants for part time positions.

Students in FURI receive \$750 for their research assistance during a semester and \$250 for the same assistance during a summer session for a research commitment of five hours per week. They are required to attend the FURI colloquia held three times each semester, and once each summer session. Students are also required to prepare a final report of activities in a format (e.g. journal, paper, poster presentation, etc.) specified by their faculty mentor, and to attend the Experiential Education Expo.

## Provost's Undergraduate Research Grants

The Provost's Office sponsors a number of undergraduate research projects in the fall, spring and summer semesters (for application deadlines go to [http://www.research.neu.edu/students/undergraduate\\_research/](http://www.research.neu.edu/students/undergraduate_research/)). Awards up to a maximum of \$1,000 are provided to support student research such as purchase of supplies, software, reference books, or travel to research sites and professional meetings.

Students who wish to be considered should first discuss possible topics with their faculty sponsor. Students supported by this initiative agree to complete a final survey at the conclusion of the project. They should also provide a final summary to Vice Provost Malcolm Hill at the end of the project. The Provost's Office encourages all students supported by this initiative to consider presenting the results of their research at a campus-wide event such as the Arts & Sciences Experiential Education Expo held each spring.

## List of Faculty Research Interests

The following list contains a telephone number, e-mail address and a brief description of research interests for faculty in the Department of Chemistry and Chemical Biology who have supervised undergraduate students in the past five years. Since a particular faculty member may be on sabbatical or short on laboratory space, their inclusion on this list does not obligate them to participate in the undergraduate research programs in any given year. In addition, new faculty may join the department too late to be included in the brochure. For the latest information, see Prof. Kirss in 318 Hurtig (617-373-4513 or [rkirss@neu.edu](mailto:rkirss@neu.edu))

## **Prof. Geoffrey Davies**

Room 408 Hurtig; 617-373-2834; g.davies@neu.edu

### *Inorganic/Materials Chemistry*

Prof Davies and the Humic Acid Research Group are studying the isolation, purification, properties and structures of humic acids (HAs), the brown biomaterials responsible for water retention, metal binding and solute adsorption in soils, sediments and water. Earth's HAs have more carbon than all living things. HAs stick to clays and minerals, which prevents them from being washed away. Prof. Davies' group has developed techniques for the purification and preparation of standard samples of humic acids from many sources, and uses techniques such as X-ray fine structure spectroscopy for HA characterization and analysis. They were the first to isolate HAs from a live plant. Their data indicate that HAs isolated from different sources in different countries have the same or similar metal binding sites and molecular structures. Studies of HAs' environmental roles include immobilization by attachment to clays and minerals for bioremediation applications and the effects of bound metals on HAs adsorptive properties. Better understanding of the structure and properties of HAs informs proper agriculture, soil creation, maintenance and remediation practices. The Humic Acid Research Group hosts the international Humic Substances Seminar held every year at Northeastern (see [www.hagroup.neu.edu](http://www.hagroup.neu.edu)).



## **Prof. Patricia Mabrouk**

Room 111 HT ; 617-373-2845; p.mabrouk@neu.edu

### *Bioinorganic, Biophysical and Bioanalytical Chemistry*

Our research has largely been in the area of chemical biology and is focussed on the development of a molecular level understanding of the rules governing biomolecular recognition in heme proteins and heme enzymes. A number of these proteins perform key biochemical functions such as oxygen transport (cytochrome c), oxygen storage (myoglobin), and detoxification (cytochrome P450). We have taken a novel and unconventional approach to this problem that involves the dissolution and subsequent spectroelectrochemical study of a select series of heme proteins and enzymes in a variety of nonaqueous solvents using a wide range of spectroscopic (UV-vis, CD, RR, and NMR) and electrochemical methods. Recently, nascent interests and efforts in green chemistry and materials science have led to the development of a second distinct area of research activity in our lab. We are currently investigating the electrochemical and enzymatic synthesis of conducting polymers and other important polymers in supercritical fluids.



## **Prof. Rein Kirss**

Room 318 HT, 617-373-4513; rkirss@neu.edu

### *Inorganic Chemistry*

Our research is directed toward the synthesis, characterization and reactivity of organometallic compounds with potential applications to organic synthesis and novel materials. We are exploring: 1) the synthesis of achiral and planar chiral pentadienyl ruthenium compounds as catalysts for carbon-carbon cross-coupling reactions; 2) electrocyclic reactions of transition metal coordinated pentadienyl ligands as routes to fused [3.n.0] rings; and 3) preparation of metallocene and open-metallocene based materials with novel electronic and magnetic properties.



## **Prof. Robert Hanson**

Room 206 HT; 617-373-3313; r.hanson@neu.edu

### *Bioorganic and Medicinal Chemistry*

My research group focuses on the application of contemporary organic chemistry to the design, synthesis and characterization of biologically active small molecules. In particular, the research utilizes palladium-catalyzed coupling of organoboranes and -stannanes, solid phase and solution combinatorial chemistry, molecular modeling and computer-assisted drug design, as well as conformational analysis with high field NMR. The areas to which these methods are applied include steroid hormone receptor modulators, therapeutic agents for drug addiction, anti-Parkinsonism agents, and receptor selective radioimaging agents. The projects are multi-disciplinary and involve collaborators from a variety of local, national and international institutions. The work is supported by grants from NIH, DoD, and DOE.



## **Prof. Graham Jones**

Room 102 HT; 617-373-2822; gr.jones@neu.edu

### *Organic Chemistry*

Our research group is active in a number of areas of contemporary bio-organic and medicinal chemistry. A central theme of our program is the design of bioactive molecules on the basis of specific cellular and nuclear targets, and our projects are typically collaborative efforts with researchers at the nearby Harvard Medical School. One area of recent interest has been the enediyne antitumor



agents and their metabolites. Capable of inducing damage to duplex DNA, derivatives of these natural products are also able to target specific bulged DNA and RNA microenvironments, which have been implicated in a number of neurodegenerative diseases. Our synthesis program has developed a number of lead compounds for anticancer and molecular biology applications. Another interest is in enzyme activated prodrugs. An example of this class has been in PSA activated anti-prostatic agents and image contrast markers, where localized concentration of this important enzymatically active biomarker trigger release of the active agent.

We are also active in developing new reagents and methodology of organic synthesis. We have pioneered the use of arene-chromium carbonyl complexes as enantioselective catalysts, and have employed these highly effective reagents in the synthesis of a number of bioactive natural products. We are also engaged in collaborative work validating theoretical and computational methods for the design of reagents and medicinal agents and in the understanding of biological pathways.

## **Prof. Eugene Smotkin**

Room 417 HT; 617-373-7526; e.smotkin@neu.edu

### *Materials Chemistry*

The central theme of Prof. Smotkin's group is the discovery of better materials for clean energy sources and processes. This includes the development of catalysts and supports for electrochemical reactors for synthesis, power generation and environmental remediation. This multidisciplinary effort includes development of synthetic methods, spectroscopic analysis and computational modeling of nanostructured materials. High throughput analytical instrumentation is developed for comparative and fundamental studies of catalyst libraries. Towards these ends, Laser Activated Membrane Introduction Mass Spectrometry (LAMIMS) has been developed for high throughput fundamental studies of heterogeneous catalysts and Array Electrochemical Reactors have been developed for evaluation of electrocatalysts. We also continue to develop potential dependent Fourier transform infrared spectroscopy, X-ray absorption spectroscopy and X-ray diffraction methods to probe the buried catalyst interfaces of operating electrochemical reactors.

**Enantioselective Nozaki-Hiyama-Kishi Reaction:** This is a cross-disciplinary project that includes design and testing of novel ligands using traditional and combinatorial approaches. Our goal is to design unique combinatorial screening



procedures and apply them to address a long-standing problem, design of an enantioselective version of the chromium catalyzed aldehyde alkylation.

A relatively new field developed in the Smotkin group is the study of non-Faradaic processes occurring at electrode surfaces. These processes include acid catalyzed organic transformations at electrode surfaces that do not involve electron transfer from the electrode to the reactant. Solvent free reactors such as polymer electrolyte membrane electrochemical reactors are used for power generation and for development of new organic transformations at electrode surfaces.

## **Prof. Zhaohui “Sunny” Zhou**

Room 424 HT; 617-373-2868; z.zhou@neu.edu



### *Analytical, Bioorganic and Medicinal Chemistry*

Undergraduate students who are committed to active and independent research are always welcome to Sunnyland. All undergraduate students will work closely with Professor Zhou and other group members, and summer support may also be available. Many former undergraduates in Sunnyland presented their work at conferences, received research awards, published papers in peer-reviewed scientific journals, and went to graduate schools and medical schools.

Sunnyland applies organic chemistry, analytical chemistry and protein engineering to biology and medicine. One program is to devise new methodologies to characterize protein post-translational modifications, such as methylations and protein processing via proteolysis, which are involved in cancer and autoimmune diseases. In addition, a general strategy is envisioned to selectively decorate proteins, such as protein pharmaceuticals in biotechnology industry. A second program area is the mechanistic study of biologically important enzymes, towards the design and synthesis of inhibitors as drugs. Current targets include several pathways involved in bacterial communication and biofilm formation, a major clinical problem with no effective treatment.

**Prof. Thomas Gilbert**  
**(Chemical Education)**

Room 57 LA/216 HT; 617-373-8175;  
t.gilbert@neu.edu



*Chemical Education*

Contextual Approaches to Teaching Chemistry: This research includes an NSF-sponsored collaboration with high school science and math teachers and faculty from Northeastern University's College of Engineering to develop a contextual pedagogy based on urban engineering learning modules that spans upper level high school math and science courses and the chemistry, physics and calculus courses taken by freshmen engineering majors.

**Prof. Mary Ondrechen**

Room 122 HT; 617-373-2856; mjo@neu.edu



*Theoretical Chemical Physics*

Prof. Ondrechen's group works in the areas of theoretical and computational chemistry and chemical biology. Areas of interest include functional genomics (prediction of the functional roles of gene products - proteins), modeling of enzyme-substrate interactions, bioinformatics, electron transfer materials, proton transport materials, and modeling for proteomics applications. With the sequencing of the human genome and the genomes of hundreds of other species, structural genomics efforts are now discovering thousands of new protein structures. The next question is: What do these structures actually do? We are working on the development of new methods to predict protein function from structure. Our THEMATICS method requires only the structure of the subject protein and thus works for proteins that bear no resemblance to previously characterized proteins. Current THEMATICS projects deal with the analysis of specific enzymes of biological and medical importance, as well as application of an automated version of THEMATICS to computationally screen large numbers of protein structures. We are working in partnership with the Institute for Complex Scientific Software (ICSS) at Northeastern University on the automated version of THEMATICS. We are also building Quantum Mechanical / Molecular Mechanical (QM/MM) models for enzymes that use vitamin B6 as a cofactor.

## **Prof. David Budil**

Room 108 HT; 617-373-2369; d.budil@neu.edu



### *Physical Chemistry*

Prof. Budil's group is interested in the physical behavior of macromolecules, including both synthetic polymers and biopolymers such as large proteins and DNA. Their principal investigative tool is high field electron spin resonance (ESR) spectroscopy. Developmental research continues on a novel extension of standard ESR spectroscopy that requires superconducting magnetic fields and far-infrared light. This research led to a novel, patented design for a 220 GHz ESR spectrometer that provides unique capabilities. The use of high fields dramatically increases the dynamic and chemical information obtainable by spin-labeling polymers and proteins.

Current research projects in the Budil group include: (1) "Electrostatic mapping" of protein and polymer surfaces using the sensitivity of nitroxide spin-labels to local electric fields at high ESR frequencies; (2) ESR studies to discriminate the dynamic behavior of different bound forms of spin-labeled DNA; (3) Molecular dynamics-based simulation of ESR spectra to correlate spectroscopic results directly with molecular models; (4) High-field ESR studies of the ultrafast primary light reaction in photosynthesis. Prof. Budil's group is applying high-frequency methods to examine new structural details of the working states of the photosynthetic reaction center, which in turn reflect how the host protein directs the primary reaction. Other collaborative projects that require ESR spectroscopy are also under way. Our group is interested in the physical behavior of macromolecules, including both synthetic polymers and biopolymers such as large proteins. Specific research projects include: (1) Development of a novel extension of standard electron spin resonance (ESR) spectroscopy that requires superconducting magnetic fields and far-infrared light. The use of high fields dramatically increases the dynamic and chemical information obtainable by spin-labeling polymers and proteins by analogy with high-field NMR; (2) "Electrostatic mapping" of protein and polymer surfaces using the sensitivity of nitroxide spin-labels to local electric fields at high ESR frequencies; (3) Studies of the linear electric field effect (FEFE) on organic radicals at high ESR field; (4) Molecular dynamics-based simulation of ESR spectra to correlate ESR spectroscopic results directly with molecular models; (5) High-field ESR studies of the ultrafast primary light reaction in photosynthesis. We are applying our high-frequency methods to examine new structural details of the working states of the photosynthetic reaction center, which in turn reflect how the host protein directs the primary reaction.

## **Prof. Sanjeev Mukerjee**

Room 417 HT; 617-373-2382; s.mukerjee@neu.edu



### *Physical Chemistry*

Our research activity is an interdisciplinary approach to understand charge transfer dynamics at two and three dimensional electrochemical interfaces. These encompass the areas of solid state chemistry, polymer membrane synthesis, spectroscopy and electrochemistry of materials. Currently our group has active research programs in development of new electrocatalysts and elevated temperature proton exchange membrane for polymer electrolyte membrane fuel cells (PEMFCs) for energy conversion, high capacity and energy density materials for primary and secondary batteries and fundamental studies of corrosion mechanisms and development of inhibitors. Research efforts in the area of electrocatalysis include cathodic oxygen reduction and anodic CO tolerance, and Methanol oxidation reactions. Search for new hydrogen intercalation compounds with higher capacity and corrosion resistance include both AB<sub>5</sub> and AB<sub>2</sub> type nickel metal hydrides. Lithium intercalation compounds are focussed on both anodes (such as composite oxides of Tin) and cathodes such as layered vanadium oxides and network spinels such as doped lithium manganese oxides. A new initiative has been launched on development of aqueous elevated temperature proton exchange membranes for fuel cell applications. This effort involves new polymer membrane synthesis, characterization for proton and reactant transport as well as developing a fundamental understanding of the dynamics involved in this transport phenomenon using advanced molecular modeling. As part of these research efforts, our group uses advanced in situ synchrotron spectroscopic methods of x-ray absorption (XANES and EXAFS), x-ray scattering and far infrared. Synchrotron based x-ray absorption spectroscopy offers unique insights into electrode processes by providing simultaneous electronic and short-range atomic order information of electrode materials under actual in situ cell operating conditions. This electrode substrate information is complemented by use of synchrotron based in situ x-ray diffraction and IR spectroscopy, both possessing advantages of higher resolution and, in the case of IR spectroscopy, the ability to see far infrared thus extending scope and quality of these measurements.

## **Prof. Paul Vouros**

Room 215 HT; 617-373-2840; p.vouros@neu.edu

### *Analytical Chemistry*

The central focus of our research is the area of mass spectrometry and its applications to bio-organic analysis. Our efforts involve the investigation of both fundamental and applied problems. We have established a strong reputation for the development of techniques of interfacing separation methods—gas chromatography, liquid chromatography, and capillary zone electrophoresis—with mass spectrometry. Optimization of these sample delivery systems has enabled us to advance the state of the art for trace level analysis of biological samples. Much of our applied work is being done in collaboration with colleagues from the bio-medical community in the Greater Boston area and beyond.



## **Prof. Max Diem**

Room 316 HT; 617-373-2922; m.diem@neu.edu

### *Biophysical Chemistry*

The research in Prof. Diem's laboratory is centered on the development of physical/ optical methods for medical diagnosis. In contrast to standard histo-pathology, where cells and tissues are examined visually under a microscope, we measure changes in cellular composition using molecular fingerprint techniques.



The research being carried out is divided into two major areas. In our work on tissue diagnostics, we have developed methods for the detection and identification of secondary (metastatic) tumors in lymph nodes. We are working on producing instrumentation and software that can analyze lymph node sections in the operating room, and provide the surgeon with an objective diagnosis of the spread of disease.

The second major research area is the detection of cellular abnormality in a sample of exfoliated cells, or cells obtained by any other means (e.g., thin needle aspiration). We can distinguish normal from cancerous cells in such samples by the same optical measurements used for tissue diagnostics, and sophisticated multivariate statistical methods. This work opens the possibilities of designing systems for cancer screening.

In the past, numerous undergraduate students have participated in this research, working along with graduate students and postdoctoral research associates. This research may be particularly suitable for students intending to attend medical school at a later date.

## **Prof. Penny Beuning**

Room 6 Hurtig; 617-373-2865; p.beuning@neu.edu

### *Biochemistry*

The genomic integrity of living organisms is constantly under threat from DNA damage, which can block normal cellular DNA replication. However, a specialized family of DNA polymerases exists with the ability to replicate damaged DNA templates, allowing cells to tolerate some DNA damage. *E. coli* has two of these specialized polymerases with largely non-overlapping substrate specificities. Part of this project seeks to understand the structural basis of this specificity using protein design and directed evolution.

A second project in the lab focuses on protein clamps that encircle DNA and provide for efficient DNA replication. Alternative forms of these protein clamps exist in species from bacteria to humans and seem to play a role in dealing with DNA damage. We are determining the role of alternative DNA-binding protein clamps in cellular resistance to DNA damage and stress. We use biochemical and biophysical techniques to investigate the function and regulation of these clamps.



## **Prof. John Engen**

Room 341 MU; 617-373-6046; j.engen@neu.edu

### *Bioanalytical Chemistry and Mass Spectrometry*

Research in the laboratory centers on the use of state-of-the-art mass spectrometry (MS) to study the conformations and movements of proteins and protein machines. Mass spectrometry can be used to study protein conformation if the proteins in question are labeled with a structure-dependent labeling method such as amide hydrogen exchange (HX).

Proteins contain a number of hydrogens that can exchange with hydrogen in the surrounding solvent. The most useful hydrogen to follow is the backbone amide hydrogen. If the normal H<sub>2</sub>O solvent is changed to D<sub>2</sub>O, the protein gradually becomes deuterated. Because deuterium and hydrogen differ in mass by 1 dalton, the incorporation of deuterium (aka, hydrogen exchange) into a protein can be monitored with high resolution mass spectrometry.

The rate of HX depends on hydrogen bonding and solvent accessibility. Folded proteins can have amino acids with HX rates as much as 1 billion times slower than the same amino acid that is not in a folded protein. Protein folding and unfolding, whether in cells or in the test tube, represent large changes in protein structure, hydrogen bonding and solvent accessibility that can be investi-



gated with HX MS. Smaller structural changes critical for protein function can also be probed with HX MS.

Projects of current interest include: (1) the analysis of structural changes in the Src-family of tyrosine kinases during interactions with regulatory proteins and (2) the analysis of the conformational features of viral proteins that are not amenable to crystallography or NMR.

## **Prof. Philip Warner**

Room 219 HT; 617-373-4415; p.warner@neu.edu



### *Organic Chemistry*

My research goals are to apply theoretical methods to interesting and important problems in organic chemistry. An example of this is the use of quantum theory to understand the electronic and stereoelectronic contributions to the molecular orbitals participating in enediyne cyclizations (the Bergman cyclization). This rearrangement is utilized by a large and important group of DNA binding and cleaving agents, some of which are clinically useful chemotherapeutic compounds. It is hoped that our theoretical work can lead to the design of even more potent derivatives. For example, several of these compounds use p- p stacking as a structural feature, and tweaking the nature of this interaction appears to significantly effect cyclization rates.

A large component of my research is concerned with orbital interaction through space. When this interaction involves a cyclic array of electrons, the molecules belong to the “aromatic” class, in this case termed “homoaromatic”. One recent concern has been the size limits to homoaromaticity, a subject which has not been investigated. We find that previous qualitative expectations do not apply, and homoaromaticity in some systems extends to rather large rings. Also, neutral bishomoaromaticity (double through space interaction) is possible, but end somewhere around an 18-membered ring. We are also interested in replacing some bridging ring carbons with other elements, like silicon. Preliminary results show unusual effects. A related study of 11-membered ring aromatic cations has uncovered the first example of Möbius antiaromaticity.

**For More Information Contact:**

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Director of Undergraduate Programs  
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rkirss@neu.edu