

UNDERGRADUATE  
RESEARCH  
IN CHEMISTRY  
AT MISSOURI STATE  
UNIVERSITY

(Revised April, 2020)

## UNDERGRADUATE RESEARCH IN CHEMISTRY AT MISSOURI STATE UNIVERSITY

An education in chemistry usually begins with a high school course that introduces elements, ions and inorganic compounds and continues with general chemistry courses in college. These experiences are followed by the study of organic compounds, analytical methods, physical chemistry, and more inorganic compounds. The undergraduate program may also include biochemistry, polymer or environmental chemistry.

As time progresses, your knowledge of chemistry grows. But as graduation approaches, uncertainty may remain as to what can be done with this vast amount of chemical information.

The Chemistry Department at Missouri State University has provided a solution to this problem. Each semester two special courses are offered in which you may apply your knowledge of chemical theories and laboratory skills toward the solution of a specific chemical problem. You can join one of our faculty members in a search for new chemical knowledge and/or the solution of a real life concern. Called *research*, you will find this activity listed in the University catalog and the class schedule as CHM 399 (no course prerequisite) and CHM 499. These research courses are available for 1-3 hours credit per semester, and each may be repeated to a total of 5 hours.

Starting a research project is a little more involved than registering for other courses, so you may need some additional information on how to proceed.

1. The first step is to decide that you want to do research. You must also decide when. We suggest that you wait at least until your second year of college, but you may enroll for research in any semester or summer term with the permission of the instructor or advisor. Research courses are listed with an "arranged" time, so you and your research advisor will develop a schedule for you to carry out your work. Usually, this will be between 8:00 and 5:00 Monday through Friday, so you may want to keep some blocks of time available as you arrange your semester's activities.
2. The second thing you need to do is to select a research area and an advisor. When you are ready, you should read the Research Packet available in the Chemistry Office, TEM 423, or online to direct you in this process. Select an area of chemistry that interests you; this does not necessarily mean that you have had a course in this specific area. However, you will need to discuss your background and interests with chemistry faculty members as you consider your options. You will be instructed to visit with at least five research advisors to discuss the types of problems they would be willing to direct. If unable to physical contact the five research advisors, contact the five advisors by email or other chosen method of electronic communication. When you submit the form to the department administration, you will also submit this evidence of the faculty communication so the department administration can verify you have contacted the required five advisors.

3. You must be enrolled in the Research Portfolio Blackboard site, have completed the Safety Training and passed the safety quiz prior to enrolling in the class. Please have the Safety Coordinator physically sign and date the Undergraduate Research Request form (last page of this packet) to verify you have completed this. If this cannot physically be completed, please ask the Safety Coordinator to send an email to the department administration stating you have completed the Safety Training, passed the quiz prior to enrolling in the class, signed the waiver and that the Blackboard records are updated.
4. If able to physically complete the above steps, after meeting with the faculty advisors and completing the safety training, return the appropriate Research Request Form to the chemistry Office with your preferences listed one through three. If unable to physically complete the above steps, email the appropriate above discussed materials to the department administration. The Chemistry Department Head will assign research advisors to ensure that students are able to work in an area of interest and to avoid overloading a few research directors.

After you have been assigned an advisor, you will be granted online permission to enroll in the course. The departmental secretary will send you an email notifying you that permission has been granted by your advisor. The enrollment for research will cover one semester or summer term but may be repeated until the maximum of 5 hours is reached. Each credit hour requires a minimum of 48 hours of documented laboratory work. The exact number of documented hours per week is up to the individual research advisor, but the minimum number is 3 hours per week per credit hour. This is a MINIMUM amount, and some research advisors expect more, and an average value is 3-6 hours per week per credit hour.

5. When your project begins, your advisor will assign you an appropriate space in a laboratory. You should keep careful records of your research work and a log of the time spent on the project. This must be in the form of a formal laboratory notebook, containing detailed records and notes on your research progress.
6. At the end of the semester a written report must be submitted to your research advisor. A grade of Incomplete, 'I' will be assigned until the final draft of the paper has been submitted to the research advisor by the grade deadline. The advisor will provide the grade based on performance in the lab as well as the technical aspects of the paper.
7. Students enrolled in CHM499 will be required to present their results in some type of public forum. The possibilities include a poster or oral session at a regional or national meeting/conference (ACS, MAS, Sigma Xi, etc) or a local conference (such as the CNAS Undergraduate Research Day, 700/701 seminars, meetings of the Chemistry Advisory Board, etc). The research advisor will help to determine the appropriate venue. An appropriate person (additional faculty member, recruiter, session coordinator) will need to sign off on a student's presentation if the advisor will not be present.

8. Students who are repeating the course need to complete the appropriate page at the back of this packet only and turn it into the Chemistry office, if capable of physically turning the form to the office. If not physically capable, ask your research advisor to send an email to the office stating that you may repeat 399/499 for another semester and the Safety Coordinator to send an email to the department administration stating you have completed the Safety Training, passed the quiz prior to enrolling in the class, signed the waiver and that the Blackboard records are updated.

#### SPECIAL INSTRUCTIONS DURING COVID-19

Rather than the earlier discussed five faculty you are required to meet with, during COVID-19 you will only need to contact one faculty. This faculty will need to send an email to the department office stating you have permission to work with this person. You are still required to complete the research/safety material working with the Safety Coordinator. At the back of this brochure, there is a specific form to complete during this time.

#### FORMS:

If you are taking CHM 399/499 for the first time, you will use the form Fillable form if the student is taking 399/499 Revision 1.

If you are repeating CHM 399/499, you will use the form Fillable form if the student is repeating 399/499 Revision 1.

If you are taking CHM 399/499 for the first time during COVID-19, you will use the form Fillable form if the student is taking 399/499 Revision 1 during COVID.

**Gautam Bhattacharyya (TEM 421)**

Our research centers on better understanding the difficulties students have learning organic chemistry with the ultimate goal of creating instructional materials and interventions. We are particularly interested in helping students learning mechanistic reasoning using the electron-pushing formalism (EPF). Not only is this type of mechanistic reasoning at the core of instruction and scientific practice in organic chemistry and biochemistry, they are integral to pharmacology, toxicology, and physiology, to name a few areas of the biomedical sciences.

One of our current areas of interest is to develop verbal descriptions of mechanisms that could eventually be used in textbooks. To that end, we recently published – with then MSU chemistry major Michael Harris – our study of the types of descriptions that would help students reproduce, either in their minds or on paper, the corresponding electron-pushing diagrams. Using the general guidelines resulting from this research we intend to construct descriptions for a set of electron-pushing mechanisms central to the study of organic chemistry. After testing their effectiveness with students in organic chemistry courses, we will assess the effects that a better ability to visualize mechanisms have on students' ability to solve mechanism problems on exams or homework assignments.

In another line of research, we are interested in how students interpret and give meaning to the diagrammatic representations of molecules and electron-pushing mechanisms. Specifically, we are interested in identifying the aspects of the diagrams which organic chemistry students prioritize and their reasons for doing so.

*Prerequisites: Ability to work independently, creativity, and tenacity*

**Richard Biagioni (TEM 458)**

I am primarily interested in applications of analytical techniques to problems in a variety of areas, and have been engaged in collaborative projects with faculty of several other departments. Instrumental methods employed include inductively coupled plasma - atomic emission spectroscopy (ICP-AES) and atomic absorption spectroscopy (AAS), along with a variety of chromatographic methods (GC, GC/MS, HPLC).

I would prefer students who have successfully completed CHM 160 through CHM 171; completion of CHM302 (Introduction to Analytical Chemistry) would also be beneficial.

**Eric Bosch (TEM 104A)**

My current research interests are in coordination chemistry and crystal engineering. In the field of coordination chemistry I am designing, preparing and evaluating new ligands to complex specific transition metal cations. Potential applications include metal-specific sensors, cation scavengers and novel porous materials. In the field of crystal engineering we are preparing matching pairs of donor and acceptor molecules that co-crystallize. This is basic research that specifically probes the weak intermolecular forces that hold molecules together in the solid state.

*Prerequisites: CHM 342.*

**Bryan Breyfogle****(TEM 425)**

My primary research interests are in the area of chemical education. The development and implementation of technology-mediated classroom and laboratory activities at the undergraduate and K-12 levels is the primary focus of this research. Research in this area will provide students pursuing science education degrees practical experience in developing technology-based learning tools for chemistry.

A secondary area of interest involves electrodeposition and characterization of metal oxides and binary metal oxide systems (oxides with more than one metal). Work in this area will involve collaboration with the Physics, Astronomy and Materials Science Department for characterization of the electrical and optical properties of these metal oxide thin films.

**Natasha DeVore****(TEM 448)**

My research interests are in the field of protein biochemistry. All of my projects involve studying the structure and function of human proteins. Many of the proteins that we study contain a heme and belong to the cytochrome P450 family. Cytochrome P450 enzymes are involved in a number of different processes including the breakdown of foreign compounds and synthesis of steroids and eicosanoids. Techniques used in my lab group include molecular biology to clone or modify genes in bacterial plasmids, expression of human proteins in *E. Coli*, purification of proteins with affinity chromatography, followed by enzymology and X-ray crystallography. It is helpful to have taken biochemistry but not required.

**Nikolay Gerasimchuk****(TEM 456)**

Current research interest is in the area of the oxime-bearing amplydentate ligands and their metal complexes. Several projects are currently under development in my research group.

One includes synthesis, structural and spectroscopic studies of Pd(II) and Pt(II) complexes with a variety of cyanoxime ligands. Complexes are intended for *in vitro* studies of their cytotoxicity using cancerous cell lines such as HeLa (cervical cancer), WiDR (colon carcinoma), IGROV (ovarian cancer) and EVCA (breast cancer). Performed screening will allow selection of the best compounds for investigation of their antitumor activity *in vivo*.

Second project is aimed at the preparation and characterization of coordination polymers that exhibit interesting properties such as: a) solid state electrical conductivity, b) fluorescence in the NIR region, c) non-linear optical properties. These compounds prove to be very useful for molecular electronics applications, and can be deposited as thin films at ambient conditions on dielectric surfaces.

Lastly, the most recent project involves preparation, characterization and biological studies of a new family of organoantimony(V) oximates as non-antibiotic antimicrobial agents.

*Prerequisites:* CHM 375, CHM 376 and CHM 342.

**Reza Herati****(TEM 454)**

My current research interests are in the area of polymer/organic chemistry. More specifically, we are interested in synthesis and modification of polymers for various applications. Current projects include: (a) synthesis and characterization of dendrimers consisting of a poly(ethylene glycol) blocks and various dendrons, particularly bio-degradable dendrons and their applications in drug delivery and (b) investigation of the mechanisms of RNA/DNA interaction with nanomaterials to form RNA/DNA nanoconjugates.

**Gary Meints****(TEM 452)**

Damage to the structure of deoxyribonucleic acid (DNA) can lead to mutagenesis, cancer, and other serious medical conditions. Elaborate repair mechanisms have evolved in many species to deal with damage to their genomes. While a significant amount of information is known about the mechanisms of repair, there are still many mysteries. My current research interests include investigating the role of conformational variability and flexibility of damaged DNA by determining the local (small scale) backbone motions and structure. In particular, I am interested in how these properties assist interactions with repair proteins. Specific types of damage (lesions) include those with relevance to cancer-related mutagenesis and the associated repair mechanisms, such as lesions caused by reactive oxygen species, environmental contaminants, UV radiation, and base pair mismatches. Local DNA structure and dynamics are determined using solid and solution-state nuclear magnetic resonance (NMR) spectroscopy and Raman scattering. Spectroscopy is a powerful tool for determining numerous types of molecular properties. Students in my group will learn a wide array of skills to aid in their investigations of DNA motions, and will discover how chemistry can bridge fields as diverse as physics and biology.

**Mark Richter****(TEM 477)**

Work centers on studying light emitting systems using photoluminescence (the generation of excited states using light) and electrogenerated chemiluminescence (the generation of excited states using electrochemistry).

**Cyren Rico****(TEM 412)**

The general goal of Dr. Rico's Lab is to understand the mechanism of the fate, transport, transformation, and impacts of cerium oxide nanoparticles (CeO<sub>2</sub>-NPs) in the environment. The various research questions are tackled using different disciplines in environmental chemistry, analytical chemistry, and plant/agricultural science. Various approaches (plasma-based, IR and synchrotron spectroscopies, molecular and isotopic techniques) are employed to understand the fate, transport, transformation, and impacts (e.g. toxicity, benefits) of CeO<sub>2</sub>-NPs in soil and plant systems. Broad research questions that will be pursued include the understanding differential mechanisms of CeO<sub>2</sub>-NPs uptake in barley and wheat, and exploring the impacts of CeO<sub>2</sub>-NPs on food transfers, nitrogen cycling and plant epigenetics.

**G. Alan Schick****(TEM 104)**

Current research interests lie in the general area of materials chemistry. Most projects of the group focus on characterizing molecule-molecule and molecule-surface interactions in terms of how they can be manipulated to produce novel molecular assemblies and device structures. These projects typically involve molecular self-assembly and micropatterning methods. Students in the group have opportunities to become familiar with a host of molecular properties and characterization techniques, including phase behavior, spectroscopic analysis, microlithography, nano-scale imaging, and cleanroom protocol. Application areas include electronic device fabrication and formulations of medicated topical creams and gels.

**Matthew Siebert****(TEM 408)**

Research in the Siebert group is best described as applied theoretical organic chemistry, or, the application of computer simulations to questions of interest to organic, biological, and organometallic chemistry. Current research projects include:

- Cycloaddition reactions creating fluorenones
- Gold homogeneous catalysis
- Biosynthesis of rotenoid natural products
- Thermal cracking of fatty-acid methyl esters (FAMES)
- Spectroscopic properties of biomolecules

*Prerequisites:* CHM 342.

*Additional information can be found at:* <http://people.missouristate.edu/msiebert/>

**Erich Steinle****(TEM 417)**

Research projects in this group focus on the field of sensor technology. More specifically, we are interested in utilizing several electrochemical techniques including potentiometry and impedance spectroscopy to study various types of materials for possible sensor applications. One major project involves ion-selective electrodes (ISEs), devices that precisely measure the concentration of specific anions or cations in aqueous solutions (i.e., fluoride in drinking water, sulfates in wine). Our particular goal is to find promising compounds that have strong and reversible interactions with target anions and cations. These compounds, known as ionophores, are then placed into polymeric membranes, mounted into ISEs, and are then exposed to various test solutions to measure native selectivity advantages. Another project in the group is in the emerging discipline of nanotechnology. We are studying alumina and gold membranes with nano-sized channels (10-100nm in diameter) running the length of the membrane. These channels have many unique transport and sensor abilities due to their small size. Furthermore, we modify these nanochannels with various types of chemistries (i.e., sol-gel or thiol attachments) to enhance the properties. Many different research projects within these two major projects (ISEs and nanotechnology) are available and can be tailored to fit student interests and future plans.

**Adam Wanekaya****(TEM 463)**

Current research in this laboratory focuses on the fabrication, modification, characterization and application of nanoscale materials. Nanoscale materials have diameters that are 1000 times smaller than the average human hair. Because of their small size, they manifest extremely fascinating and useful properties which can be exploited for a variety of applications. We intend to integrate these nanomaterials (specifically conducting polymers and carbon nanotubes) into functional devices with specific applications in chemical sensing, biomedical sensing and remediation of heavy metals and other toxins from the environment.

**Fei Wang****(TEM 106)**

My research interest is in the field of solid state chemistry and energy-related materials. To address the energy crisis, people all around the world are developing new techniques to harvest energy from new energy sources and improve the efficiency of energy consumption. These techniques rely on the performance of many solid state materials, such as photovoltaic materials, permanent magnet, and superconductors. My current project is on thermoelectric materials, which can convert a temperature difference into a voltage. They have many applications such as harvesting waste heat from car engines and transform it into electricity. My research features a combination of experimental and theoretical techniques. Students in my group can obtain knowledge in solid state synthesis (with high temperature furnaces), X-ray crystallography, and first-principle electronic band structure calculations.

**Keiichi Yoshimatsu (TEM 404)**

The Yoshimatsu group works in the areas of 1) analytical chemistry, 2) polymer chemistry, and 3) chemical biology. The projects currently ongoing in the group include:

A) Inexpensive and portable analytical ‘tools’ made of wax-printed papers: We spot appropriate reagents onto wax-patterned filter papers and utilize these papers for selective detection of target analytes in water, food, or biological samples.

B) Stimuli-responsive polymers: This project involves organic synthesis of polymer materials and/or characterization of organic polymer-based materials to develop novel materials that are useful for detecting various chemical, physical, or biological stimuli.

C) Synthetic peptides: Solid-phase peptide synthesis (SPSS) is a technique to prepare peptides, a class of biomolecules, by chemical synthesis. We design and synthesize various peptides that often incorporate ‘unnatural’ (i.e. non-canonical) building blocks for analytical or biomedical applications.

D) Protein engineering: This project adapts the modern technology in molecular biology including recombinant DNAs, site-directed mutagenesis, polymerase chain reaction (PCR), protein expression in bacterial cells to develop new engineered proteins for analytical and biomedical applications.

For more information on the projects, please visit our group website (<http://kyoshimatsu.wixsite.com/yoshimatsulab>).