USNA Chemistry Department

Research Project Courses - The **Capstone** Option

Capstone vs. Research

Capstone (SC476)	Research (SC495/496)
• **1 semester** "research" + 2 chem electives = 9 total credits (6 lec + 3 lab) • work with a **lab partner** on a project selected from a list or design your own project • **group** poster, paper and presentation during Spring of 1/C • leaves time for other programs e.g. Serv. Academy exchange; semester abroad	• **2 semesters** of research + 1 chem elective = 9 total credits (3 lec + 6 lab) • typically work alone but with a **faculty mentor** in his/her area of research • **individual** poster and papers during Fall and Spring of 1/C • presentation during Seminar • possibly attend a scientific meeting

Capstone vs. Research

Research – highly specialized
- small (but essential) part of a big picture
- you contribute, but usually not your own overall plan
- chance to see/do something NO ONE ever did before
- product meant for dissemination to wider scientific community

Capstone – closer to past experience - “Special Project” for 1 semester
- you can answer a question COMPLETELY
- you can pick YOUR OWN question and design entire plan
- might not be completely new, but definitely new to you
- can provide chance to improve lab experience for future classes

Both – draw upon, and build upon, previous classroom/lab experience
- exciting, boring, easy, difficult, triumphant, frustrating, novel, repetitive – maybe all in one day!
- very educational and rewarding overall

Past/Present Capstone Projects (1)*

- Fabrication and Study of Transparent Wood
- Art Conservation Chemistry – create and study pigments; develop associated art conservation teaching tools
- Bioprospecting for New Biofuels and New Antimicrobial Compounds – grow and harvest bacteria and/or algae to screen for useful natural products
- Construction and Evaluation of a Simple Spectrometer – build and study an absorption or emission spectrometer
- Construction and Characterization of a Home-Made DSC – build and optimize a low-cost version of the differential scanning calorimeter to make thermal analysis available to institutions with a limited budget

**See details on Capstone Projects page; 2023 projects could include these and/or others*
https://www.usna.edu/ChemDept/_files/documents/capstone/SC476%20CAPSTONE%20PROJECTS%20s17.pdf

Past/Present Capstone Projects (2)*

- Chemistry Relating to Forensic Investigations – explore the science behind "*CSI*", examining ink/paper document forensics, fingerprint development science, or X-Ray fluorescence forensic analysis

- "Lab-on-a-Chip" Student-Fabricated Microfluidic Devices – create an entire synthetic and analytical laboratory on a single microscope slide

- Developing an HPLC Analysis for B-Vitamins – work on development of an IL experiment focused on simultaneous analysis of the B-vitamin group

- Plebe or IL Lab Development Project – revise or extend an existing Plebe or IL lab experiment, or create a new one. If there is time, have the Plebes try it out !

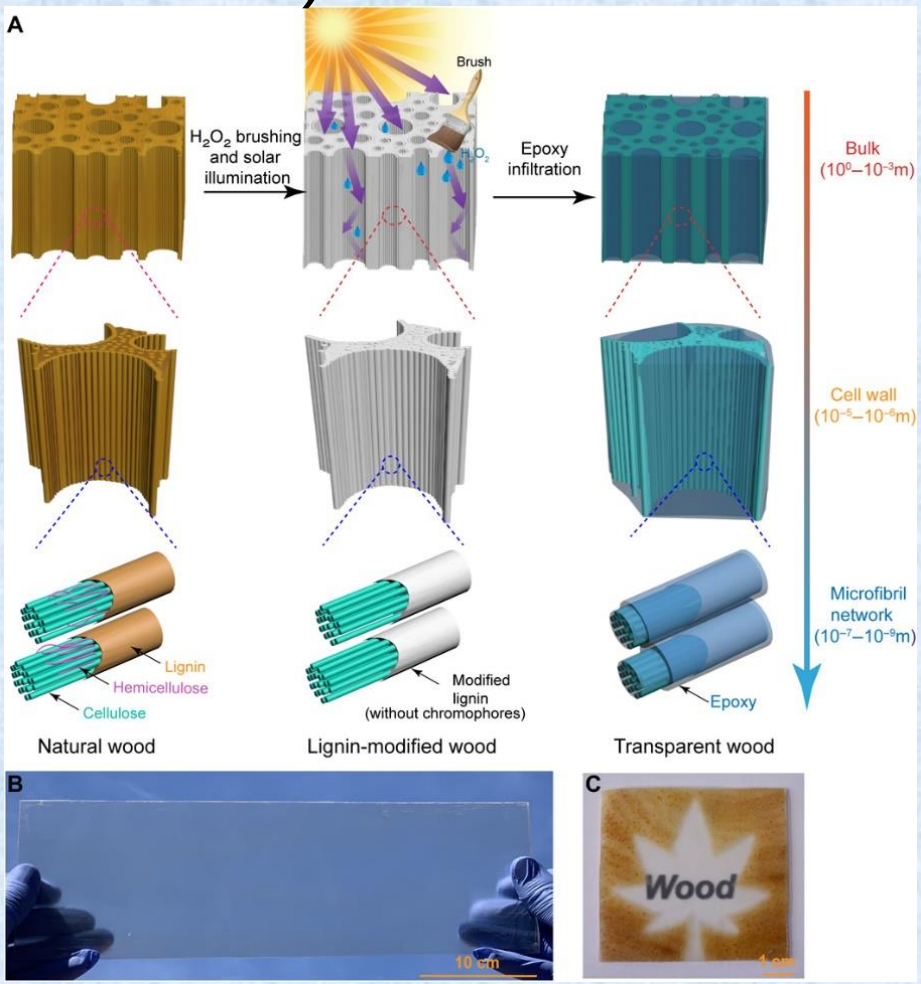
- Student-Designed Project – what's *YOUR* idea? (within reason, of course!)

**See details on Capstone Projects page; 2023 projects will include these and/or others*
https://www.usna.edu/ChemDept/_files/documents/capstone/SC476%20CAPSTONE%20PROJECTS%20s17.pdf

How does it work?

Idea: Study of Transparent Wood (Xia, et al, Sci. Adv. 2021; 7:eabd7342)

1. Reproduce outcome
2. Plan a scientific study, e.g.
    1. Test different woods
    2. Test different wavelengths
    3. Test strength
    4. ???

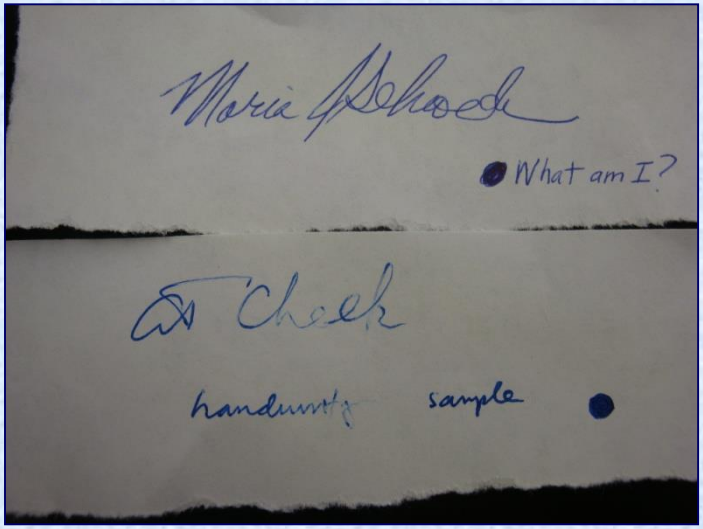


Some Previous Capstone Projects

Classification and Identification of Blue and Black Ink Found in Common Pens

Candice Luby and Dane Thorleifson (’09)

Field trip to FBI-DC



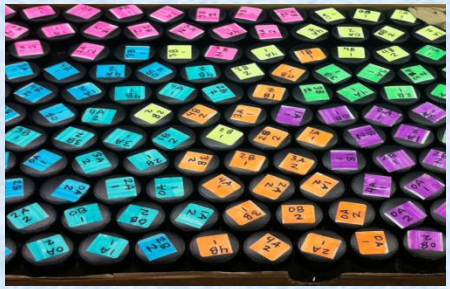
“unknown inks”

Can inks be characterized by their chemical components? What is the best experimental method to do this?

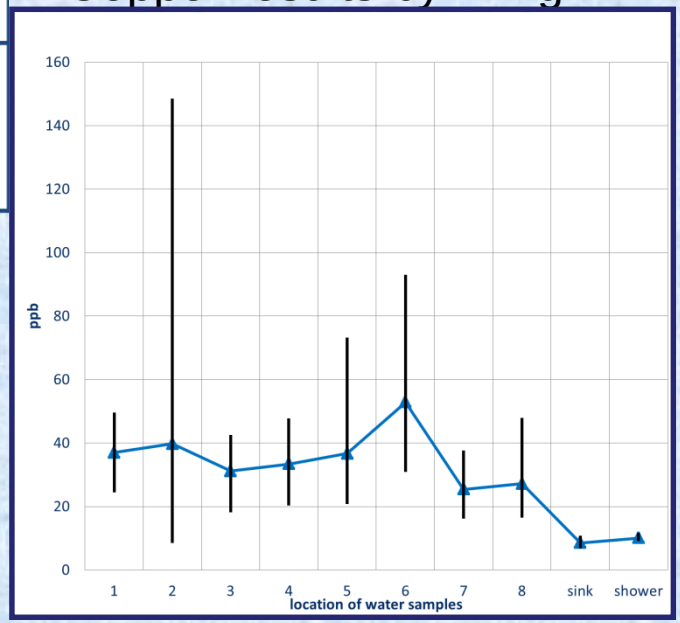
Determination of Trace Metals in Bancroft Hall Drinking Fountain Water

Britney Conkel and Nicole Glab (’12)

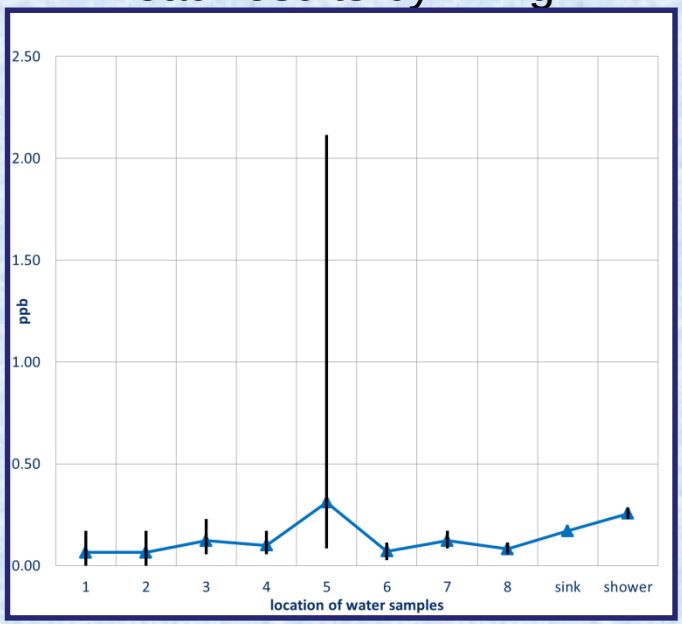
Contaminant	Copper (Cu)	Lead (Pb)
MCL (ppb)[1]	1300	15
MCLG (ppb)[1]	1300	0
City of Annapolis Detected (ppb)[4]	9	2
NSAA Level Detected (ppb)[2]	50	5
Capstone Results Detected (ppb)	36	0.12
Likely Source	Corrosion of plumbing systems	Corrosion of plumbing, erosion of natural deposits



Copper results by Wing



Lead results by Wing

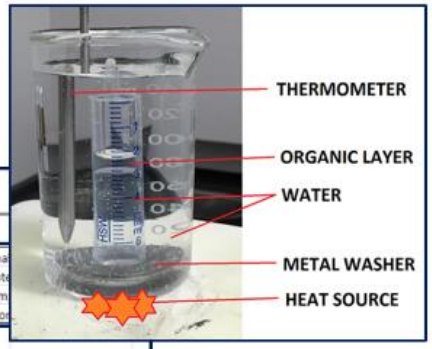


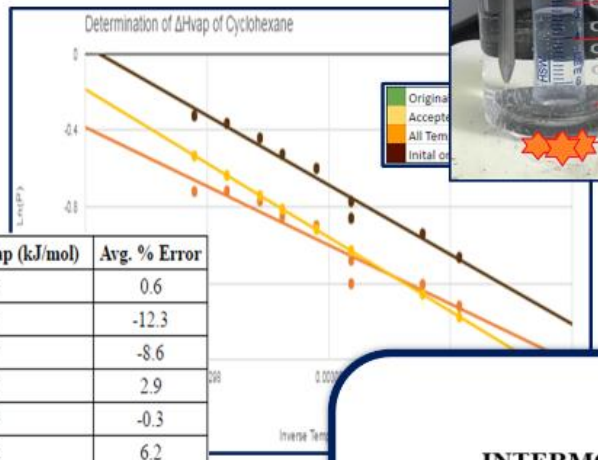
5th Wing water, anyone?

Plebe Lab Development – Vapor Pressure and Heat of Vaporization of Organic Liquids

Jonathan Cabarrus and Michael Brown ('16)

$$\ln P = \left(\frac{-\Delta H_{vap}}{R}\right)\left(\frac{1}{T}\right) + C$$





Experiment 12Z	Average ΔHvap (kJ/mol)	Accepted ΔHvap (kJ/mol)	Avg. % Error
Water	40.4	40.7	0.6
Toluene	40.1	35.7	-12.3
Cyclohexane	35.5	32.7	-8.6
Heptanol	63.3	65.2	2.9
Heptane	36.5	36.4	-0.3
Nonane	41.2	43.9	6.2

SC476 Capstone Research Spring 2016

Experiment 12Z

(Adapted from Expt 12E by MIDN 1/C Cabarrus & 1/C Brown) FV 4-18-16

INTERMOLECULAR FORCES AND THE LIQUID-VAPOR EQUILIBRIUM[1]

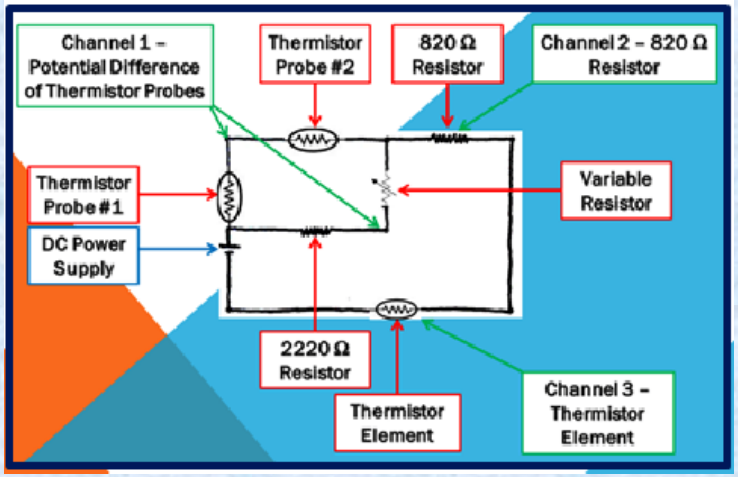
MATERIALS: 150 mL beaker, 6 mL graduated plastic syringe sealed at the tip, digital thermometer, hot plate, plastic bin, 2" metal washers

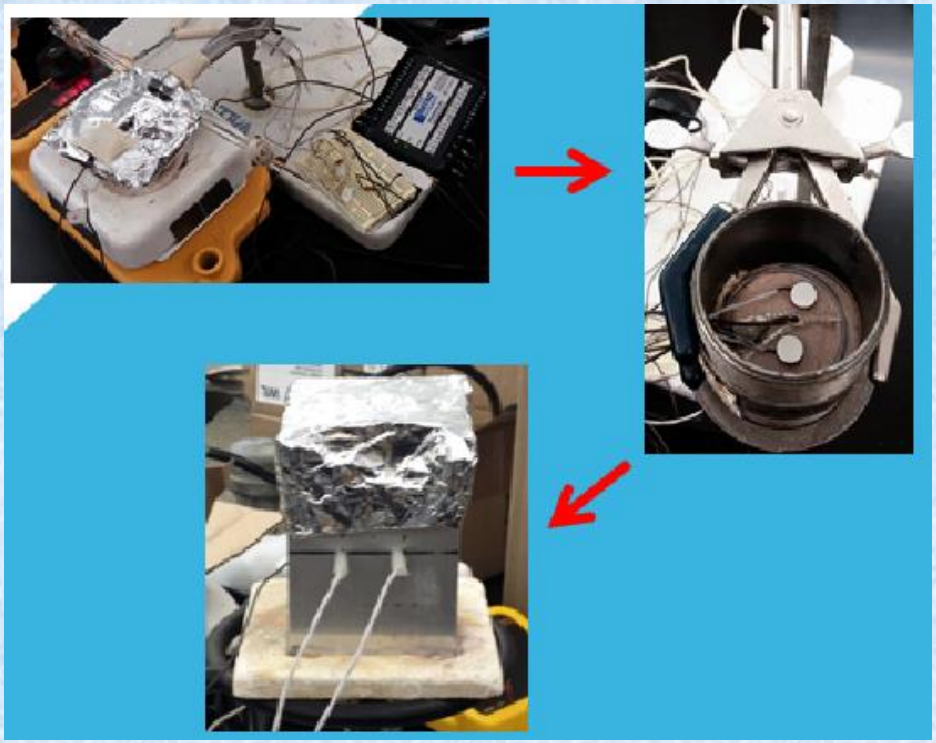
PURPOSE: The purpose of this experiment is to measure the effect of temperature on the vapor pressure of several liquids. The data will be analyzed to extract values for the heat of vaporization, ΔH_{vap}, and interpreted in terms of intermolecular forces.

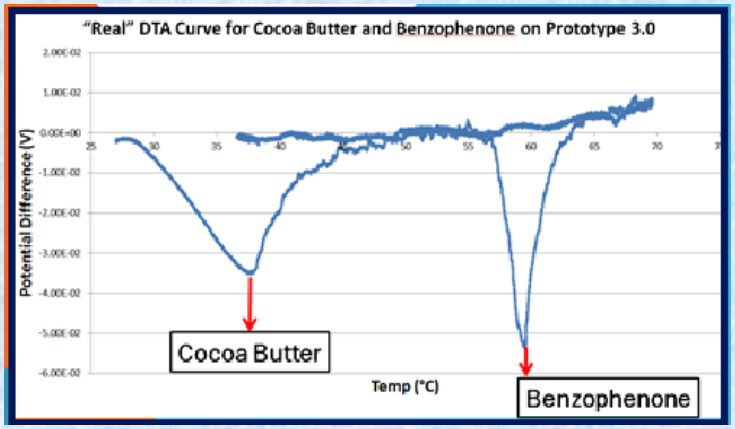
Their "Exp. 12Z" was used in SC111, PUBLISHED in 2019

Construction of a Home-Made Differential Scanning Calorimeter

Michelle Morneault and Georgy Zotkin (’15)







Total cost ~ $200
(vs. ~ $40,000 for commercial DSC)

Plebe Lab Development Project – The Stoichiometry of Ancient Metallurgy

Justin Dion (’14)

$$Cu_2CO_3(OH)_2\,(s) \rightarrow 2\,CuO\,(s) + CO_2\,(g) + H_2O\,(g)$$

$$2\,CuO\,(s) + C(s) \rightarrow 2\,Cu\,(s) + CO_2\,(g)$$

Plebes testing the lab

THE STOICHIOMETRY OF ANCIENT METALLURGY

Adapted by: MIDN 1/C Justin Dion

Materials: Ring stand (2), tripod stand, clay triangle, small porcelain crucible with lid, Bunsen burner (2), malachite chips, granular (“fish bowl”) charcoal, crucible tongs, forceps, striker, weighing boat

Ref: Yee, Gordon T.; Johnson, Chris E. *J. Chem. Educ.* **2004,** *81*, 1777-1779

Purpose: The purposes of this experiment are: (1) To prepare elemental copper through the techniques used by Stone Age men circa 3000 B.C.E; and (2) to trace the stoichiometry of a 2 step reaction through percent yield determinations at each step.

Learning Objectives:

1. Master the proper and most effective use of a Bunsen burner
2. Understand basic stoichiometry and be able to calculate the expected and % yield of each step of a reaction
3. Recognize and appreciate the historical aspects of metallurgy and apply them to a contemporary laboratory environment

Pre-lab: Complete the attached pre-lab questions **before lab.**

Other Previous Capstone Projects

- *Survey of Cold Water Bacteria in the Severn River*

  Natalie Lemek (‘19)

- *Development of Forensic Tools for Smoke Residue and Deposition Analysis*

  Seamus Cobb, Sean Wade (’08)

- *Synthesis and Characterization of Azo Naphthol Dyes*

  Mary Campbell (’18)

- *A 5-Step Synthesis of an Anti-Malarial Drug Candidate*

  James Prieto, Jonathan Woolfolk (‘10)

Other Previous Capstone Projects

- *Chemical and Biological Studies of Fermentation*
  Chad Theriault, Charles King (’09)
- *Characterization of the Electrochemical Exfoliation Method of Graphene Production*
  Jose DeJesus, John Dodd (‘17)
- *Home-Built Fluorimeter*
  Daniel Abney, Rick Murphy (’11)
- *Determination of Anti-Oxidants in Foods via the Briggs-Rauscher Oscillating Reaction*
  Jordan Armstrong, Christopher Hood (’13)

Capstone vs. Research - How to Choose?

Consider the coursework

- What elective courses may be available, and when; how do they match your interests and time available?

Consider the projects

- Do any faculty research projects stir particular interest, or do you like the Capstone projects or have an idea of your own that you want to pursue?

Consider your own personality

- how well do your interests, your goals, and the way you like to approach problems match the different options?

2022-2023 Elective Courses*

Fall 2022 CHEMISTRY / BIOLOGY ELECTIVES

SC412: Environmental Chemistry (3-0-3) – Prof. Luning-Prak

SB453: Neuroscience and Development (3-2-4) – Prof. Rehill

SC485A: Surface Chemistry: Methods and Applications (3-0-3) – CAPT Spencer

SC485C: Organometallics: Bonding, Catalysis and Award-Winning Reactions (3-0-3) –Prof. Farrell

SB/SC485F: Applications of Molecular Biology and Biochemistry (2-2-3) – Prof. Basta

for more details go to
https://www.usna.edu/ChemDept/ChemMajor/ChemBioElectives.php

* availability of any elective course depends on enrollment; not all electives count towards Chemistry major requirements

2022-2023 Elective Courses*

Spring 2023 CHEMISTRY / BIOLOGY ELECTIVES

SC336: Biochemistry II (3-0-3) – Prof. O'Carroll

SC416: Analytical Chemistry in Forensic Investigations (3-0-3) –Prof. Copper

SC486A: Atmospheric Chemistry: Advanced Topics in Physical Chemistry (3-0-3) – Prof. Teichert

SC485C: Polymer Synthesis: From ATRP to Ziegler-Natta (3-0-3) – Prof. Lin

SC486D: Current Topics in Organic Chemistry (3-0-3) – Prof. Whitaker

for more details go to
https://www.usna.edu/ChemDept/ChemMajor/ChemBioElectives.php

* availability of any elective course depends on enrollment; not all electives count towards Chemistry major requirements

Resources to Help you Decide

- Chem website, Majors, Research/Capstone Projects

  http://www.usna.edu/ChemDept/ChemMajor/capstone.php

  → Policies, requirements for both

  → Capstone Projects offered for Class of 2022

  → Recordings of Research Briefs

- Chem website, Majors, Chem Electives for AY

http://www.usna.edu/ChemDept/ChemMajor/ChemBioElectives.php

- Chem website, Faculty Info – Research Interests

  http://www.usna.edu/ChemDept/faculty/index.php

- 1/C chemistry majors, chemistry faculty, your Ac adviser, posters around department

What do I do for Pre-Registration?
(28 Feb-3 Mar)

- If you know you want to do Research, pre-register for SC495.

  (you will need to follow the faculty-midshipman research matching process to obtain a faculty advisor, and write a proposal which is due by Registration)
- If you know you want to do Capstone, select a chemistry elective for fall, or another course if you want 2 electives in the spring.

  (talk to your Academic Adviser to plan your courses)
- If you're unsure, it's ***better to pre-reg for an elective*** now; then if you want to choose research, you can change to that later (before Registration).

Matching Process

- **Listen to all briefs**

- **Schedule meetings with faculty (at <u>least</u> 3) to discuss potential research opportunities. Do this as soon as you identify something of interest to you!**

- **Submit ranked preferences for research/research advisor or capstone by due date (TBA)**

- **Department will match midshipmen with faculty. Any student not matched will have an opportunity to meet with more faculty**

So Why Choose Capstone?

- Only 1 semester, less lab hours (overall), shorter project, smaller time commitment
- The experience is just like research – you plan your experiments, solve your own problems, make your own decisions
- You can pursue your own interests (if you want), not a faculty member's
- You don't need to find a research mentor
- None of the faculty research areas interests you
- More chances to select Chemistry electives (2)
- More collaboration (part of a class/team), less on your own
- Some projects can qualify for Bioscience designation