Off-campus undergraduate summer research opportunities in chemistry, biochemistry, materials science. etc.

- Programs at other universities:
  

- Programs at governmental institutions:
  
  **National Institutes of Health (NIH), Bethesda, MD:**
  [https://www.training.nih.gov/programs/ugsp](https://www.training.nih.gov/programs/ugsp)

  **Internships at National labs:** Los Alamos, Sandia, Pacific Northwest, Argonne, Lawrence Livermore, and many others, !
  ([https://orise.orau.gov/internships-fellowships/undergraduates.html](https://orise.orau.gov/internships-fellowships/undergraduates.html))
Summer Research Opportunities at Bowdoin

- **Chemistry Department (James Stacy Coles/Littlefield/Mayo) Fellowships**
  
  [http://www.bowdoin.edu/chemistry/research/index.shtml](http://www.bowdoin.edu/chemistry/research/index.shtml)
  
  Deadline March 4 2022 at noon.

- **Institutional (Faculty sponsor required)**
  
  [https://www.bowdoin.edu/student-fellowships/summer-fellowships/overview.html](https://www.bowdoin.edu/student-fellowships/summer-fellowships/overview.html)
  
  The phase one online application (Deadline Feb 11) will require you (the student) to provide:
  - contact information for your faculty mentor
  - an uploaded PDF of your unofficial academic history from Polaris
  - a brief paragraph describing your proposed research (This will not be considered during the evaluation process; it is purely for the benefit of your faculty mentor.)

- **Phase 2 Deadline Feb 22**
<table>
<thead>
<tr>
<th>CHEMISTRY:</th>
<th></th>
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<tbody>
<tr>
<td><strong>James Stacy Coles</strong></td>
<td>$480/week for 8 to 10 weeks of full time research; housing subsidy; funding for research supplies.</td>
</tr>
<tr>
<td><strong>Summer Research Fellowships</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Littlefield</strong></td>
<td>$480/week for 8 to 10 weeks of full time research; housing subsidy; funding for research supplies.</td>
</tr>
</tbody>
</table>
Contacts for more information

Chemistry Department

Rick Broene
rbroene@bowdoin.edu
Emily Murphy
emurphy@bowdoin.edu

Institutional Fellowships

Cindy Stocks, Director
cstocks@bowdoin.edu
How to reduce the cost of CO$_2$ capture?

Separate CO$_2$

13% CO$_2$ 77% N$_2$ 6% H$_2$O
How to reduce the cost of CO$_2$ capture?

13% CO$_2$  77% N$_2$  6% H$_2$O

Linker (organic)

Node (metal)

Metal-Organc Frameworks "MOFs"
Metal-organic frameworks

Tailor-make a MOF

Computational design of hypothetical MOFs

Real MOFs → Building Blocks → Hypothetical MOFs

137,000 Hypothetical MOFs

- 5 Nodes
- 42 Linkers
- 13 Functional Groups

We are a computational chemistry lab!

High performance computing at Bowdoin College
Moving charges to harness solar energy

How do we convert light into the controlled movement of charges?

- Electron
- Proton

\[
\begin{align*}
\text{CO}_2 & \quad \text{H}_2\text{O} \\
\text{C}_6\text{H}_{12}\text{O}_6 & + \text{O}_2
\end{align*}
\]

Image from Wikipedia
**Photoacids:** excited state proton transfer (ESPT)

2-naphthol (2OH)

\[ pK_a = 9.5 \]

\[ pK_a^* = 2.8 \]

\[ H_3O^+ \]

Tune the photoacidity or the ESPT mechanism using **structure and environment**

- solvents from liquid to ionic liquids
- supramolecular/proteins
- polymers
- nanoparticles
The Takematsu group: We are a photochemistry family

Group members:
Isaac Bediako (2024)
Rachel Nealon (2023)
Alex Kreines (2022)
Oliver Nix (2022)

Alumni:
Alec Goffin (2021)
Gabby Vandendries (2021)
Eva Verzani (2021)
Sean Xie (2021)
Paige Brown (2019)
Kacie Nelson (2019)
Laura Cotter (2018)
Malcolm Groves (2017)
Alexander Poblete (2017)
Holly Rudel (2017)
Jonathan Welch (2017)
Brandon Tate
b.tate@bowdoin.edu

Chemical Sustainability
Renewable Fuel
Organometallic Catalysis
The hydrogen fuel cycle

H₂O → H₂ + 1/2 O₂

sustainable electrolysis

energy released

H₂ → H₂O + 1/2 O₂
Gas-to-liquid fuel cycle

Bimetallic catalysts

Ar = 2,6-diisopropylphenyl

Bimetallic catalysts

Chemical tools to discover and target glycans on pathogenic bacteria

Danielle H. Dube
Bowdoin College, Department of Chemistry & Biochemistry
Bacteria are coated with distinctive sugars that are absent from human cells and vary across bacterial strains. => Potential targets for antibiotics and immune-based therapies.
Bacterial glycosylation is difficult to study

Our approach: Use unnatural sugars to probe and perturb glycan biosynthesis

Discover novel bacterial glycans with probes

Inhibit glycans that are unique to pathogens with defective analogs
Metabolic probes and inhibitors open the door to query unknowns

Glycan structure

Glycan function

role in colonization & disease?

Glycan targets

selective perturbation?

altered glycans?
Why Transition Metals?

Variety
- Oxidation states available
- Number of ligands
- Geometry- d orbitals increase possibilities
- Ligand binding

Periodic Properties
- If Co doesn’t work, maybe Rh or Ir will work
Olefin Dimerization

2,1 Insertion

Desired Linear Product

1,2 Insertion

Branched Product

More Steric Hinderance

Less Steric Hinderance
Predict more favorable ratios with smaller cone angle

Cone Angle

Leads to 1,2-insertion
(yields branched products)

Leads to 2,1-insertion
(yields linear $\alpha$-olefins)

Steric interference minimized

Steric interference maximized
Small Cone Angle Ligands

- Backbonding to carbene restricts rotation
- Chelate of N and Cp prevents rotation
- Isonitriles move bulky part farther from Co

N Heterocyclic Carbene

Z = OCH$_3$, H, F, CF$_3$, NO$_2$
Identification techniques
The Gorske Lab: Synthesis of biomimetic molecules for chemical biology and catalysis

Synthesis of protein mimics for investigating the roles of cellular signaling in disease.

common techniques
chemical synthesis – solution and solid phase
NMR spectroscopy and X-ray crystallographic analysis
HPLC purification and mass spectrometry
Protein binding assays

protein-protein interactions
- cellular signaling
- Alzheimer’s disease
- cancer

\[ n \rightarrow \pi^* \text{ interactions} \]
\[ \text{C–H} \cdots \pi \text{ interactions} \]
The Gorske Lab: Synthesis of biomimetic molecules for chemical biology and catalysis

Developing enzyme mimics for trifluoromethylation

Efavirenz

\[
\text{R} = \text{H, Me} \\
\text{Catalysts (B*)} \\
\begin{align*}
\text{Me}_3\text{Si-CF}_3 & \rightarrow \text{Me}_3\text{Si-O-CF}_3 \\
R &= \text{Me}: 70-94\% \text{ ee}
\end{align*}
\]

The Gorske Lab: Synthesis of biomimetic molecules for chemical biology and catalysis
Applications of analytical chemistry to address questions in chemistry and biology
Identification of Signaling Molecules in Crustaceans

**Electrophysiology**

**Genetics/Transcriptomics**

Identify Active Neuropeptides

**Mass Spectrometry**

With Patsy Dickinson (Bowdoin)
Project 1: What mechanisms underlie differences in modulatory capacity for closely related crab species?

- **Pugettia producta**
  - Eats only kelp
  - Not responsive to many neuropeptide modulators

- **Libinia emarginata**
  - Highly diverse diet
  - Responsive to neuropeptide modulators

**Goal:** Use mass spectrometry to compare the identities and concentrations of neuropeptides
Project 2: What are the identities of antimicrobial peptides (AMPs) present in lobster circulatory fluid?

**Goal:** Use mass spectrometry and transcriptomics to identify crustin-family AMPs from the lobster, *H. americanus*

Projects 1 and 2 will use methods to extract and analyze small and large peptides coupled with the predictive power of transcriptomics.
Project 3: What products are produced by photodegradation of pharmaceuticals with and without a photocatalyst?

Assess Kinetics

No catalyst

With catalyst

Goal: To use chromatography and mass spectrometry to monitor kinetics and identify photoproducts.
Key Dates:

College Wide

February 11, 2022 (noon)*   Phase One Deadline
February 22, 2022 (noon)*   Phase Two Deadline

Chemistry
March 4, 2022 (noon)*   Chemistry Deadline