Bowdoin College

Department of Chemistry and Biochemistry Majors Handbook

2011 - 2012

Current and prospective student material included

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I. INTRODUCTION

The Chemistry Department hopes that students majoring in Chemistry and Biochemistry will find this handbook useful. Its purpose is to provide a single source of information on the opportunities and resources available and to give the requirements of the major and related activities.

Because there is more to a major than just taking courses, we encourage you to become actively involved in departmental activities and in independent research. Since the Chemistry faculty members have diverse research interests, this handbook lists each faculty member's primary research area as well as recent student research projects and publications.

II. THE MAJOR: GOALS AND REQUIREMENTS

A. Overview

The Chemistry major can serve as preparation for many career paths after college, including the profession of chemistry, graduate studies in other branches of science, medicine, secondary school teaching, and many fields in the business world. The number and type of courses you take to complete and supplement your major should be dictated by your interests and the career path you are considering after Bowdoin. For example, students planning to pursue graduate studies in chemistry would benefit from additional advanced level courses in their area of interest. Students interested in meeting rigorous national standards in chemistry may consider completing the requirements for an American Chemical Society-certified chemistry major.

The department strongly encourages you to engage in independent research during your time at Bowdoin. Opportunities are available during the academic year through intermediate and advanced level independent study and honors, and are also available during the summer. Academic year research at the advanced level can be used to meet requirements for the chemistry major. On all projects, students share with their faculty adviser the responsibility for planning, executing, and reporting their investigations.

The department stresses the importance of independent work and believes that these experiences provide a more realistic exposure to science than that gained from course work alone. These research experiences also provide an excellent opportunity to develop a relationship with a faculty mentor, who will then be able to provide valuable guidance and write informed letters of recommendation for future education and employment.

The department encourages you to round out your chemistry major with relevant courses in other departments, depending on individual needs. These might include electives in other departments that provide opportunities for writing and speaking, or courses concerned with social and environmental issues. Students interested in providing a particular interdisciplinary emphasis to their chemistry major should consider additional courses in biology, biochemistry, computer science, economics, education, geology, mathematics, or physics.

The Biochemistry major is an interdisciplinary program that combines the perspectives of biology and chemistry and gives interested students access to information and research in related fields such as molecular biology and biophysics. This handbook provides information about both chemistry and biochemistry major and honors project requirements. It also summarizes information about the research interests of chemistry department faculty, who can supervise independent study and honors research projects to meet requirements for the biochemistry major. Many research opportunities are also available in biology, and interested students should consult the biology and biochemistry web pages for more information about research projects outside of chemistry.

B. Your Major Advisor

After you declare your major you should select an advisor within the Chemistry (or Biochemistry) program. Although your advisor may change as you move through the program (and develop close ties with a particular faculty member through courses and research interests) you should always have one faculty member identified as your primary advisor. Your advisor will help you define your academic program and will also be a good source of information about academic year and summer research opportunities. Your advisor will also be a valuable resource as you make decisions about your future after Bowdoin.

C. Major Requirements

The following is a summary of courses required to complete the chemistry, biochemistry and interdisciplinary majors. The Chemistry Department supports interdisciplinary majors in biochemistry, chemical physics, as well as a coordinate major with environmental studies. The requirements for these interdisciplinary major programs are also listed below. Students interested in a coordinate major with environmental studies should consult the College Catalogue regarding ES requirements.

Chemistry Major Requirements:

The required courses are C**hemistry 102 or 109, 210, 225, 240, 251, 252, and 205 or 226;** and any two upper level electives including **Chemistry 232**, any Chemistry course at the **300** level, and one semester of **400**-level independent study in Chemistry. In addition to these chemistry courses, chemistry majors also are required to take **Physics 103 and 104** and **Mathematics 161 and 171**.

Becoming certified as an American Chemical Society major requires taking specific advanced level electives in chemistry **(Chemistry 232, 310 and 340),** two semesters of laboratory-based independent study and **Mathematics 181.** Students interested in this certification program should consult with the department.

Because new courses may be added to the curriculum, students should consult with the Biochemistry Committee concerning possible electives not listed here. Moreover, you may have tested out of some of the core courses and therefore do not need to take them. If you are not sure, consult with a member of the Biochemistry Committee.

Requirements for the Major in Biochemistry

All majors must complete the following courses: **Biology 102 or 109, 224, Chemistry 102 or 109, 225, 226, 232, 251; Mathematics 161, 171; Physics 103, 104.** Students should complete the required biochemistry core courses by the end of their junior year so that they may take upper-level courses and participate in research in the senior year. Majors must also complete two courses from the following: **Biology 210** (same as **Environmental Studies 210**), **212**, **214**, **217**, **218**, **253**, **257**, **266**, **304**, **306**, **307**, **314**, **317**, **333**, **401–404**; **Chemistry 210**, **240**, **252**, **305** (same as **Environmental Studies 305**), **306** (same as **Environmental Studies 306**), **325**, **326**, **331**, **401–404**; **Physics 223**, **401–404**. Students may include as an elective one 400-level course. Students taking independent study courses for honors in the biochemistry major should register for **Biochemistry 401–404**.

Bowdoin College does not offer a minor in biochemistry.

Because new courses may be added to the curriculum, students should consult with the Biochemistry Committee concerning possible electives not listed here. Moreover, you may have tested out of some of the core courses and therefore do not need to take them. If you are not sure, consult with a member of the Biochemistry Committee.

Chemical Physics Requirements:

1. **Chemistry 102** or **109**, **251**; **Mathematics 161**, **171**, and **181**; **Physics 103**, **104**, **223**, and **229**.

2. Either **Chemistry 252** or **Physics 310**.

3. Two courses from **Chemistry 310**, **340**, or approved topics in **401** or **402**; **Physics 251**, **300**, **320**, **357** (same as **Earth and Oceanographic Science 357** and **Environmental Studies 357**), or approved topics in **401**, **402**, **451**, or **452**. At least one of these must at the 300 level or above. Other possible electives may be feasible; interested students should check with the departments.

D. Grade Policy

Students are expected to maintain a minimum level of academic performance in the courses offered for the Chemistry and Biochemistry majors.

D Policy: Only one D is allowed in courses required for the major. This D must be offset by a grade of B or higher in another course also required for the major.

Cr/D/F Policy: Generally, courses for the major must be taken on a graded basis. Under special circumstances, however, a student may petition the Department Chair to take one required chemistry course and/or one other course required for the major (Math 161, Math 171, Physics 103, or Physics 104) on a non-graded, Cr/D/F basis.

E. Departmental Seminars

There are a number of events and activities that take place during the academic year to enhance the Chemistry and Biochemistry major experience. They range from formal seminars and majors meetings to informal social gatherings, for example bowling and cookouts. They normally take place on Friday afternoons from 2:30-4:00 PM in Druckenmiller 20, and all majors are expected to attend seminars and other activities. The faculty views the seminars as a particularly valuable part of the academic program and assumes that students with a serious commitment to a broad education in chemistry would want to attend all seminars regardless of areas of focus. Students should check their email, the chemistry website and the bulletin boards in the Cleaveland/Druckenmiller Hall for the weekly listing of seminars and special events.

III. THE CHEMISTRY/BIOCHEMISTRY FACULTY

Richard D. Broene, (On Leave 2011/12) Professor of Chemistry (B.S., Hope, Ph.D. University of California, Los Angeles). Organic Chemistry, organometallic-mediated organic synthesis, catalyst design, and new synthetic methodologies.

Ronald L. Christensen, (On Leave 2011) James Stacy Coles Professor of Natural Sciences (A.B., Oberlin, A.M., Ph.D. Harvard). Physical Chemistry, photobiology, organic photochemistry and low temperature, electronic spectroscopy.

Michael P. Danahy, Visiting Assistant Professor (B.A. Bates College, Ph.D. Princeton University) Inorganic Chemistry

Danielle H. Dube (on leave 2011), Assistant Professor, (B.A. Cornell University, Ph.D. University of California, Berkeley) Biochemistry and organic chemistry. Chemical tools to target, alter and understand glycosylation.

Benjamin C. Gorske, Assistant Professor (B.A. Lawrence University, Ph.D. University of Wisconsin, Madison) Organic and Bioorganic Chemistry, foldamers, organocatalysis, and cell signaling

Yi Jin Kim Gorske, Visiting Assistant Professor (B.A. University of California, Berkeley, PhD. University of Wisconsin, Madison) Organic Chemistry.

Jeffrey K. Nagle, Charles Weston Pickard Professor of Chemistry (B.A., Earlham, Ph.D. University of North Carolina). Inorganic Chemistry, inorganic photochemistry, metal-metal bonding, and electron transfer.

Elizabeth A. Stemmler, Professor of Chemistry (B.S., Bates, Ph.D., Indiana). Analytical Chemistry, negative ion mass spectrometry, ion-molecule reactions, and analytical applications of MALDI-FTMS.

Daniel M. Steffenson, Visiting Professor of Chemistry (A.B., Cornell College, Ph.D. Harvard University) Physical Chemistry

Dharni Vasudevan, Associate Professor (B.S. Massachusetts Institute of Technology, MSE Johns Hopkins, Ph.D. Johns Hopkins). Environmental Chemistry, surface complexation theory, sorption, desorption and coordination of organic and inorganic compounds at the soil/mineral-water interface.

NOTE: Biology faculty who participate in the Biochemistry Program include:

- Bruce D. Kohorn
- Barry A. Logan
- Anne E. McBride

Other faculty in Biology can supervise honors and independent study projects in support of the Biochemistry major.

IV. ACADEMIC YEAR AND SUMMER RESEARCH

A. Overview

Students are strongly encouraged to pursue research during the academic year and summer. These experiences provide unique opportunities for students to venture outside the standard curriculum and demonstrate abilities that are not always apparent in more structured laboratory settings. Research projects are arranged with the approval and advice of a sponsoring faculty member and are usually closely related to the faculty member's on-going research.

Students seriously considering research should contact members of the faculty with whom they might want to do a project. The faculty profiles section and the projects and papers listed below provide a staring point to get ideas about possible research areas. Through a discussion with a faculty member you will discuss research options, time commitments, and other factors, in order to reach a mutually agreed-upon project.

Students should keep in mind that the number of independent study students a faculty member can take on might be limited by the number of people a lab can comfortably accommodate as well as the number of projects a faculty member can effectively oversee. It is best to talk to that faculty member as early as possible about project options.

The academic year is not the only time a student may pursue research within the chemistry department. Depending on the project and the amount of time a student wants to devote to that particular project, the summer also provides an excellent opportunity to explore scientific research with a faculty member. Juniors often start their research project in the summer before their senior year and continue that research throughout the academic year, culminating in an honors project. Seniors have also been able to continue their research through the summer after graduating. **Information about fellowships and summer research funding can be found in section IV E.**

B. Chemistry and Biochemistry Honors and Independent Study Projects Supervised by Chemistry Faculty (2011-2012)

Arey, Teresa '11
Advisor: Dharni Vasudevan
The Effect of the Cation-□ Interaction on the Sorption of Cationic Amines to Montmorillonite

Cardamone, Andrew '11
Advisor: Dharni Vasudevan
Phosphate Source-Sink Dynamics in Androscoggin River Sediments

Champasa,Paggard '11
Advisor: Danielle Dube
Discovering *Helicobacter Pylori's* glycoproteins using metabolic oligosaccharide engineering

Leone, Ginger '11
Advisor: Jeff Nagle
Synthesis of Cobalt Oxide Nanoparticles in Methane-Oxygen Co-Flow Flames

Peacock-Villada, Alexandra '11
Advisor: Ron Christensen
Electronic Spectroscopy of Allowed and Forbidden Transitions in Long Polyenes

Song, Jung Gun '11
Advisor: Beth Stemmler
Quantitative Determination of Crustacean Neuropeptites in Response to Physiological Stress

Turner, Kufe '11
Advisor: Ben Gorske
Controlling *cis/trans* Isomerism in Thiopeptoids using the Thione Aromatic $n \rightarrow \pi^*$ Interaction

Wang, Bo '11
Advisor: Danielle Dube
Synthesis of Azidosugar Substrate to Selectively Label *Helicobacter Pylori's* Pseudaminic Acid

Zhang, Tina '11
Advisor: Dharni Vasudevan
Effect of Soil Properties on Cationic Amine Sorption

C. Summer Research Projects with Chemistry Faculty

The Department of Chemistry has fellowships available for summer 2010 research in the areas of Chemistry and Biochemistry. The fellowships in honor of Spike Coles, 9th President of Bowdoin College, President of Research Corporation, and Physical Chemist, are funded by a generous grant from the Research Corporation. This program intends to provide an exceptional hands-on research opportunity for Bowdoin College students.

The following is a list of students who completed research the summer of 2011.

Arey, Teresa '11- The Effect of the Cation –π Interaction on the Sorption of Cationic Amines to Montmorillonite

Bowden, Zara '13- Investigation of Binding Interactions within and Among Polythiomaides

Cardamone, Andrew '11- Synthesis and Characterization of Closthioamide Derivatives

Champasa, Kanoswan '11- Discovering Helicobacter Pylori's Glycoproteins using Metobolic Oligosaccharide Engineering

Childs, Adam '14- New Solid Phase Methods for Polythiamide Construction

Chin. Daniel '12- Chemoenzymatic Synthesis of an Azidosugar that will enable targeting of Helicobacter Pylori with Therapeutics

Clifford, Kaitlin '12- The Synthesis of Sterically Hindered Metallocene Catalyst

Comen, Craig '12- Synthesis of a Cobalt Water Oxidation Catalyst Using Flame Chemistry

Connon, Chelsea '12- ADF Computational Chemistry Project: Computational Studies of the Photochemical Properties of Some Group (Ruthenium and Osmium) Compounds

Corso, Arnie '12- Metal Contaminant Source-Sink Dynamics in Androscoggin River Sediments

Cui, Zhenghao '12 – Synthesis of 4-Phenyl-Phosphorin Ligand of Cobalt Catalysis

Del Toro, Juan '13- The Chemical Analysis of Hemolymph from the Lobster *Homarus Americanus* as a Function of Molt Cycle Stage

Dupont, Allison '12- Impacts of Land Management Practices on Soil Nitrogen Dynamics in Maine Agricultural Soils

Esonu, Onyi '12- Examination of Putative Helicobacter Pylori Glycoproteins

Heyde, Keith '11- Modeling Population Dynamics in Linked Carbon Sequestration and Hydrogen Production Systems

Kaewsapsak, Pornchai '12-Synthesis of Phosphine Warheads to Eradicate Pathogenic
Ko, Imelda '14 – Investigating the Unique Bioactive Properties of Closthioamide

Kinnear, Heather '12- Effects of Temperature on Intermolecular Interactions Involved in Aniline Sorption to Montmorillonite

Longwell, Scott '12 –Helicobacter Pylori's Glycoproteins

Polasky, Dan '12- Elucidation of a Putative Enzyme Catalyzed C-Terminal Methylation Reaction

Rawden, Katherine '12- Synthesizing a Cobalt Catalyst to Dimerize Linear □ -Olefins Using Isocyanides as ligands to Encourage Yields of Linear Product

Rone, Hassan '13- The Purification and Mass Spectral Characterization of Synthetic Polyenes

Ryss, Jonathan '12- Development of a Peptoid Catalyst for Enantioselective Trifluoromethylation of Ketones.

Steward, Sam '12 – Purification and Optical Spectroscopy of Polyene Antibiotics

Vozniak, Taylor '12- Synthesis of a Cobalt Catalyst for Linear □ -Olefin dimerization

Zhang, Ivan '11- Synthesis and Characterization of Closthioamide Derivatives

D. Recent Departmental Publications

(* indicates Bowdoin undergraduate co-author)

Professor Broene

R. D. Broene "Review of: Petr Stepnicka, *Ferrocenes: ligands, materials and biomolecules*, in *Appl. Organomet. Chem.,* **2009**, *23*, 334.

L. A. Colip, A. T. Koppisch, **R. D. Broene**, J. A. Berger, S. M. Baldwin, M. N. Harris, L. J. Peterson, B. P. Warner, E. R. Birnbaum "A rapid method for quantifying heavy atom derivatives for multiple isomorphous replacement in protein crystallography", *J Appl. Cryst,* **2009**, *42*, 329-332.

R. L. Christensen, M. G. I. Galianato, E. F. Chu, J. N. Howard, **R. D. Broene**, H. A. Frank "Energies of Low-Lying Excited States of Linear Polyenes" *J. Phys. Chem. A* **2008**, *112*, 12629-12636.

R. D. Broene "Reductive Coupling of Unactivated Alkenes and Alkynes" in *Metal Catalyzed Reductive C-C Bond Formation* "Topics in Current Chemistry" vol . 279, Michael Krische Editor, Springer Verlag, Heidelberg, 209 (2007)

R. D Broene, M Brookhart, W. M. Lamanna, A. F. Volpe, Jr. "Cobalt Catalyzed Dimerization of a-Olefins to give Linear a-Olefin Products" *J. Am. Chem. Soc.* **2005**, *127*, 17194.

R. L. Christensen, E. A. Barney*, **R. D. Broene**, M. G. I. Galinato, and H. A. Frank, "Linear Polyenes: Models for the Spectroscopy and Photophysics of Carotenoids," Archives of Biochemistry and Biophysics **2004**, *430*, 30-36.

Professor Christensen

"Ultrafast Excited State Relaxation in Long-chain Polyenes," M. R. Antognazza, L. Lüer, D. Polli, R. L. Christensen, R. R. Schrock, G. Lanzani, and G. Cerullo, *Chemical Physics* **373**, 115-121 (2010).

"Synthesis and Optical Spectroscopy of Oligo (1,6-Heptadiynes) with a Single Basic Structure Prepared Through Adamantylimido-based Molybdenum Wittig and Metathesis Chemistry," C. Scriban, B. S. Amagai, E. A. Stemmler, R. L. Christensen, and R. R. Schrock, Journal of the American Chemical Society, 131, 13441-13452 (2009).

"Excited Electronic States and the Photochemistry and Photophysics of Carotenoids," H.A. Frank and R.L. Christensen in *Carotenoids, Vol. 4: Natural Functions,* G. Britton, S. Liaaen-Jensen, and H. Pfander (eds.), Springer, pp.167-188 (2008).

"Energies of Low-Lying Excited States of Linear Polyenes," Ronald L. Christensen, Mary Grace I. Galinato, Emily F. Chu, Jason N. Howard, Richard D. Broene, and Harry A. Frank, J. Phys. Chem. A 2008, **112**, 12629-12636 (2008).

"Symmetry Control of Radiative Decay in Linear Polyenes: Low Barriers for Isomerization in the S_1 State of Hexadecaheptaene," Ronald L. Christensen, Mary Grace I. Galinato, Emily F. Chu, Ritsuko Fujii, Hideki Hashimoto, and Harry A. Frank, J. Am. Chem. Soc., **129** (6), 1769 -1775 (2007).

"Synthesis of Oligoenes that Contain up to 15 Double Bonds from 1,6-Heptadiynes," Constantin Czekelius, Jillian Hafer, Zachary J. Tonzetich, Richard R. Schrock, Ronald L. Christensen, and Peter Müller, J. Am. Chem. Soc., **128** (51), 16664 -16675 (2006).

"Femtosecond Time-Resolved Absorption Spectroscopy of Astaxanthin in Solution and in □ -Crustacyanin," R.P. Ilagan, R.L. Christensen, T.W. Clapp, G.N. Gibson, T. Pascher, T. Polivka, and H.A. Frank, **109**, 3120-3127 (2005).

Professor Dube

M. B. Koenigs*, E. A. Richardon* and **D. H. Dube**, "Metabolic profiling of *Helicobacter pylori* glycosylation", *Mol. BioSyst.*, **2009**, DOI: 10.1039/b902178g.

D. H. Dube, E. J. Greenblatt and J. J. Kohler, "Development of a two-hybrid assay capable of analyzing glycosylated proteins", *In prep.*

D. H. Dube, C. L. De Graffenried and J. J. Kohler, "Regulating cell surface glycosylation with a small-molecule switch", *Meth. Enzymol.*, **2006**, *415*, 213-229.

D. H. Dube†, J. A. Prescher†, C. N. Quang* and C. R. Bertozzi, "Probing mucin-type O-linked glycosylation in living animals", *Proc. Nat'l Acad. Sci. USA*, **2006**, *103*, 4819-4824. [†These authors contributed equally to this work.]

D. H. Dube and C. R. Bertozzi, "Glycans in cancer and inflammation: potential for therapeutics and diagnostics", *Nat. Rev. Drug Disc.*, **2005**, *4*, 477-488.

J. A. Prescher†, **D. H. Dube**†, and C. R. Bertozzi, "Chemical remodeling of cell surfaces in living animals" *Nature*, **2004**, *430*, 873-877. [†These authors contributed equally to this work.]

Professor Gorske

"New Strategies for the Design of Folded Peptoids Revealed by a Survey of Noncovalent Interactions in Model Systems." **Gorske, B. C.**; Stringer, J. R.; Bastian, B. L.; Fowler, S. A.; Blackwell, H. E. *J. Am. Chem. Soc.* **2009**, in press.

"Regio- and Stereoselective Synthesis of Fluoroalkenes by Directed Au(I) Catalysis." **Gorske, B. C.**; Mbofana, C. T.; Miller, S. J. *Org. Lett.* **2009**, *11*, 4318-4321.

"Local and Tunable n→π* Interactions Regulate Amide Isomerism in the Peptoid Backbone." **Gorske, B. C.**; Bastian, B. L.; Geske, G. D.; Blackwell, H. E. *J. Am. Chem. Soc.* **2007**, *129*, 8928-8929.

"Tuning Peptoid Secondary Structure with Pentafluoroaromatic Functionality: A New Design Paradigm for the Construction of Discretely Folded Peptoid Structures." **Gorske, B. C.**; Blackwell, H. E. *J. Am. Chem. Soc.* **2006**, *128*, 14378-14387.

"Interception of Quorum Sensing in *Staphylococcus aureus*: A New Niche for Peptidomimetics." **Gorske, B. C.**; Blackwell, H. E. *Org. Biomol. Chem.* **2006**, *4*, 1441-1445.

"*N*-[1-(Pentafluorophenyl)ethyl]acetamide." Guzei, I. A.; **Gorske, B. C.**; Blackwell, H. E. *Acta Crystallogr., Sect. C: Cryst. Struct. Commun.* **2006**, *62*, o286-o288.

"Expedient Synthesis and Design Strategies for New Peptoid Construction." **Gorske, B. C.**; Jewell, S. A.; Guerard, E. J.; Blackwell, H. E. *Org. Lett.* **2005**, *7*, 1521-1524.

Professor Nagle

Roberts, M. N.; Carling, C.-J.; Nagle, J. K.; Branda, N. R.; Wolf, M. O. "Successful Bifunctional Photoswitching and Electronic Communication of Two Platinum(II) Acetylide Bridged Dithienylethenes", *J. Am. Chem. Soc.* **2009**, *131*, 16644-16645.

Roberts, N. M., Nagle, J. K., Finden, J. G., Branda, N. R., Wolf, M. O., "Linker-Dependent Metal-Sensitized Photoswitching of Dithienylethenes", *Inorg. Chem.*, **2009**, 48, 19-21.

Bickelhaupt F. M.; **Nagle, J. K**.; *Klemm, W. L. "The Role of *s-p* Orbital Mixing in the Bonding and Properties of Second-Period Diatomic Molecules", *J. Phys. Chem. A*, **2008**, *112, 2437-2446*..

Maliarik, M.; **Nagle, J. K**.; Ilyukhin, A.; Murashova, E.; Mink, J.; Skripkin, M.; Glaser, J.; Kovacs, M.; Horváth "Metal-Metal Bonding in Tetracyanometallates (M = Pt^{II}, Pd^{II}, Ni^{II}) of Monovalent Thallium. Crystallographic and Spectroscopic Characterization of the New Compounds $Tl_2Ni(CN)_4$ and $Tl_2Pd(CN)_4$", *Inorg. Chem*., **2007**, *46*, 4642-4653.

Professor Stemmler

C. Scriban, B.S. Amagai*, **E. A. Stemmler**, R. L. Christensen, "Synthesis and Optical Spectroscopy of Oligo(1,6-Heptadiynes) with a Single Structures and Terminal Methylene Groups Prepared Using Adamantylimido-based: Molybdenum Wittig and Metathesis Chemistry" *Journal of the American Chemical Society*, in press.

E. A. Stemmler, E. A. Bruns*, C. R. Cashman*, P. S. Dickinson, and A. E. Christie, "Molecular and mass spectral identification of the broadly conserved decapod crustacean neuropeptide pQIRYHQCYFNPISCF: The first PISCF-allatostatin (Manduca sexta- or C-type allatostatin) from a non-insect" *General and Comparative Endocrinology*, in press.

P. S. Dickinson, T. Wiwatpanit*, E. R. Gabranski*, R. J. Ackerman*, J. S. Stevens*, C. R. Cashman*, **E. A. Stemmler** and A. E. Christie, "Identification of SYWKQCAFNAVSCFamide: a broadly conserved crustacean C-type allatostatin-like peptide with both neuromodulatory and cardioactive properties", *Journal of Experimental Biology*, **212**, 1140-1152 (2009).

J. Lichter, S. Billings, A. C. Finzi, D. Gaindh*, R. B. Jackson, R. Ryals, **E. A. Stemmler**, S. Ziegler, W. H. Schlesinger, "Forest soil carbon dynamics under elevated CO_2: Soil carbon sequestration in a pine forest after nine years of atmospheric CO_2 enrichment", *Global Change Biology*, **14**, 2910-2922 (2008).

P. S. Dickinson, **E. A. Stemmler**, E. E. Barton*, C. R. Cashman*, N. P. Gardner*, S. Rus*, H. R. Brennan*, T. S. McClintock, A. E. Christie "Molecular, mass spectral, and physiological analyses of orcokinins and orcokinin precursor-related peptides in the American Lobster *Homarus americanus* and red swamp crayfish *Procambarus clarkii*", *Peptides*, **30**, 297-317 (2009).

A. E. Christie, C. R. Cashman, C. M. Smith, K. M. Beale, **E. A. Stemmler**, D. W. Towle, P. S. Dickinson, "Identification and characterization of a *Homarus americanus* tachykinin-related peptide (TRP)-encoding cDNA: genetic confirmation of the TRPs APSGFLGMRamide and TPSGFLGMRamide in the American Lobster", *Peptides*, **29**, 1909-1918 (2008).

P. S. Dickinson, **E.A. Stemmler**, A. Christie, "The pyloric neural circuit of the herbivorous crab *Pugettia producta* shows limited sensitivity to many neuromodulators that elicit robust effects from this system in more opportunistically feeding decapods", *Journal of Experimental Biology*, **211**, 1434-1447 (2008).

Professor Vasudevan

D. Vasudevan, G.L. Bruland, B.S. Torrance*, V.G. Upchurch*, A.A. MacKay. **2009**. pH-dependant Ciprofloxacin Sorption to Soils: Interaction mechanisms and soil factors influencing sorption. *Geoderma*, 151, 68-76.

Cooper, E.M. and **D. Vasudevan**. **2009**. Hydroxynapthoic acid isomer sorption to goethite. *Journal of Coloid and Interface Science,* 333, 85-96.

Carrasquillo, A.J., G. L. Bruland, A. A. MacKay and Dharni Vasudevan. **D. Vasudevan**. **2008.** Sorption of ciprofloxacin and oxytetracycline zwitterions to soils and soil minerals: Influence of compound structure. *Environmental Science and Technology* (accepted, in press).

Fimmen, R.L., D.D. Richter Jr., **D. Vasudevan**, M.A. Williams, L.T. West. **2008**. Rhizogenic Fe-C redox cycling in deep upland soils: A hypothetical biogeochemical mechanism that drives crustal weathering. *Biogeochemistry* (2008) 87:127–141

Fimmen, R.L., T.D. Trouts, D.D. Richter, **D. Vasudevan**. **2008.** Improved speciation of dissolved organic nitrogen in natural waters: amide hydrolysis with fluorescence derivatization. *Journal of Environmental Sciences* (in press, for publication in Volume 20)

Trivedi, P. and **D. Vasudevan**. **2007.** Spectroscopic Investigation of Ciprofloxacin Speciation at the Goethite-Water Interface. *Environmental Science and Technology,* **41**, 3153-3158.

Jones, A.D., G. L. Bruland, S.G. Agrawal, **D. Vasudevan**. **2005.** Factors influencing oxytetracycline sorption to soils. *Environmental Toxicology and Chemistry***, 24,** 761–770.

E. Research Fellowships

To aid students in their summer and academic year research, a number of options are available. The chemistry department offers Coles Research Fellowships in Chemistry and Biochemistry, individual faculty have research grants, and there are college-wide fellowships (including Surdna, Langbein, Doherty). Application deadlines for these programs are generally the last week of March, but be sure to check with a faculty member in advance for the exact date, stipend amount, as well as the availability of other new fellowships. The Coles and Surdna Fellowships are described below.

James Stacy Coles Research Fellowships in Chemistry and Biochemistry: The Coles Research Fellowships are administered by the Chemistry Department. There are five to eight Coles fellowships available each summer to support research in the areas of Chemistry and Biochemistry. The fellowships honor Spike Coles, the 9th President of Bowdoin College, President of Research Corporation, and a Physical Chemist, and are funded by a generous endowment from the Research Corporation. These fellowships provide an exceptional hands-on research opportunity for Bowdoin College students. Students will work closely with a Bowdoin faculty member on a mutually acceptable research project, full time, for ten weeks in the summer. A list of participating faculty and project descriptions is available in early January. Applications are due in March. Check the Chemistry Department website for more information.

Surdna Foundation Undergraduate Research Fellowship Program: Fellowships are awarded

annually to highly qualified seniors. Each Surdna Fellow participates under the direction of a faculty member(s) in a research project in which the faculty member is independently interested. The purpose of the Program is to engage the student directly in serious research. Each project to which a Surdna Fellow is assigned must therefore justify itself independently of the Program, and the Fellow is expected to be a participant in the research, not a mere observer or helper. Surdna Fellows are chosen each spring for the following summer or academic year. Awards are made on the basis of the candidate's academic record, particular interests and competence, the availability of an appropriate research project, and a faculty member's recommendation. Acceptance of a Surdna Fellowship does not preclude working for Honors and the financial need of a candidate does not enter into the awarding of fellowships. Surdna Fellows are, however, obligated to refrain from employment during the period of their appointment. The stipend is for part-time research during the academic year or full-time research in eight weeks of the summer. Candidates for Surdna grants should be nominated by a member of the faculty. Proposals should include a description of the project written by the faculty, a description of the project written by the student, a title, a course transcript, the department or program in which the work will be done, and whether the request is for the summer or the academic year.

V. HONORS REQUIREMENTS

Honors is a distinction awarded at the end of a year of advanced independent study (Chem 401 and Chem 402) to students whose projects merit this recognition, as determined by the Chemistry Department or Biochemistry Committee. Students who receive this distinction for their work must meet eligibility standards (such as grade requirements), must participate in required honors activities (such as attending and engaging in seminars and workshops), must present their project in the required oral and written formats (as noted below), and must demonstrate, through their independent engagement in the project, their ability to plan and execute experiments, their ownership of the project and relevant literature, and through the quality of their final thesis, that their project has risen to a level worthy of receiving the award of Honors.

A. Requirements for Honors in Chemistry

1. A "B" average in courses submitted for the major with the additional requirement that the Candidate shall have received no more than two grades below a B in these courses. Courses submitted for the major shall include work in other departments that may be required for the Chemistry Major. If you have any questions about qualifying for honors please consult with a member of the Department.
2. Two semesters of Independent Study (Chem 401 and 401) devoted to the study of a single topic.
    a. At the outset of the project, the student should clearly define the goals and objectives of the research with the advisor. This may include a written proposal or detailed literature search containing the requisite background material.
    b. Because independent study is not a highly structured activity, the department expects students to approach it in a conscientious manner with full knowledge of the time commitment needed. The student should establish a schedule with their advisor that recognizes the commitment involved for the scholarly research proposed. This commitment will typically average 12 hours a week, including time spent in the laboratory, library, examining data, and thinking about your project.
3. Regular attendance at Departmental Seminars and participation in the majors program workshops. To a large degree, the education of a chemist goes far beyond course and laboratory work and into the real world of the practicing chemist. The department provides the

opportunity to discover this world through regularly scheduled Friday afternoon seminars presented by chemists in various professions. Typically, the speaker will be available to discuss their job and related opportunities with students at a seminar luncheon or at pre-seminar socials. In addition, the Department has designed Friday workshops on laboratory note book and record keeping, effective oral and poster presentations, critical reading and deconstruction of journal articles, strategies for scientific writing, strategies for effective peer critique, and construction of effective results and discussion sections. These activities are designed integrate your scientific background, develop your ability to explore scientific questions independently, and present scientific information through a complete research experience.

4. Favorable consideration of the project by the Department at a mid-year review. This will be done before the end of the Fall Semester and will contain the following components:

    a. A brief written summary of the project by the Candidate due prior to the oral presentation. This paper should be a concise summary of the project background, goals, and work completed to date. It should include a bibliography and should be between five and ten pages in length.

    b. An oral presentation by the Candidate to the Department and other interested persons toward the end of the first semester. This will be a 20 minute presentation based on the written summary and any preliminary results. Each presentation will be followed by a short discussion of what was presented.

    c. A written response to the Candidate from the Department.

5. Second Presentation. This will be in the form of a poster session normally given during the second semester reading period. The presentation will be a summary of the results of the project based on the results and discussion section of the Honors Thesis. Further details will be provided early in the second semester.

6. Favorable consideration of the Honors Thesis by the Department. Requirements for the preparation of the Thesis are established by the Faculty and may be obtained from the Librarian. In addition, the announced deadlines for the production and approval of the thesis must be met. The research advisor and two other members of the Department will serve as readers of the Honors Thesis.

7. In unusual circumstances, certain students may find themselves unable to meet one or more of these requirements. In such cases, you should meet with your advisor and discuss the possibility of petitioning the Chemistry Department for a modification of the requirements for honors.

B. Guidelines for Chemistry Department Honors Thesis

In addition to instructions published by the Library, a Chemistry Department Honors Thesis should adhere to the following guidelines:

1. Abstract: This is usually one or two paragraphs at the beginning of the thesis summarizing what was done, the results and the conclusions. It sometimes is difficult to summarize a year's work in a brief form, so special care should be taken in writing this important part of your thesis.

2. Introduction: Your thesis should include an introductory chapter giving background material on previous work done on the subject of your project. Other logical sections include an experimental section, results sections, and discussion and conclusions section. Appendices should be used for computer programs and other sorts of detailed information. Sections and subsections of paper should be numbered in some reasonable way (e.g. 1, 1.1, 1.1.2, 1.2, etc. or

Roman Numerals) as a guide to organization. These will be the basis for your Table of Contents.

4. References: Should be numbered consecutively with no ibids's, loc.cit.'s, etc. Consult the American Chemical Society Style Guide for proper form for references. References should be grouped together at the end of the paper. General bibliographies of readings should not be given at the end of paper. Give proper credit by giving a proper reference.
5. Figures: These should be numbered consecutively from the beginning to the end of the paper (don't start numbers over for each chapter) and must include proper figure captions. Figures should not have page numbers and should be designed with margins sufficient for final binding. Neatness is particularly important here.
6. General advice
    a. Plan ahead--leave enough time for figures, copying (if you need special paper, don't wait until the last minute), binding, etc.
    b. Read the official "Honors Papers for Deposit in Library." When in doubt or if you feel that there are contradictions between Chemistry Department Guidelines and Library Guidelines, consult your advisor.
    c. Consult previous honors papers (there is a good selection on Reserve in the Hatch Science Library) for models of organization, form, etc.

When in doubt, ask questions--the final form of your Honors Thesis is the joint responsibility of you and your advisor.

C. Honors in Biochemistry

Students seeking honors in Biochemistry who carry out their research projects under the supervision of a faculty member in Chemistry must meet the honors requirements for Chemistry as described above. The research advisor or one of the readers must be a member of the Biochemistry Committee. Students working on research projects under the supervision of a faculty member in Chemistry should follow the chemistry department guidelines for honors (see Section V A.)

VI. LETTERS OF RECOMMENDATION

The faculty welcomes the opportunity to write letters of recommendation for their students. In order to strengthen the reference and be sure that it is finished in a timely fashion, please follow these guidelines when requesting a recommendation.

1. Do **NOT** leave a request for a recommendation in a faculty member's mailbox a few days before the deadline.
2. Make an appointment to talk with the faculty member writing your recommendation well in advance of the recommendation deadline.
3. Bring the following to the appointment: recommendation form(s) on which you have completed the sections that you, the applicant, should complete (don't forget the waiver section!);
    - a written program description (or job description, if for an employer);
    - addressed and stamped envelopes (if the reference needs to be mailed, rather than picked

up by you).

3. As a courtesy to faculty, try to keep those who have written letters informed of the outcome of your applications.

VII. STUDENT EMPLOYMENT IN THE DEPARTMENT

During the academic year the chemistry department employs students in a number of capacities. Each year the number and types of positions may vary, but in general the positions available include:

1. Lab Assistants - lab sections in many courses have a student assistant to help with the running of the lab.

2. Prep Persons - some introductory and upper level courses employ students to prepare solutions and other materials necessary for the teaching labs.

3. Office Assistant – assist in the Chemistry Department office with photocopying, filing, and other office duties.

VIII. APPLYING TO GRADUATE SCHOOL

Applying to graduate school can seem bewildering. The following is meant to provide some guidance about procedures and strategies for selecting appropriate universities to which to apply. Reading this is a first step in the planning process. You should discuss your graduate school plans and interests with your major advisor during the latter part of your junior year. You should also talk to second semester senior Chemistry and Biochemistry majors who have applied to graduate schools.

Selecting a School

The main factor you should consider in selecting a graduate school, of course, is the quality of the program. But how can you evaluate a particular program? Begin by asking your professors, especially those whose research interests are in an area in which you plan to continue your studies. Examine appropriate journals over the last five years and tally up which universities seem to be the most active in publishing in your field of interest. The ACS Directory of Graduate Research (available in the Chemistry Office) is a very useful resource for learning about different graduate programs.

Once you have narrowed your choice of universities, try to visit them. You will learn at least as much from your student colleagues as from the faculty, so try to judge what sort of interactions you will have with them. Ask about graduate student life and the quality of life in the local town or city. Inquire also about the financial situation, particularly the availability of research stipends, of teaching assistantships and summer funding. In chemistry, at least, every reputable university should provide some sort of financial aid.

Application to Graduate School

Apply to several programs. There are numerous reasons for being rejected from a particular graduate program, many of them out of your control, such as retirement or departure of the most appropriate potential advisor, or the shortage of funds to support graduate students. Increase your odds by sending out more than one application, although don't lower your standards so much that you end up enrolling in a weak program just because you were accepted there.

Graduate schools consider a variety of factors in selecting students. Although undergraduate

grades and breadth of course work are important, a strong showing on the Graduate Record Exam (GRE) can go a long way towards compensating for a modest grade point average. What is most important is evidence of independent research, especially a successful senior project. Your performance on your project will be described in the letter of recommendation from your research advisor.

Your application essay should highlight what you have done outside of the classroom. Although nobody really expects an undergraduate to be able to propose a specific Ph.D. thesis topic, you should define your general interests and demonstrate your familiarity with current problems in the field. A prospective advisor will be most concerned about your interest in, commitment to, and potential in his or her field. The best way to give your letter and application substance, then, is to have done something in the field as an undergraduate. During your junior/senior summer or earlier, try to find an interesting summer research job, even if it doesn't pay as much as "normal" summer jobs. Ask your college professors if they know of summer opportunities at Bowdoin or elsewhere. Read the bulletin board outside the departmental offices for summer job/program announcements. You will discover a wide range of opportunities, stipends, and grants at various institutions across the country.

Letters of recommendation can carry a huge amount of weight. So think carefully about whom you want to write letters on your behalf, get to know them personally, and impress them with your promise. It can be helpful to have one or two of your letters from professional researchers outside of Bowdoin if they know you well. Clearly, your senior research advisor is a key recommender.

During the fall of your senior year, consider applying for a National Science Foundation Predoctoral Fellowship -- don't miss the early November deadline! Such fellowships often rely heavily on undergraduate grades, research experience, and letters of recommendation.