Handbook for Chemistry and Biochemistry Majors

2001-2002

TABLE OF CONTENTS

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 career 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, and geology and chemistry, 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 109, 210, 225, 226, 240, 251, 252, 254**, and any two upper level electives: **Chemistry 262** and courses at the 300 level or above. In addition to these chemistry courses, chemistry majors also are required to take **Physics 103, 104** and **Mathematics 161 and 171**.

Becoming certified as an American Chemical Society major requires taking specific advanced level electives in chemistry **(Chemistry 310 and 340),** along with additional courses in mathematics.

Biochemistry Major Requirements:

All majors must complete the following courses: **Biology 104, Biology (Chemistry) 261, 262, 263**; **Chemistry 109, 225, 226, 251**; **Mathematics 161, 171**; **and Physics 103, 104.** Students should complete the required biochemistry core courses by the end of their junior year. Majors must also complete three (3) elective courses from the following: **Biology 210, 212, 214, 217, 218, 224, 255, 303, 307, 317, 333, 401-404**; **Chemistry 210, 240, 252, 254, 270, 330, 401-404**; **Physics 223, 401-404.** Students may include as electives up to two 400-level courses.

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 Committee on Biochemistry.

Those planning to engage in independent study in biochemistry should complete at least one of the following courses prior to the senior year: **Biology 212, 218, 263**; **Chemistry 210, 240, 254, 263.** Students taking independent study courses for the biochemistry major should register for **Biochemistry 401-404.**

Chemical Physics Requirements:

1. **Chemistry 109, 251**; **Mathematics 161, 171,** and **181 or 223**; **Physics 103, 104, 300.**
2. Either **Chemistry 252** or **Physics 310.**
3. Three courses from **Chemistry 252,254,332,335,340,350, 401, 402**; **Physics 223, 229, 310, 320, 350, 451, 452.** At least two of these must be below the 400 level. Other possible electives may be possible. Interested students should check with the departments.

Geology and Chemistry Requirements:

1. **Chemistry 109** and four courses from the following: **Chemistry 210, 225, 226, 240, 251,** and approved advanced courses.
2. **Geology 101, 102, 202, and 262**.
3. Two courses from the following: **Geology 220, 260, and 275.**
4. **Physics 103** and **Mathematics 161** and **171.**

D. Grade Policy

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

and Biochemistry is as follows:

> Only **one** D is allowed in courses required for the major. This D must be offset by an A or a B in another course also required for the major.

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 seminars and majors meetings to bowling and cookouts. They normally take place every Friday afternoon from 4-5:30 PM in Druckenmiller 20, and all majors are expected to attend seminars and other activities. The faculty view the seminars as a particularly valuable part of the academic program and assume 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 and the bulletin boards in the Cleaveland / Druckenmiller Hall for the weekly listing of seminars and special events.

III. THE CHEMISTRY FACULTY

Faraj Abu-Hasanayn, Visiting Assistant Professor (B.S. American University of Beirut, Ph.D. Rutgers). Inorganic Chemistry, computational chemistry.

Richard D. Broene, Associate Professor (B.S., Hope, Ph.D. University of California, Los Angeles). Organic Chemistry, organometallic-mediated organic synthesis, strained aromatic hydrocarbons, and new synthetic methodologies.

Ronald L. Christensen, Professor (A.B., Oberlin, A.M., Ph.D. Harvard). Physical Chemistry, photobiology, organic photochemistry and low temperature, electronic spectroscopy.

Robert de Levie, Adjunct Professor (B.S., M.S., Ph.D., University of Amsterdam, the Netherlands), Analytical Chemistry, electrochemistry, including double layer effects, ion transport through membranes, electrochemical oscillators, redox processes; use of computers in chemical data analysis.

Brian R. Linton, Assistant Professor of Chemistry and Biochemistry (B.A., Allegheny College, Ph.D. University of Pittsburgh) Bioorganic Chemistry, organic synthesis of protein mimetics, molecular recognition, and receptor-mediated chemical synthesis.

Dana W. Mayo, Research Professor Emeritus (B.S., Massachusetts Institute of Technology, Ph.D. Indiana). Organic Chemistry, chemistry of natural products and structural interpretation of infrared spectra.

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

David S. Page, Professor (B.S., Brown, Ph.D. Purdue). Environmental Analytical Biochemistry, pollution biochemistry and toxicology; fate and effects of hydrocarbons and other pollutants on marine communities.

Eric S. Peterson, Assistant Professor of Chemistry (B.A. Gustavus Adolphus College, Ph.D. University of California, Berkeley). Biophysical Chemistry, protein dynamics, conformational changes and reaction kinetics; time-resolved laser spectroscopy.

Elizabeth A. Stemmler, Associate Professor (B.S., Bates, Ph.D., Indiana). Analytical Chemistry, negative ion mass spectrometry, ion-molecule reactions, and the analysis of organic pollutants.

NOTE: Biology faculty who participate in the Biochemistry Program include Professors Kohorn, Logan, McBride, and Steinhart. 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, etc., 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 IIIE.**

B. Chemistry and Biochemistry Honors and Independent Study Projects Supervised by Chemistry Faculty (2000-2001)

Abir Biswas '01 (Honors Project with Professors Page and Laine)
"Using Chemical and Physical Measurements in a Stratified Sediment Core to Make Inferences About Past Human Activity in the New Meadows River Area"

Ha-Yeon Cheong '01 (Independent Study Project with Professor Abu-Hasanayn)
"Quantum Chemical Investigation of the Kinetics and Thermodynamics of CO Dissociation from η^5-LM$(CO)_3$X (M = Mo, W; L=Cyclopentadienyl, Indenyl; X=halogen)"

Darcy Corson '01 (Independent Study Project with Professor Peterson)
"Sol-gels and Their Utility in Isolating Transient Intermediate Protein Structures: Characterization of Myoglobin Conformational Substrates"

Rosanne Marie DeMaio '01 (Honors Project with Professor Peterson)
"Sol-Gel Encapsulation of Proteins"

Heather Erin English '01 (Honor Project with Professor Linton)
"Modeling Antiparallel β-Sheet Peptides through the Use of an Internal Cyclohexane Tether"

David MacDonald '02 (Independent Study Project with Professor Page and the Maine State Police Forensic Chemistry Laboratory in Augusta)
"Analyzing fire debris residues for hydrocarbon accelerants by gas chromatography / mass spectrometry"

John Meyers '02 (Independent Study Project with Professor Christensen)
"Conformational Disorder in Polyenes"

Anne Christine Powell '01 (Honors Project with Professor Page)
"The Combined Effects of Anaerobiosis and Tributyltim on the Energy Metabolism of the Blue Mussel, *Mytilus edulis*"

Matthew Stanton '02 (Independent Study Project with Professor Broene)
"Zirconium-stabilized Benzyne Routes to Sterically Biased BisIndenyl Ethane Derivatives"

Lindsay Tethal '02 (Independent Study Project with Professor Linton) "Highly Flexible Beta-Sheet Peptidomimetics."

Erik David Woodbury '01 (Honors Project with Professor Broene)
"The Synthesis of C_2-Symmetric Lathanocene Catalysts from the Zirconium-Mediated Coupling of Two Alkynes"

Eri Matsuhisa Yoshida '01 (Honors Project with Professor Broene)
"Synthesis of C_2-Symmetric *Ansa* Lanthanocenes"

C. Summer Research Projects 2001 (with Chemistry Faculty)

Scott Barbuto '03 (with Professor Linton) "Synthesis of (10-Methylcarbamoyl-9,10-dihydro-anthracene-9-yl)carbamic acid *tert*-butyl ester"

Libby Barney '03 (with Professors Broene and Christensen) "Synthesis, Purification, and Photochemical Characterization of Dimethyl Polyenes"

Kris Bosse '02 (with Professor Broene) "The Synthesis of Bis-Cyclopentadienyl Ligands for Enantioselective Catalysis"

Ana Conboy '04 (with Professor Stemmler) "The Analysis of Archeological Collections for the Determination of Oil Identity Using Fatty Acid Analysis"

Arij Faksh '03 (with Professor Christensen) "Conformational Disorder in Conjugated Polyenes"

Kristen George '03 (with Professor Broene) "Synthesis of Lanthanide Metal and Sugar Coordination Products and An Investigation of their Catalytic Properties"

Ariele Hanek '03 (with Professor Broene) "Enantioselective Synthesis of Tethered Bis-Indenyl-Metallocene Catalysts"

Justin Hardison '03 (with Professor Stemmler) "Qualitative and Quantitative Analysis of Microbial Communities found in Soil Sampled From Swan Island, ME"

David Kim '02 (with Professor Peterson) "Sol-Gel Encapsulation of Myoglobin"

Adrienne Luoma '03 (with Professor Linton) "The Synthesis of Anion-Binding Receptors and Analysis of Host-Guest Complex Strength"

David MacDonald '02 (with Professor Linton) "The Synthesis of 4-*tert*-butoxycarbamoyl –1-4-bis-butylcarbzmoyl-butyl)-carbamic acid and N-(4-Butylcarbzmoyl *tert*-butyl ester-butyl) benzamide"

Matt Oliff '02 (with Professor Peterson) "Sol-Gel Encapsulation of Myoglobin"

Tenley Scholfield '03 (with Professor Broene) "Modeling Things that Explode: Addition of Amino Acids to Lanthanide Catalysts as an Approximation of Amino Acid Addition to Actinide Catalysts"

Jan Welch '04 (with Professor Linton) "Nitro-Aldol Reaction of Benzaldehyde and Iron-Nitronate Complexes"

D. Recent Departmental Publications

(* indicates Bowdoin undergraduate co-author)

Professor Abu-Hasanayn

Faraj Abu Hasanayn, Ha-Yeon Cheong* and Mathew Oliff*, "Identification of Jahn-Teller Effects in Both Singlet and Triplet Low Energy States of [h6-(Benzene)Nb$(CO)_3]^+$" *Angewandte Chemie*, accepted for publication.

F. Abu-Hasanayn, W. Herkstroeter: "Energy Transfer to the Low Energy Triplet States of 1,3-Dicarbonyl Azomethine Dyes: The Role of Unique Geometries and Nonadiabatic Behavior" *The Journal of Physical Chemistry (A)* **107**, 1214-1222 (2001).

F. Abu-Hasanayn, A. Streitwieser, "Kinetics and Isotope Effects of the Aldol-Tishchenko Reaction between Lithium Enolates and Aldehydes", *Journal of Organic Chemistry* **63**, 2954 (1998).

Professor Broene

C. A. G. Carter, K. D. John, Mann, G., R. L. Martin, T. M. Cameron, R. T. Baker, K. L. Bishop*, R. D. Broene, and S. A Wescott in *Advances in Group 13 Element Chemistry*, ed. P. S. Shapiro and D. A. Atwood, ACS Symposium Series, in press.

R.D. Broene, R.T. Baker " Silylborations, Stannylborations, and Silylstannations" in Encyclopedia of Catalysis. Spring 2002.

F.M. de Rege, D.K. Morita, K.C. Ott, W. Tumas, R.D. Broene " Non-covalent immobilization of homogeneous cationic chiral rhodium-phosphine catalysts on silica surfaces" *J.Chem. Soc. Chem. Commun*., 1797 (2000).

Professor Christensen

H.A. Frank, J.S. Josue, J.A. Bautista, I. van der Hoef, F.J. Jansen, J. Lugtenburg, G. Wiederrecht, and R.L. Christensen, "Spectroscopic and Photochemical Properties of Open-Chained Carotenoids,"*Journal of Physical Chemistry B*, **106**, 2083-2092 (2002).

P. Wood, I.D.W. Samuel, R. Schrock, and R.L. Christensen, “Conformational Disorder in Long Polyenes,”*Journal of Chemical Physics* **115**, 10955-10963 (2001).

R.L. Christensen. "The Electronic States of Carotenoids," in *The Photochemistry of Carotenoids*, H.A. Frank, A.J. Young, G. Britton, and R.J. Cogdell (eds.), Kluwer Academic Publishers, pp. 137-160 (1999).

Professor de Levie

R. de Levie, “Linear graphs for understanding acid-base titration curves”, *Chemical Educator*. **6**, 210-216 (2001).

R. de Levie, “How to use Excel in analytical chemistry and in general scientific data analysis”, Cambridge University Press, 2001.

R. de Levie, “Stochastics, the basis of chemical dynamics”, *Journal of Chemical Education* **77**, 771-774 (2000).

Professor Linton

Brian R. Linton, M. Scott Goodman, Erkang Fan, Scott A. van Arman and Andrew D. Hamilton "Thermodynamic Aspects of Dicarboxylate Recognition by Simple Artificial Receptors",. *J. Org. Chem.*, in press.

Brian Linton "Host-guest Chemistry: Combinatorial Receptors",. *Methods in Molecular Biology*, **2001**, in press.

Brian R. Linton, Andrew J. Carr, Brendan P. Orner and Andrew D. Hamilton. "An Efficient One-Pot Synthesis of 1,3-Multisubstituted Guanidines from Carbamoyl Isothiocyanates", *J. Org. Chem.*, **2000**, *65*, 1566.

Professor Mayo

D.W. Mayo, R.M. Pike, and P.K. Trumper, “Microscale Organic Laboratory”, 4th ed., Wiley: New York, 1999.

Professor Nagle

H. Yersin, D. Donges, J. K. Nagle, R. Sitters, M. Glasbeek, "Site-Selective Emission, Excitation, and Optically Detected Magnetic Resonance of the Pd(II) Oxinate Complex Pd(qol)2" *Inorganic Chemistry*, **39**, 770-777 (2000).

J. K. Nagle, "Luminescent Exciplexes and Excimers Resulting From Metal-Metal Bond Formation", *Spectrum*, **12**, 15-19 (1999).

C. N. Pettijohn*, E. B. Jochnowitz*, B. Chuong*, J. K. Nagle, A. Vogler, "Luminescent Excimers and Exciplexes of Pt^{II} Compounds", *Coordination. Chemistry Reviews*, **171**, 85-92 (1998).

Professor Page

P.D. Boehm, D.S. Page, W.A. Burns, A.E. Bence, P.J. Mankiewicz, and J.S. Brown, "Resolving the Origin of the Petrogenic Hydrocarbon Background in Prince William Sound, Alaska". *Environmental Science and Technology* **35(3),** 471-479 (2001).

A.E. Bence, W.A. Burns, P.J. Mankiewicz, D.S. Page and P.D. Boehm, Comment on "PAH refractory index as a source discriminant of hydrocarbon input from crude oil and coal in Prince William Sound, Alaska" by F.D. Hostettler, R.J. Rosenbauer, K.A. Kvenvolden. *Organic Geochemistry* **31**(9), 931-938 (2000).

Page DS, Boehm PD, Stubblefield WA, Parker KR, Gilfillan ES, Neff JM, Maki AW. Hydrocarbon Composition and Toxicity of Sediments Following the *Exxon Valdez* Oil Spill in Prince William Sound, Alaska. *Environmental Toxicology and Chemistry*. **21(7)**: (in press) (2002)

Professor Peterson

J. Huang, L. J. Juszczak, E. S. Peterson, C. F. Shannon, M. Yang, S. Huang, G. V. A. Vidugiris, and J. M. Friedman, "The Conformational and Dynamical Basis for Ligand Binding Reactivity in Hemoglobin Ypsilanti (β99Asp → Tyr): The Origin of the Quaternary Enhancement Effect" *Biochemistry* **38**, 4514-4525 (1999).

M. Falconi, A. Desideri, A. Cupane, M. Leone, G. Ciccotti, E. S. Peterson, J. M. Friedman, A. Gambacurta, and F. Ascoli "Structural and Dynamic Properties of the Homodimeric Hemoglobin from the Scapharca inaequivalvis Thr72 → Ile Mutant: Molecular Dynamics Simulation, Low Temperature Visible Absorption Spectroscopy and Resonance Raman Spectroscopy Studies" *Biophysical Journal* **75**, 2489-2503 (1998).

E. S. Peterson and J. M. Friedman "A Possible Allosteric Communication Pathway Identified Through a Resonance Raman Study of Four β37 Mutants of Human HbA" *Biochemistry* **37**, 4346-4357 (1998).

Professor Stemmler

E.A. Stemmler and C. Segovis* "Formation of $\cdot CH_2OC(O^-)CR_2$ Distonic Radical Anions by the Reaction of $O^{-\cdot}$ with Dimethyl Glutarates", *Journal of Mass Spectrometry*, **36**, 685-688 (2001).

E.A. Stemmler, E. Yoshida*, J. Pacheco*, J. Brunton*, E. Woodbury*, and T. Solouki. "The Reactions of $O^{-\cdot}$ with Methyl Benzoate: An NICI and FT-ICR Study", *Journal of the American Society of Mass Spectrometry*. **12**, 694-706 (2001).

E.A. Stemmler, "Mass Spectrometry", in *Microscale Organic Laboratory* , 4th ed.; D.W. Mayo, R.M Pike, P.K. Trumper, John Wiley&Sons, New York, 1999; pp 600-617.

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, Dohery). 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. Typically, there are 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

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 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. 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 Kamerling lunch or at pre-seminar socials.
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 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.
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, 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. Members of the Department of Chemistry may be asked to serve as primary reviewers or secondary readers. 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 VA).

VI. LETTERS OF RECOMMENDATION

The faculty welcome 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 to this 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 employment
   - addressed and stamped envelopes (if the reference needs to be mailed, rather than picked up by you)
4. 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 – help Ms. Labbe in the Chemistry Department office with photocopying, filing, and other office duties.

Students interested in department jobs should talk to Judy Foster in (laboratory positions) or Ms. Labbe (office positions).

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 Chem 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 PhD 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.