

# HANDBOOK FOR CHEMISTRY CONCENTRATORS



**BROWN UNIVERSITY**

**2007 – 2008**

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## CHEMISTRY CONCENTRATION PROGRAMS

### Concentration Requirements

#### Chemistry AB

Chemistry 0330, 0350, 0360, 0500, 1140, 1150 and 1160 plus two advanced science/math electives. One of the electives should be a chemistry course. Note that the physical chemistry courses (1140, 1150 and 1160) have mathematics and physics prerequisites.

#### Chemistry ScB

The Chemistry Department has three tracks for the Sc.B. Chemistry Concentration – A Chemistry track, a Chemical Biology track and a Materials Chemistry track. These tracks are not separate concentrations – your degree will still be a Sc.B. in Chemistry. The Chemical Biology track is designed for students who have a strong interest in the interface of chemistry with biology. The Materials Chemistry track is designed for students who have a strong interest in the interface of chemistry with nanoscience and materials science.

#### *Concentrating in Chemistry – Three tracks:*

The required/recommended courses for the three tracks are given below.

**Chemistry track:** 0330, 0350, 0360, 0500, 1140, 1150, 1160, 2Math, 2Phy, 0970, 0980, + 7 electives (at least 3 must be CHEM); **20 total courses.**

**Chemical Biology Track:** 0330, 0350, 0360, 0400, 1140, BIOL 0280, 1230, 1240, 2Math, 2Phys, 0970, 0980, 3 courses from the following [BIOL 0470; 0500; 0510; 0530; 0800], + 3 other electives; **20 total courses.**

**Materials Chemistry track:** 0330, 0350, 0360, 0500, 1060, 1140, 1150, 1700, 2Math, 2Phys, 0970, 0980, BIOL 1090, +5 electives; **20 total courses.** (*For students with a more ENGN bent, the following substitutions can be made – ENGN 0030/0040 can be substituted for PH; ENGN 0410 can be substituted for CHEM 1060; ENGN 0720 for CHEM 1150*)

In each of these cases, 0970/0980 should be carried out with a faculty member with an appointment in the Chemistry Department. Research with faculty advisors outside Chemistry may be allowed in some special cases. In this event, the student should a) prepare a proposal for the research to be carried out and b) identify a faculty member in the Chemistry Department who will serve as a second advisor and the second reader for the thesis. A thesis is required to be eligible for graduation with Honors.

	Standard Track	
	Fall	Spring
1 <sup>st</sup> Year	Chem 0330	Chem 0350
2 <sup>nd</sup> Year	Chem 0360	Chem 0500
3 <sup>rd</sup> Year	Chem 1140	Chem 1150/1160

Area	Elective Courses
Organic Chemistry	Chem 1450, 2410, 2420, 2430
Inorganic Chemistry	Chem 1060, 2310, 2320
Physical Chemistry	Chem 1620, 2010, 2020, 2770, 2780
Biochemistry	Biomed 2800, 1270
Other Chemistry	Chem 0400, 1230, 1240 Chem 1170, 1560

The science electives required in the ScB program may be additional Chemistry courses or courses from other departments geared to a student's interests. Additional courses in Applied Math or Computer Science are particularly recommended. See the Concentration Advisor for further guidance and counsel.

**ScB or AB?** The answer depends on your long-range goals as well as your immediate interests. If you have other interests you want to pursue – perhaps a second concentration in the Humanities or Social Sciences – the ScB program may place too many demands on your time and the AB program may make more sense. The experience of Independent Study is extremely important if you are considering graduate school, but you don't have to be an ScB candidate to do Independent Study. Graduate schools and employers will take a look at your record of courses, necessarily the degree itself. Ultimately the choice boils down to how many of your courses at Brown are dedicated to your concentration, and how many explore other options.

### *Honors in Chemistry*

The Honors program provides a way of recognizing a student who has performed to a high standard in his or her concentration program. The recognition takes the form of an extra inscription on the diploma: "Honors in Chemistry." Interestingly, this is the only way in which the concentration can be mentioned on the diploma. Otherwise the diploma simply says, "Baccalaureato in Scientia" or "Baccalaureato in Artibus."

All ScB Chemistry concentrators, and any AB Chemistry concentrator who completes the following requirements, are candidates for Honors; no separate application is necessary.

The requirements for Honors in Chemistry are:

- A reasonable grade record in concentration courses. Normally, this means a grade point average of 3.2 or better, although in exceptional cases (students who have done an outstanding job in independent study), the cutoff can be relaxed to 3.1 or even 3.0.
- Two semesters of Independent Study (Chem 0970, 0980 or equivalent). (See below for Guidelines and Requirements associated with Independent Study.)
- A Thesis in a form approved by the research advisor, and recommended by the research advisor and a second faculty reader. The Concentration Advisor often serves as the second reader although you are free to ask other faculty to do so. The Thesis and faculty approvals must be completed no later than the last week in April.
- Approval by the Department of Chemistry.

### *Independent Study*

Independent Study in Chemistry means **RESEARCH** under the direction of a faculty Research Advisor. The choice of a Research Advisor is crucial to your success. Your Research Advisor will suggest a project, provide the space and facilities needed, help with the design and execution of experiments and guide you in the interpretation of your results. The Research Advisor is committed to spending a lot of time with you, and you should do your best to fulfill your end of the bargain.

Chem 0970, 0980 are courses that (like all Brown courses) are expected to fill about 25% of your time. Unlike most other courses, however, there are no lectures or exams to pace your progress. It is all too easy to put off research when a paper is due or an exam is imminent in another course. Success in Independent Study requires a degree of self-discipline that you may not have had to apply to other courses. Most students find that a *minimum* of 15-20 hours per week is needed to show any progress in research.

### **When to do an Independent Study**

Almost all students carry out Independent Study during their Senior year at Brown, often for their Senior Thesis. By that time, you will have completed the core courses in Chemistry and thus will have the necessary background for a research project. However, many students elect to start research during their Junior, Sophomore, or even Freshman year. It all depends on your class and extracurricular schedule, commitment and interest, and time-management capabilities.

The University has a program of Undergraduate Teaching and Research Assistantships (UTRA) for the support of research students during the summer. There are often other sources of funding.

In any case, applications for summer support are due early in the second semester (usually the first week in February) so that a successful application requires advance planning.

### **Finding a Research Advisor and Registering for Independent Study**

- If you hope to spend the summer on an UTRA, you should start looking for a Research Advisor during the preceding fall so that you can secure permission before Christmas and be ready with an application for support in early February. If you don't plan to spend the summer, you should be looking for an Advisor in the spring and have permission secured before leaving the campus in May.
- Define the general area of chemistry you would like to work in.
- Check out the possibilities in your chosen area. Visit the Chemistry Department individual faculty web sites for information.
- Consider several possible projects before making up your mind – don't jump at the first opportunity. Choose three or four faculty you might be interested in working with and arrange appointments to discuss possible projects. Then narrow your list to one and return for a more detailed conversation. If you are still interested, ask for permission to enroll in Independent Study. Note that faculty time and lab space is not unlimited and that some faculty members may have to limit the number of undergraduate research advisees. Don't be discouraged if you get turned down – hopefully you will have a second choice as a back up.

### **Reporting Your Results**

- **Oral Presentation:** At the end of the second semester – usually Monday and Tuesday afternoons of the first week in May – all students writing Senior Theses in Chemistry and Biochemistry are expected to give 20-minute oral presentations on their work to an audience of faculty, graduate students and undergraduates.

### **Research Practices in the Department**

For students carrying out research in the department, consult the graduate student handbook on the department website. This handbook contains information regarding laboratory safety, departmental/university policies and procedures, along with important safety information for undergraduates who perform research. All students engaged in laboratory research are required to complete all lab safety trainings and the Undergraduate Research Authorization Form available on the department website.

## Independent Study away from Brown

Many universities, government laboratories and industrial research establishments sponsor undergraduate summer research programs. Notices of such programs are on file in Ms. Gen Goditt's office (GeoChem 239) and in Dean Nancy Thompson's office (Arnold 124).

Students sometimes develop a project in laboratory away from Brown, continuing over several summers. Very rarely, such a project may be used to satisfy the Independent Study requirements in a Brown concentration program. Since every case is different, no general guidelines have been formulated, but if you would like to pursue such an option, see one of the Concentration Advisors.

### *Prizes*

The Department of Chemistry annually awards a number of prizes to undergraduates:

- **The Freshman Chemistry Achievement Award:** A chemistry book is awarded to the top student in each lecture section of Chem 0330.
- **The Merck Index Award:** A copy of *The Merck Index* is awarded to the top students in Chem 0360.
- **The Junior Prizes in Chemistry and Biochemistry:** The outstanding Junior concentrators in Chemistry and Biochemistry are honored by the Junior Prize, which consists of a year's membership in the American Chemical Society (ACS) and a treatise on chemistry.
- **The Paul Cross Prize in Physical Chemistry:** Awarded to a Senior who has demonstrated special promise in physical chemistry, the Cross Prize carries a cash award of \$100.
- **The Leallyn B. Clapp Prizes:** Awarded for the best Senior Thesis in Chemistry and Biochemistry, the Clapp Prize carries a cash award of \$100.
- **CRC Prize:** A copy of the *CRC Handbook of Chemistry and Physics* is awarded to the newly declared concentrator with the best academic record.

### *Seminars, Colloquia and Special Lectures*

Regularly scheduled seminars in physical, organic and inorganic chemistry and biochemistry, as well as a Departmental Colloquium feature talks by faculty, graduate students and visitors from other institutions. The seminar program is intended to supplement and enrich the material available through formal course offerings. Suggestions for topics or speakers are welcome and should be brought to the attention of the seminar organizers. Notices of the seminars and

colloquia are posted a week in advance on the bulletin boards on each floor. Seminars are usually held in GeoChem 351 and colloquia are held in MM 115.

The Chemistry DUG usually sponsors a Colloquium each year, choosing the topic, inviting the speaker and arranging for his or her entertainment.

Lecture series honoring John Howard Appleton (who taught at Brown from 1862 to 1914) and Leallyn Burr Clapp (who taught here from 1941 to 1988) are often of special interest to undergraduates. Both lectures are followed by a reception to honor the guest lecturer. The Appleton Lecture is preceded by a reception especially for undergraduate concentrators and is followed by a dinner to which Senior concentrators are invited.

### **The Chemistry DUG**

The Chemistry Departmental Undergraduate Group (Chem DUG) allows Chemistry and Biochemistry concentrators (and prospective concentrators) to get together on a monthly basis, usually over an informal dinner. Besides providing an alternative to dormitory food, the meetings serve as a source of information about topics such as summer research opportunities (at Brown and elsewhere), the best ways to apply to graduate schools and the pros and cons of MD/PhD programs. Occasionally the DUG will arrange for a presentation from a faculty member on some interesting scientific topic. In the past there have been presentations on Thomas Edison (complete with some of his light bulbs and a working Edison record player), the nature of chemical warfare agents and the total synthesis of morphine. Roughly once a year, the DUG also brings an outside speaker to Brown for the purpose of giving a general interest seminar.

The DUG is run by its own officers. They set the meeting dates and arrange for whatever program there might be. However, there is a faculty advisor for the DUG and a secretary, Ms. Gen Goditt, who helps with organizational matters and serves as a resource for information of interest to concentrators. Descriptions of summer programs, fellowships, graduate schools and the like as well as up-to-date copies of the ACS's *Directory of Graduate Research* are all kept in Ms. Goditt's office (GeoChem 239).

### ***Beyond Brown***

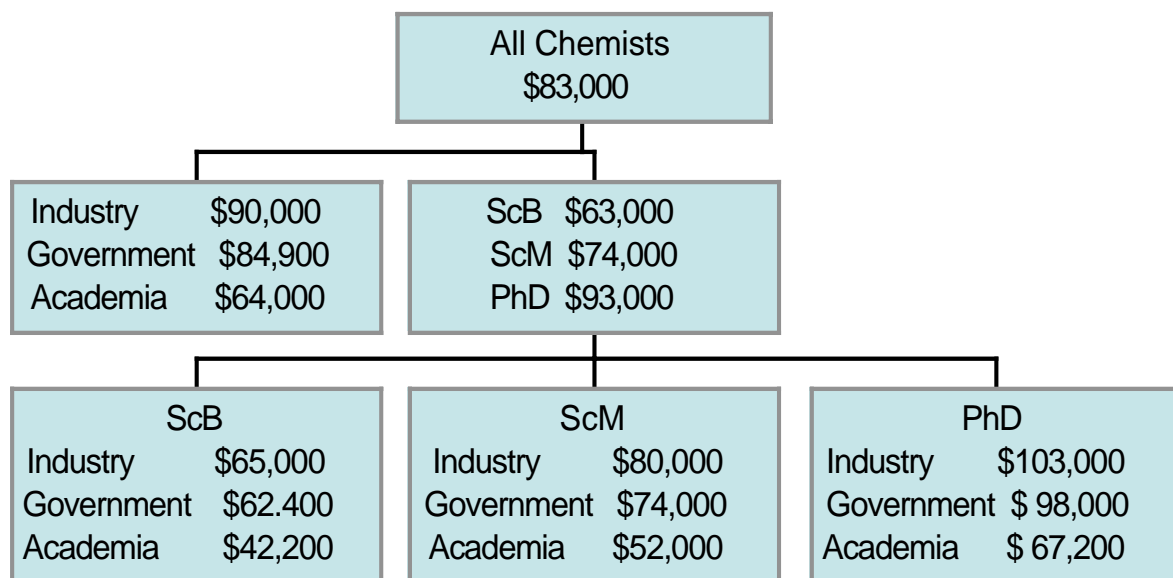
#### ***What Becomes of Chemistry Graduates?***

About two thirds of chemistry majors go on to further education including Graduate School for chemistry, biochemistry, engineering, business, law, education and medical/dental school.

Ultimately, nearly 60% of all people working as chemists or biochemists earn a PhD degree, about 20% get an ScM and the remaining 20% work with a bachelor's degree. About 10% of chemists and biochemists (almost entirely PhDs) end up in academic jobs. About 40% work for hospitals (clinical chemistry, pharmaceutical chemistry, etc.) or for government agencies (research laboratories such as the Argonne National Laboratory and the National Institutes of Health labs, enforcement agencies such as EPA or FDA, state health departments and environmental agencies and a variety of other jobs). The remaining 50% work in industry. The

chemical industry includes companies producing “heavy chemicals” (sulfuric acid, sodium hydroxide, etc.) petrochemicals (plastics, dyes, etc.), synthetic fibers and other polymers, pharmaceuticals and a wide variety of specialty chemicals. Chemists and biochemists are also mainstays in the emerging industries that exploit biotechnology and in companies involved with microelectronics, batteries, fuel cells and solar cells, ceramics, cosmetics, food processing, pollution control, environmental analysis and coating technology.

Although chemistry is not one of the very highest paying professions, chemists generally do all right. The chart shown below gives median base salaries as of 2005, as determined by the American Chemical Society’s Employment & Salary Survey.



The survey statistics show a financial incentive toward getting a higher degree. The statistics may be somewhat misleading, however, in that (i) it is often easier to find a job at the Bachelor’s level than at the ScM or PhD level and (ii) ScB chemists often cease being chemists (in the eyes of the ACS) after several years in industry. The jobs available to people with ScB degrees tend to be somewhat limited in scope (sales, quality control, analytical chemistry, etc.) so that many ScBs move out of chemistry and into business after a few years in industry. In that sense, an ScB offers an entry into the technology-based industries that is parallel to that for people with engineering, business, law or economics training. Careers in industry often start with an ScB in chemistry or biochemistry.

If you are interested in science as a lifetime career, you should plan on an advanced degree, preferably a PhD. You may or may not earn more money, but you are much more likely to stay a scientist.

## *Applying to Graduate School*

If you plan to go on to graduate school in chemistry, biochemistry or related discipline, you should begin serious work in the fall of your Senior year with the intention of submitting applications before the holiday break. ***Speak with your research advisor and other faculty members and solicit their suggestions about the application process.*** Here is a list of steps for Graduate School applications.

**Define a Direction:** Your first step is to define your goals and the constraints on your choice of institutions. What field do you want to pursue? Do you have regional requirements? Are your grades and research experience good enough to get into a first rank school? Choosing a graduate school is rather different than choosing a university with a good undergraduate institution. When you applied to Brown, you were choosing a university with a good undergraduate program with strength in the sciences; after you got here, you narrowed the choice to a concentration program. When you apply to Graduate School, you are choosing a department or program within a university and, after getting there, you will narrow the choice to a particular Research Advisor. Thus, in applying to a Graduate School, you should look beyond the university to the department and even more narrowly at the research faculty within the department.

**Survey the Possibilities:** Graduate school searching in chemistry and biochemistry (and chemical engineering) is made much easier by a publication of the ACS, the *Directory of Graduate Research*. The ACS Directory lists all MS or PhD-granting Departments of Chemistry, Biochemistry, Chemical Engineering, Pharmaceutical Chemistry, Clinical Chemistry and Polymer Science in the US and Canada. The listing includes brief descriptions of faculty research interests and recent publications. It is worth spending some time with this Directory. Here are some things you will want to consider with answers easily found in the Directory:

- Size of Program: How many faculty? How many graduate students? Student to faculty ratio? The size of a program is important. Big programs generally will have a diversity of interests, but may be impersonal; in a small program, you may not get lost in the shuffle, but research facilities may be less extensive.
- Are most faculty actively involved in research or are there just a few active people? Generally speaking, the best departments are those where everybody is involved in research.
- Is the department a group of individual research groups with little interaction or is there active collaboration? Publications with two or more faculty names can be taken as evidence of a collaborative atmosphere.
- Perhaps most important of all, there should be at least two faculty with whom you could imagine working. Read some recent papers to test your interest. Don't consider a place with only one possible Research Advisor – when you get there, you may find that he or she just moved or that you can't get along with that individual.

After narrowing your choices to 5 – 7 schools, talk with faculty at Brown. We have contacts in many departments and will be able to offer you further insights.

**Contact Some Departments.** Write to each of your prospects, asking for their graduate study brochures and for application materials. Read the brochures, carefully reconsidering the points mentioned above. At the very end, consider finances. If you are admitted, you **will** be offered a Teaching Assistantship or Fellowship; find out the stipend. Stipends don't vary that much from department to department – whatever differences there are will be small compared with your post-PhD salary – but there may be differences in the cost of living (big cities are generally more expensive than rural communities).

### **The Application Process**

- You should plan to take the Graduate Record Examination. Generally speaking, the GRE is not as important as the SATs were for college or the MCATs are for medical school admission, but most of the better graduate schools require it.
- Letters of recommendation are by far the most important component of a Graduate School application. You should of course get a letter from your Research Advisor. Choose other references from faculty who know you and can speak glowingly about your accomplishments and potential.
- Send in the application. Most departments have deadlines for receipt of graduate applications. Although these are frequently flexible, your chances of success are generally better if you adhere to the deadline.
- Although you shouldn't take admission for granted, don't lose any sleep over the process. Remember that you are coming from a first-rate institution at a time when most institutions desperately want well-qualified graduate students.

### **The Final Choice**

If at all possible, visit the departments to which you have been admitted. Most departments encourage visits by prospective students and will pay some or all expenses. Some have special days set aside for orientation of admitted students. Ask about the possibility of visiting if the offer isn't made explicitly. When you visit, you should be thinking of whether you are going to be happy and productive as a graduate student. Talk with graduate students to get their reactions. What is the tenor of the place? Are faculty accessible? Are the facilities good? Is the load for Teaching Assistants reasonable? How many courses will you be expected to take? When do you start research? What exams – comprehensives, cumulatives, and research propositions – must you pass along the way? How long does it take to get a degree? Where do the graduates of the program go – post-doctoral, industry?

A final word of advice: Go to the best program you can get into and be the best student there!

### ***Applying to Medical School***

For advice on medical school applications, you should contact Dean Simmons, Associate Dean of the College for Health and Law Careers. All meetings with Dean Simmons regarding health careers questions/issues are by appointment. Call or stop by the Health Careers Office to make an appointment with Dean Simmons (863-2781; University Hall 213). Email: [hco@brown.edu](mailto:hco@brown.edu) But please don't hesitate to ask for help and further advice from your Research Advisor or from other Chemistry or Biochemistry faculty.

### ***Finding a Job***

The Brown Placement Office has many ways to help with a job search. In addition, you should check the classified ad sections in the ACS's weekly news magazine, *Chemical and Engineering News*, as well as those in major newspapers such as *The Boston Globe* and *The New York Times*. The ACS operates an Employment Clearinghouse at its Fall and Spring National Meetings. Many companies have interviewers on hand to recruit scientists.