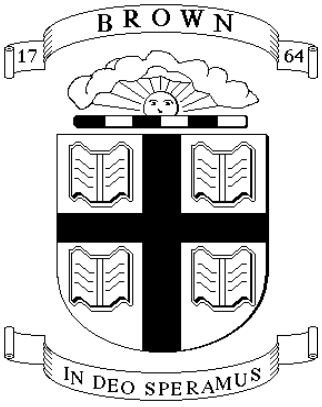
HANDBOOK FOR CHEMISTRY CONCENTRATORS



BROWN UNIVERSITY

2004-05

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Beyond Brown

CHEMISTRY CONCENTRATION PROGRAMS

Concentration Requirements

Chemistry AB

Chemistry 33, 35, 36, 50, 114, 115 and 116 plus two advanced electives. Note that the physical chemistry courses (114, 115, 116) have mathematics and physics prerequisites.

Chemistry ScB

A. Twenty semester courses in Chemistry, Mathematics, and Physics with a minimum of eight semester courses in Chemistry, four semester courses in Mathematics, and two semester courses in Physics and two semesters of independent study. Included in the Chemistry courses must be Chemistry 33, 35, 36, 50, 114, l15, 116, and 97, 98 or other independent study approved by the department. The Mathematics and Physics requirements can be satisfied by Advanced Placement credit (or the equivalent). In some cases, courses in Applied Mathematics, Biology, Computer Science, Geological Sciences or Engineering may be substituted for some of the twenty, subject to departmental approval.

B. Students are advised to take at least six courses in the humanities and social studies.

Overview of AB and ScB Programs. The differences between the AB and ScB programs are summarized in the following table.

	AB	ScB
Chemistry core courses	7	7
Chemistry electives	At least 2	At least 2
Independent Study	—	2
Physics	2	2
Mathematics	3	4
Science Electives	—	4
Total Courses	14	20

For both AB and ScB candidates, the physics and mathematics requirements are treated as prerequisites which may be satisfied by placement. Thus, for example, a student who begins with Math 17 is deemed to have completed Math 9. Students who begin as prospective Engineering concentrators and

take Engineering 3, 4 are deemed to have completed the Physics requirements. In order to meet the 20-course requirement, ScB candidates should list courses completed by AP credit or other placement on the Concentration Declaration form. The core courses in chemistry, normally taken by both AB and ScB candidates, and chemistry electives, are shown in the tables below.

Standard Track

	Fall	Spring
1st year	Chem 33	Chem 35
2nd year	Chem 36	Chem 50
3rd/4th year	Chem 114	Chem 115/116

Area	Elective Courses
Organic Chemistry	Chem 145, 241, 242, 243
Inorganic Chemistry	Chem 106, 231, 232
Physical Chemistry	Chem 162, 201, 202, 277, 278
Biochemistry	Biomed 28, 127,
Other Chemistry	Chem 40, 123, 124
	Chem 117, 121, 156

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 one of the Concentration Advisors for further guidance and counsel.

ScB or AB? The difference between the AB and ScB programs in chemistry amounts to about 5 courses, to spending half your time at Brown in the sciences as opposed to two thirds. Is the difference worth it? The answer depends on your long-range goals as well as your immediate interests. If you plan to get a job as a chemist, the extra experience in the ScB program and the cachet of an ScB diploma is almost certainly worthwhile. If you plan to

go on to graduate school or medical school, the extra courses may be less important, and the title of the degree has very little significance. 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 very important if you are considering graduate school, but you don't have to be an ScB candidate to do Independent Study. If you plan to go to medical school and think you may engage in research (either basic or clinical) at some time in your life, the ScB degree will provide you with a better background to conduct research. In the end, the choice is yours, but have a talk with one of the Concentration Advisors before making a final choice.

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 Sc.B. Chemistry concentrators, and any A.B. 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 97, 98 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. The 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 97, 98 are courses which (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 which 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

For many students, independent study is carried out during the Senior year at Brown. By that time, you will have completed the core courses in Chemistry or Biochemistry and thus will have the necessary background for a research project. There are always exceptions to this generalization, however, and the Junior or even Sophomore year may make sense for you.

The ideal time to begin an Independent Study is during the summer before you enroll in the formal course. This allows you to spend full time for 10 weeks or so getting the project started and makes it much easier to accomplish something during the academic year. 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 beginning your research, 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 more 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.

• Registration for the second semester does not require so much paper work. Have your Research Advisor sign a Proposal sheet and take it to one of the Concentration Advisors for a permission slip.

Reporting Your Results

There will be two opportunities during the year to tell the world about what you have been doing in your Independent Study project:

• **Poster Session**. Following the first semester all students doing Independent Study projects in Chemistry and Biochemistry are expected to present their work on a poster displayed in the third floor corridor of the Geo/Chem building. You should plan to be present on at least one afternoon to discuss your results with faculty and your fellow students.

• **Oral Presentation**. At the end of the second semester—usually Monday and Tuesday afternoons of the first week in May—all students doing Independent Study projects in Chemistry and Biochemistry are expected to give 20-minute oral presentations on their work to an audience of faculty, graduate students and undergraduates. (Overhead and slide projectors are available.)

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. Goditt's office (239 Geo/Chem) and in Dean Thompson's office (124 Arnold).

Students sometimes develop a project in a laboratory away from Brown, continuing over several summers. Very occasionally, 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 CRC Freshman Chemistry Achievement Award**. A copy of the *CRC Handbook of Chemistry and Physics* is awarded to the top student in each lecture section of Chemistry 33.

• **The Merck Index Award**. A copy of *The Merck Index* is awarded to the top students in Chemistry 36.

• **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 and a year's subscription to a journal of the prize winner's choice.

• **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 Theses in Chemistry and Biochemistry, the Clapp Prize carries a cash award of $100.

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 (see below). Notices of the seminars and colloquia are posted, usually about a week in advance, on the bulletin boards on each floor. Seminars and colloquia are usually held in Room 351.

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. The Appleton Lecture, usually held in the spring, 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 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 M.D./Ph.D. programs. Occasionally the DUG will arrange for a talk from a faculty member on some interesting scientific topic; in the past there have been talks 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.

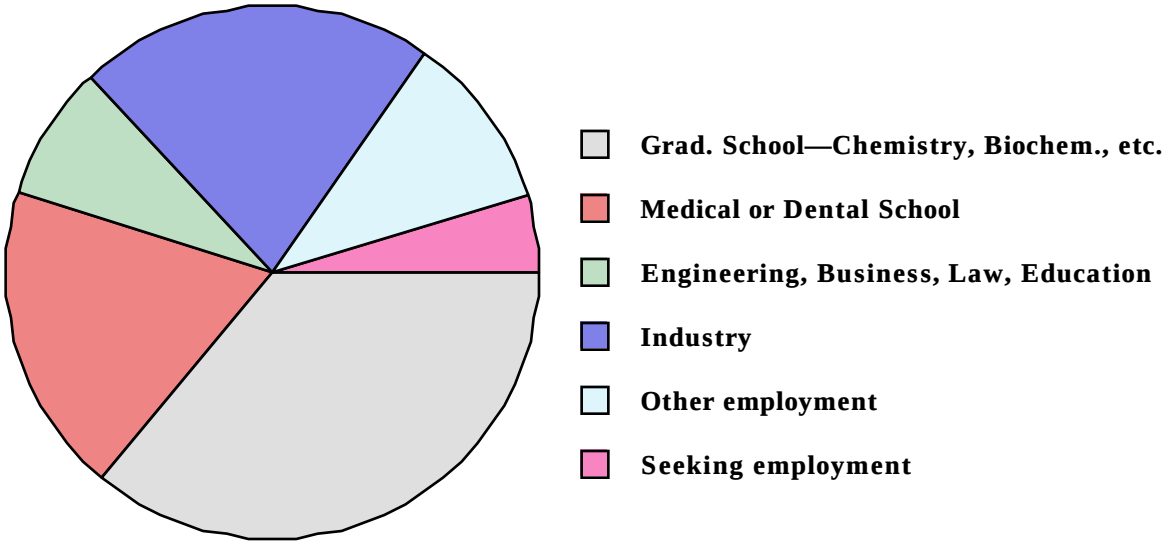
The DUG is run by its own officers. They set the meeting dates and arrange for whatever program there might be. However, there is a faculty advisor for the DUG and a secretary (Ms. Gen Goditt) who helps with organizational matters and serves as a resource for information of interest to concentrators.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

BEYOND BROWN

What Becomes of Chemistry Graduates?

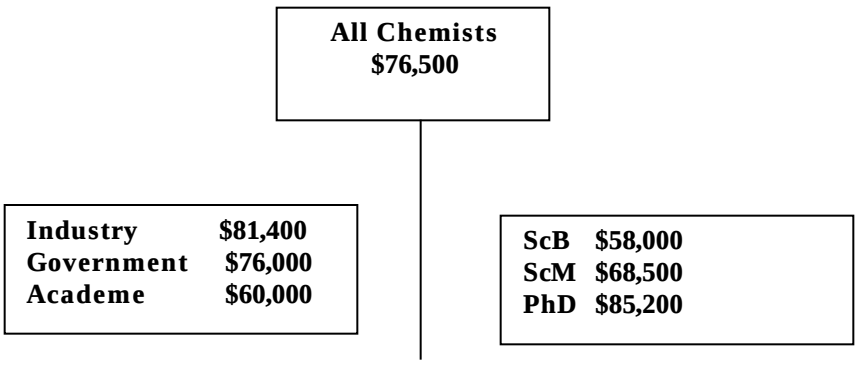
The pie chart below shows the post-commencement plans of chemistry and biochemistry graduates across the country, according to an American Chemical Society survey in June 1992. Notice that about two thirds go on to further education and that 90% of those entering the job market had jobs before commencement. Brown graduates in chemistry and biochemistry tend to go to graduate school, medical school or to the employment market in about the same proportions.

Plans of Chemistry Graduates—1992



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 PhD's) 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 which 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 paid professions, chemists generally do all right. The chart shown below gives median base salaries as of 2002, as determined by an American Chemical Society survey.



Sc.B.	
Industry	$59,000
Government	$59,200
Academe	$37,500

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 American Chemical Society) 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 ScB's 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 which 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.

In 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 a related discipline, you should begin serious work in the fall of your Senior year with the intention of submitting applications before Christmas break. 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 an 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 American Chemistry Society, *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 United States 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: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 the 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 <u>will</u> 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-Ph.D. salary—but there may be differences in the cost of living (big cities are generally more expensive than a rural community).

The Application Process

• You should plan to take the Graduate Record Examination. Generally speaking, the GRE is not as important as the SAT's were for college admission or the MCAT's 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, 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-doctorals, industry?

When you have visited, talk with your Research Advisor and with other faculty and then make the choice. 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 Ripley's office. But please don't hesitate to ask for help and further advice from your Research Advisor or from other Chemistry or Biochemistry faculty.

Getting 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 American Chemical Society's weekly news magazine, *Chemical and Engineering News*,

as well as those in major newspapers like *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. .

RESEARCH PRACTICES IN THE DEPARTMENT

For students carrying out research in the department, consult the graduate student handbook in the laboratory for safety departmental policies and procedures, along with important safety information.