Graduate Education Field Assessment Plan

Chemistry and Chemical Biology (C&CB)

In this document we address the following issues:

I. Upon receiving a Ph.D. from our program what skills do we expect our students to have obtained, what do we expect them to have learned? i.e. what do they need to achieve to graduate with a Ph.D. degree in Chemistry and Chemical Biology.

II. How do we evaluate our students? (At the end of their training, and along the way)

III. How do we verify that our Program is successful, how do we share information, communicate, and respond to ensure the goals of I are being achieved.

I. Skills to be acquired

The C&CB field expects students to have obtained proficiency in the areas of Scholarship, Research, Communication, and Independence.

Scholarship: Students must develop the ability to acquire, evaluate and synthesize knowledge in areas relevant to the broad chemical sciences, with special emphasis on their focused research areas. They must learn and apply principles from graduate courses, assimilate information from literature, and, importantly, critically evaluate published science. Through these skills, students will demonstrate a talent for selecting a scientific problem of note and novelty. We also expect that our students can educate others. This includes standard teaching of undergraduates but also the ability to educate peers and the scientific community with respect to their research results and ideas. True scholarship also requires students to view their work and interests in the greater context of the human condition. We aim to produce Ph.D. students with “curiosity, a free mind, belief in good taste, and belief in the human race.” (E.M. Forster).

Research: Carrying out productive research is of primary importance for a degree in C&CB. Students will apply the general methods of scientific inquiry to conduct observations, formulate hypotheses, design experiments, and acquire data. In short, research is the ability to ask and answer questions. Success in research requires motivation, dedication, curiosity, and the experimental and/or theoretical skills to
reveal truth in Nature. Students must apply the rigors of scientific training to the drive for discovery. In our view, graduate level education differs from all others in that acquiring and applying existing knowledge is ultimately only a means to the end of creating new knowledge. Certainly, we aspire to train our students in the methodology of science, but we also teach students how to discover and create. The form discovery takes is highly field dependent, even within Chemistry, but could for example include: discovery of a catalyst to elicit specific molecular transformations, understanding of a chemical mechanism behind a reaction, development of synthetic methodology to construct a complex molecule, the theoretical understanding of molecular and electronic structure, or revealing the molecular basis of a metabolic or cell-signaling pathway. In these endeavors students will gain field-specific technical skills, which could include laboratory techniques in synthetic chemistry, spectroscopy, biochemistry, molecular biology, and analytical methods, mathematical and statistical proficiency, computational acumen and instrument design capability. Finally, a proper understanding of ethical behavior in research and scholastic activities is critical and required of all graduate students.

**Communication:** Students must be capable of expressing their ideas, summarizing information and engaging in productive discourse with advisors, colleagues, and less experienced students. They will become effective writers and orators and learn to present and defend material in a concise, succinct manner. Proficient technical writing skills, displayed primarily in journal publications, review articles, thesis dissertations and research proposals are an absolute requirement for a degree in C&CB.

**Independence:** Ultimately, students must learn to take ownership of their research project and scholastic development. They must respond to challenges and educate themselves. When they graduate, they are expected to be the primary expert in their area of investigation. Two of the most consistent predictors for success in graduate school are maturity and motivation. Students who are accepted into our program arrive with some degree of these qualities, but we hope to enhance these aspects of their character. Through the course of their studies, many students will mature as young adults, learn to productively interact with others, manage their advisors, manage their time, take responsibility for their actions, and meet challenges in an environment much less structured than an undergraduate educational program.

**II. Student Evaluation**
Evaluation of student progress in C&CB begins immediately with C&CB Field oversight that continues throughout the first year and then transitions to advisor-directed assessment as students become integrated into research groups.

Field Oversight
To provide a benchmark, incoming graduate students are evaluated through their performance on accredited chemistry proficiency exams set by the American Chemical Society. Based on background and exam performance, course recommendations are made for the fall semester. Typically, students are required to take three, four-credit graduate courses in their first semester. Performance in these courses is an important early metric for student success. Course evaluation involves standard methods such as exams, self-study projects, homework assignments, and presentations. Typically, three additional courses are taken in the spring semester of the first year. After the fall semester, most students have joined research groups and have retained a Special Committee chairman, who aids them in course selection for Spring semester.

Students are trained in basic teaching techniques in the Teaching Assistant Training Program (TATP) over three weeks in July prior to their first semester. Teaching proficiency is evaluated by laboratory instructors and course faculty through formal observation and written feedback, as well as by student evaluations. Foreign students, who are non-native English speakers, are required to undergo language evaluations prior to acting as a TA. English courses are provided through the Center for Teaching Excellence to aid students requiring further development in this area. Students are re-evaluated for their speaking proficiency until it meets standards set by the graduate school and our Department. All of our students are encouraged TA in their first year, regardless of their financial support mechanism. Teaching provides an invaluable opportunity to develop communication and mentoring skills early in a student’s graduate career.

At the end of each semester, the C&CB field faculty meet to discuss course work and TA performance of all graduate students in our program. Data reviewed include course performance, teaching evaluations and research progress.

An important milestone in student progress is the A-exam or candidacy exam, usually taken at the end of year 2 or as late as the end of year 3. The format for the exam is set by the Special Committee and may include an oral defense of research and course knowledge and in some cases a written research proposal.
In either year 3 or 4 students give a 50 min research talk to their peers and faculty within the Department. This is not a formal requirement but encouraged of all students. The seminar series is run by the students themselves. In addition, there is a yearly research poster competition in which three awards are given by faculty and peer evaluators.

The final Field-mandated evaluation is the dissertation or B-exam that is administered by the student’s Special Committee. The B-exam format is mandated by the graduate school and consists of a written thesis dissertation and an oral defense.

Another major form of evaluation for our students involves peer review in the greater scientific community. Most C&CB students publish original research articles in scientific journals prior to graduation. Thus, their work is vetted by scientific peer review. Publication provides an important external quality check on their scholarly achievements and also objective feedback on their research. The writing of fellowship and grant applications serves a similar purpose and many of our students participate in these activities under the direction of their advisors.

The most important evaluation mechanisms for our students comes via their interactions with their thesis advisor, who is usually the chairperson of their Special Committee. Our program relies heavily on Apprenticeship, and thus, a large degree of student training falls to the advisor.

C&CB faculty members themselves go through extensive internal and external evaluations as part of the tenure and promotion process. Faculty success depends upon their ability to train graduate students effectively.

**Advisor Oversight**

How advisors mentor and evaluate their students varies from group to group. Common practices include informal one-on-one meetings with students, group meetings where students present their in-progress work before their advisor and peers and journal-club meetings, which train students to assimilate and critically assess current literature. Many groups also participate in less frequent joint group meetings with other laboratories that hold similar interests.

Again, an essential facet of formal training with their advisors often involves the writing of peer-reviewed scientific papers as well as grant and proposal applications.
In addition, our students attend national meetings where they present posters and in some cases give oral presentations to the broader scientific community. These activities are largely advisor motivated and directed.

**External Oversight**
Several of our students are participants on graduate student training grants from the NIH and NSF. These programs have their own evaluation mechanisms that are above and beyond that of our field. For example, the students supported by NIH training grants are typically reviewed annually by the training grant faculty.

**Responsible Conduct of Research**
Responsible conduct of research (RCR) is becoming an increasingly important component to graduate training. All of our students must take Cornell’s online RCR course, and any that are supported by NIH training grants also participate in a one semester ethics course (BIOMG 7510 Ethical Issues and Professional Responsibilities). Annual faculty-led discussions on research conduct are also encouraged.

**III. Program Verification and Response**

We verify the success of our program by several criteria:

1. What our students do after graduation. “The proof of the pudding is in the tasting”. The opportunities our students can embrace because of their C&CB degree provide the best valuation of their training. We track all of our students post graduation. Many students will take academic postdoctoral positions in top laboratories throughout the country or jobs in chemical industry. However, a Ph.D. in Chemistry provides strong training in basic analytical and problem-solving skills and as such, our graduates are often valued by professions outside of pure chemistry, e.g. medicine, law, finance, art restoration, forensics, journalism, scientific and public policy etc. In some cases our graduates have used their C&CB training to start successful companies.

2. External Departmental Review – Every 10 years the Department of C&CB undergoes an extensive external review mandated by the College of Arts and Sciences. Evaluation of our graduate program is an important component of this evaluation. All of our training mechanisms are reviewed by an external committee that conducts interviews with faculty, students and course administrators. This
provides invaluable feedback on our program and where it falls in relation to other top-rated Chemistry graduate programs across the country.

3. Wentink Symposium. Each spring several of our upcoming top graduates are nominated by their mentors to present their thesis research in an open seminar to the Cornell community. Usually two to four students are selected by a committee of faculty to receive the awards. The subsequent Wentink symposium gives the faculty a yearly view of our top students and their achievements.

4. Training Grant Applications: NIH and NSF (IGERT) graduate student training grant applications are extensive documents that require considerable data on current and past students. The reviews of these grants also provide invaluable feedback about our training programs. We view success in obtaining training grants as an important external check on the quality of our programs.

5. The procedures and mechanism outlined above provide information on the performance of graduate training in C&CB. Given these data, which are made available to the faculty, structural changes to our graduate program can be suggested at our biannual field meetings. In addition, the Director of Graduate Studies (DGS) as well as the Chair of C&CB solicit feedback on our program and facilitate the implementation of changes. Furthermore, a committee of faculty, chaired by the DGS, meets prior to and after graduate admission season (December through March) to plan for and evaluate our recruiting season. Important feedback about our program is garnered from the recruiting process. Students who are accepted into our program but decide to matriculate elsewhere are asked why they chose another program over ours. Furthermore, students who decide to attend Cornell are asked what they found attractive about our program. The information obtained is then relayed to the faculty at our Field meetings and adjustments made where deemed necessary.

Finally, it should be noted that because of the Apprenticeship nature of graduate training in chemistry, the single largest factor that determines the strength of our program is the quality of our faculty. This reflects our ability to recruit and retain exceptional young scholars as well as the maintenance of a vigilant tenure system. That said, success of our young faculty depends upon our student strength, and thus faculty recruiting and student recruiting are synergistic. Because of this we have a long-standing policy to involve our newest faculty in our graduate student recruiting process (usually before they arrive at Cornell) and to encourage our best young students to join the groups of our newest faculty. At the end of the day, the best faculty will attract the best students, the best students will create the best
faculty, who will then train the best students. Success of our Department as a whole thus reflects the quality of graduate training.