Chemistry C500 Manual
Introduction to Research
Indiana University
2024-2025

Chemistry C500
Introduction to Research

The completion of a thesis based on original research is crucial in the completion of an advanced degree in chemistry. The first-year course, "Introduction to Research" (C500), provides an opportunity for the student to learn about the diverse range of ongoing research in the Chemistry Department, to make the transition to graduate student and to participate in advanced research in the laboratory of a faculty member on a two-semester trial basis. This allows the student to both evaluate their abilities and interests, and to provide themself with first-hand knowledge about at least one research group. This course is complemented with a Professional Development Seminar series (C505) that provides guidance on how to navigate the graduate program. The C500 course also provides the student an early opportunity to survey the literature pertinent to their research project and to write a plan of their C500 research project. These processes of orientation and evaluation represent the primary objectives of C500, both from the point of view of the student and from that of the faculty and thesis committee.

C500 is completed after two semesters, whether a research project has been completed. At the end of the two semesters, students submit a report on their work, and based on this report and their own observations, **the research advisor and graduate committee assign a C500 grade**. It is imperative that the student submit their report before or at the time of the deadline. Otherwise, these project reports will be given less consideration for an award nomination. To the student's question, "Will I be able to attain a PhD?" this grade provides a concise answer: A, yes; B, maybe; C, unlikely.

Participation in C500 implies no permanent commitment on the part of either the student or the supervising faculty member beyond the first year. In other words, this course is considered an “extended lab rotation”, but with no commitment to rotate afterwards if the student desires to continue in their original Ph.D. project. Students are strongly encouraged to take advantage of this flexibility when they feel that it would be better to change research groups at the end of C500. While a reluctance to "throw away" the research efforts of the first year is only natural, it should be recognized (1) that a major benefit derived from C500 by most students is a beginning, at least, on "learning to do research," and that this experience will move with them to any new research area; (2) that first-year results usually play a very minor role in most completed PhD theses, if they are included at all; and (3) that moving to a research area in which students are developing strong interest or a group environment that works better for them could significantly enhance the quality and quantity of their personal research efforts.

PROCEDURES

Enrollment. New students entering the graduate program in chemistry normally enroll in C500 for two credit hours in their first semester and four credit hours in the spring term, submitting their final report at the end of their second semester of graduate study. Students must enroll for a total of six (6) C500 credit hours for their first year. Exceptions are made on an individual basis, commonly for students who arrive at less traditional times or do not identify a C500 advisor during the fall semester.

There are three parts to C500:

1. Attendance at C500 faculty talks and participation in C505 Professional Development Seminar, which includes discussions on identifying research interests and mentoring needs (fall semester)
2. Joining a Group and Writing a C500 Plan of Research (due Friday, January 10, 2025)
3. Research and C500 Final Report (due Wednesday, April 16, 2025)

C505 Professional Development Seminar. Students are expected to attend and participate in a seminar series held on Thursday 8:00 – 9:15 am (please review course syllabus) for a total of ~6 weeks of the fall semester. The series includes a mixture of lectures, activities and panel discussions that will involve various faculty members and senior graduate students.

The course is intended to help build the bridge that will enable the transition from undergraduate studies to graduate research activities. This course recognizes the high degree of commitment that each student makes to their personal advancement through graduate level research. This course provides a framework that allows each student to create the very best PhD for their interests. Components of the course include discussions of strategies on how to explore, evaluate, and select an ideal research group as well as how to conduct good research. Guidance will be given on how to plan for the next 4-5 years of graduate studies and what to expect as the student advances from one year to the next.

This course will provide deeper guidance on teaching strategies for the different roles a graduate student has when being an Associate Instructor (AI). Discussions will also be undertaken on the ethical issues surrounding research, from authorship to misconduct.

This course also provides guidance for the research plan, which is due to the research advisor on January 10, 2025.

A common theme of the course is how to balance research with teaching and broader outreach activities. Managing these elements leads to a balanced portfolio of activities that culminates in the production of an excellent PhD within 5 years.

Writing a Research Plan for their C500 Project. Students will write a research plan after they have joined a research group (see below for details on joining a group). These 2-page plans will match the style of the scientific portion of an NSF Graduate Research Fellowship Program (NSF-GRFP). Eligible students (e.g., U.S. citizen, national, or permanent resident) can submit an NSF-GRFP application in either their first or second year; check the rules for eligibility. Other funding agencies also offer chances to apply for fellowship support, which even includes HHMI's program to support international students. For this reason, the skills learned can be applied in multiple areas during the student's tenure at IU.

Lessons on writing the research plan will be provided during the C505 Professional Development Seminar series and a general fellowship workshop is offered during the fall semester. Students are also encouraged to consult with other members of their group and their research advisor in the preparation of the plan.

Students will submit their C500 Research Plan to their research advisor and the Graduate Office. The students should request feedback on both the writing of the document and the plans that they have outlined.

Choosing a Research Adviser. Students are strongly encouraged to read about the active research projects in faculty laboratories by visiting faculty web pages, reading papers, and meeting with senior students. Students should plan to spend 5-15 hours each week investigating multiple groups. The C500 course features a mechanism by which faculty and incoming graduate students can become acquainted.

First, students will attend short lectures given by faculty on their research. During this seminar series, students are expected to **attend the lectures given by professors in their major and minor areas and all of the Assistant Professors**. Students are expected to attend the lectures of at least 14 faculty during the seminar series (when available).

After the faculty seminars, students are to select whether they will follow the *Interview Pathway* or *Rotation Pathway* toward group selection. A webform specifying which pathway a student plans to follow is due to the Graduate Office on September 10 (by 4pm). The Director of Graduate Studies and the Graduate Standards Committee will review, balance, and finalize student group interview selections.

For the *Interview Pathway,* students are required to arrange to have multiple types of interactions with 5 research groups of their interest. These include the following: (1) meetings with faculty, (2) shadowing student(s) and/or postdoctoral scholar(s) on one or more occasions, (3) attending group meeting(s), (4) meetings with students or postdoscs to discuss the research, (5) attending a group lunch or dinner or other social gathering, (6) learning/observing how to use an instrument or a particular experiment that is specific to one group etc. ***Students are required to meet with one assistant professor*** in their area of interest, or near to their area of interest. Students will be given a C500 faculty signature sheet from the Graduate Office. Interviews will be held from September 16 and will end November 8. Students should meet with at 5 research groups through ~3 interactions each. Of these 5 research groups, students will participate in a 1-week lab immersion—either Sept 16–20 or Oct 28–Nov1.

For the *Rotation Pathway*, students will identify 5 potential rotation groups. Students are guaranteed to rotate in their top three laboratory choices. We will aim to place students in their fourth choice as well but that may be assigned to make sure there is adequate spread among the faculty**.** The nature of the rotation will be defined by the group. At a minimum, students should attend all group meetings during the rotation window, arrange for a laboratory tour, and shadow senior students at least once a week (when the laboratory space allows). A graduate student liaison will help to introduce you to the group.

Schedule:

- Rotation 1: Sept 16–27
- Rotation 2: Sept 30–Oct 11
- Rotation 3: Oct 14–25
- Rotation 4: Oct 28–Nov 8

On Wednesday, **November 13** the C500 Selection webform need to be submitted to the Graduate Office with the student's order of preference for a C500 advisor, along with the Group Selection Reflection. Students are encouraged to select **two** first-choice selections. The Director of Graduate Studies and the Graduate Standards Committee, according to the preference of each individual will make a tentative assignment of each student to a C500 advisor, pending approval by the Department Chair. Graduate students will then be assigned to a laboratory to begin their C500 course project. Students will officially join their C500 group on Monday, November 25, or as soon as possible pending committee approval.

The final C500 report will be due **Wednesday, April 16, 2025**. After the spring semester is completed, students will receive an email message from the Graduate Office, asking whether they wish to continue to do research with the C500 advisor, or if they plan to switch to a different advisor. At this point, the student should consider scheduling an appointment with the faculty advisor to discuss continuing.

Students entering in the summer prior to formal enrollment will work as personnel under the direction of a research mentor. Beginning early does not represent commitment from the student to join that research group (or from the faculty to take the student as a group member). These students will enroll in the C500 course and follow the same protocol as the rest of the entering class. Students may stay in their research group. Nevertheless, they are expected to explore the breadth of research being conducted as a part of the C500 course requirements. Students are encouraged to begin this exploration while they are conducting their summer research activities. These interactions with other research faculty and their groups lay foundations to more easily collaborate in future years and to develop the skills to reach out for collaborations with other groups in the future. The best collaborations are synergistic and usually involve groups with complementary and non-overlapping expertise.

Assignment of Students to Advisers. Assignments are managed by the Graduate Standards Committee, which can limit the number of students assigned to each faculty member, and which must approve all research assignments. The Department Chair then has final approval over the C500 assignments. The range of interests represented in each incoming class is usually quite broad, providing a reasonable match to the range of interests within the faculty. It often happens that most students can be assigned to their "first choice" of research adviser. Problems arise only when a given adviser is selected by more students than can be reasonably accommodated. When this occurs, no final decision is reached without conferring with all the students involved. Experience has shown that satisfactory arrangements can usually be found. Therefore, it is imperative that students meet with faculty outside their first choice and encouraged to select two first-choice faculty.

C500 Final Report. Research activities undertaken during the first and second semesters are devoted entirely to advancing the research project and the preparation of a final report. The final report should be a “term paper” worthy of six semester hours of credit. It must reflect sustained effort, care, and thoroughness both in the preparation of the report itself and in the related studies and research. Minimally, it should include:

1. A title that represents the topic of the work.

2. An introduction clearly stating the objective of the work.

3. A discussion of important background information. This should not be an extensive review, but it should explain the "starting point" for the work. Facts that the reader will need to know in order to follow and understand the research report should be anticipated and presented here. Any points which involve discussion of results obtained in the course of the project should be avoided in this section.

4. A description of experimental techniques and procedures (this section can be placed at the end of the report). Presentation of results (other than routine characterization of synthetic products) should be avoided in this section.

5. A results and discussion section. This should be the longest section of the report. It is impossible to provide an outline that will be generally applicable. Each project will have unique features that call for specific modes of organization. A few points that may be useful, however, are:

a. Presentation of all results before any discussion is usually difficult both for the author and for the reader. It usually is best to present each point of discussion as soon as the necessary results have been reported. This approach will help to sustain the reader's interest and will frequently lead naturally, to the presentation of the next set of results.

b. A system of headings and subheadings will be invaluable to the reader.

c. If there are fewer results than originally hoped for, the student should explain why. The C500 report is different from a conventional research report in this regard, but the making of excuses (as gracefully as possible) and an accounting for time is appropriate in a report which must be submitted by a particular deadline rather than when a project has been truly completed.

6. Include the appropriate set of references at the end of the report. All references provided by the student must be references **THEY HAVE READ**.

7. The length of the report should be 15-20 pages. Remember longer does not always mean better. An Appendix for supporting data is permissible. As a general rule, the document should be formatted for enjoyable reading by the student's advisor: 12-point font, Times New Roman, double-spaced paragraphs, clear organization, and clear figures that use readable fonts. It is always a good idea to ask senior graduate students to review the document prior to submission.

8. Students are further encouraged to discuss questions regarding the preparation of their report with their research advisers and to consult examples of the C500 report from other group members that were evaluated positively. *A time of approximately two weeks prior to the spring deadline for the completed reports*. An electronic copy in pdf form should be submitted to the Graduate Office and one copy to the C500 research adviser. Incompletes are not permitted in the second semester. As stated above, turning in a report on a timely manner is strictly enforced. Late reports or extensions will result in unfavorable circumstances for the C500 nomination. While it is true that a research adviser's casual observation of a student

might provide much of the important information on which a C500 grade is eventually based, the C500 report itself has great importance for at least four reasons.

1. For the student, contemplation of the eventual necessity of putting sensible works on paper should be a powerful motivating and organizing factor. Knowledge of the criteria employed in evaluating a report (described below) can help to guide a student's efforts by improving his or her understanding of how to translate the philosophical goals of C500 into practical activities.

2. For the potential thesis adviser, the C500 report provides the kinds of information unobtainable through casual observations. Can the student write effectively? Can the student finish things (even if only a thought, or a report – not necessarily an entire research project)?

3. For other members of the faculty, especially the graduate committee, who must somehow make an estimate of the student's potential for doctoral work, the C500 report provides a product which is, under the circumstances, the best indicator of a student's potential for completing a thesis. While this kind of evaluation must be carried out with great care and with an eye to the substantial uncertainties involved, the C500 report does represent the student's individual efforts over a substantial period of time on a project of his or her choice.

4. The report will be shared with student's thesis committee (to be assigned during the second year). Thus, the committee will get a first impression of the student, their project and the quality and quantity of research conducted during the C500 period.

The criteria employed in the grading of the C500 reports differ to some extent between various faculty members and sub-disciplines, but students should not fear that undue importance is being placed on the report (i.e., document) itself. To elaborate on this point, it is useful to list briefly three basic areas which can be considered to have equal importance in the evaluation of C500 projects:

I. The report itself
   A. Organization
      1. Is the outline of the project clear?
      2. Is the report adequately subdivided?
   B. Form and appearance
      1. Are references clear and correct?
      2. Are headings and subheading adequate?
      3. Does the report present a good appearance?
   C. Grammar, spelling and word choice
   D. Clarity of expression

II. The effort apparently devoted to C500

A. The scope and adequacy to technical developments

1. The quantity and quality of results
2. The potential demonstrated for future effort

III. The estimated potential for doctoral research (Is the work above the undergraduate level?)

A. Effective use of the literature

1. Has the student become aware of other work relevant to the project?
2. Have the findings of others been used in order to guide and strengthen the project?
3. Does the student read the previous work to improve on current technology and does he or she apply previous findings in their project.

B. Understanding of the project

1. Has the student clearly indicated the significance of the work?
2. Are the objectives, experiments, and conclusions well described and supported and has the student demonstrated an understanding of the background and project goals?

C. Correctness of science

1. Are there any scientific errors?
2. Are there any significant oversimplifications?

The C500 Award

The following April an award is presented to the graduate student who has submitted the most outstanding C500 report in the preceding academic year. Criteria for selection of the outstanding report include the quality and quantity of the research, the originality of approach, the quality of the final report, and if such document was submitted on time. The C500 award is one of our department's most prestigious awards and recognizes graduate student(s) early in their Ph.D. career.