Medicinal Chemistry Graduate Student Handbook
INTERDEPARTMENTAL GRADUATE PROGRAM IN MEDICINAL CHEMISTRY

GUIDE TO GRADUATE STUDENT REQUIREMENTS

This brief document provides a summary of the requirements that must be fulfilled to earn the Ph.D. degree in Medicinal Chemistry and the timeline for meeting these requirements. Current versions of all required forms (underlined in this document) are available on the Med Chem IDP Ctools site or from the Med Chem office.

FIRST-YEAR GRADUATE STUDENTS

New graduate students are assigned an academic advisor for their first-year in the Medicinal Chemistry IDP. This advisor will help the student with course selection and other aspects of the first-year. Prior to the beginning of the first semester, all new graduate students take the organic and biochemistry qualifying examinations, to aid in the selection of the appropriate first term courses. Those who pass enroll in Chem 540 and/or Biochem 550 or ChemBio 501 (see Curriculum on p. 7). Those whose performance indicates that they are not yet prepared for Chem 540 enroll in Chem 419. Similarly, Biochem 515 will be elected for those who need more biochemistry preparation.

PRE-MATRICULATION SUMMER RESEARCH

It is usual for a number of our incoming students to want to come to Ann Arbor early and do some pre-matriculation summer research with one of the Medicinal Chemistry faculty. The Rackham Graduate School provides financial support for Merit Fellows through the Rackham Summer Institute (SI) to do such research, with some additional educational programming. To provide an equal opportunity for incoming students who are not Merit Fellows to conduct pre-matriculation research, the Medicinal Chemistry Department will cost-share (50:50) with individual Medicinal Chemistry IDP faculty members to support this work. The Medicinal Chemistry program mimics the Rackham SI program (e.g., same stipend for work from ~June 15-August 15). Work beyond the stated time frame is optional for the student and faculty member to arrange and support.

Note that this summer research does not count as an official rotation, students must do research rotations in the Fall and Winter terms. However, the student may not rotate with the same faculty member with whom they did their pre-matriculation summer research.

To apply for funding, the faculty member should send an email to Sarah Lloyd indicating the student involved, a brief title or description of what they will do for their research and a description of how the faculty member will provide their half of the support. No funds are available for supplies, travel etc. Requests should be submitted by May 15th.
MEDICINAL CHEMISTRY 660: Responsible Conduct of Research and Scholarship (RCRS) in Pharmaceutical Sciences.

This course is REQUIRED for the ALL first year graduate students entering the College of Pharmacy (this includes Medicinal Chemistry, Pharmaceutical Sciences and Clinical, Social and Administrative Sciences) and is designed to satisfy the requirement of many government and national funding agencies for a standard course in the responsible conduct of research and scholarship in the biomedical sciences. The course has also been designed to bring a cross-section of the entire research community of the College of Pharmacy together to foster a better understanding of the contribution of each discipline in the overall bench to bedside efforts of drug discovery and patient care.

This course meets once a month from 5-7 PM for the entire school year (9 classes); pizza and drinks will be provided. Attendance and active participation is REQUIRED for every new graduate student in the COP. Every other MONTH a chapter in an ethics book will be assigned to ALL students to read as well as a short case study will be assigned to each student to presented to their classmates with class discussion following each presentation. The cases will be presented as small groups made up of students from each discipline. The book, “Scientific Integrity: Text and Cases in Responsible Conduct of Research” (3rd Ed.) by Francis L. Macrina, ASM Press, will be available for checking out from the Medicinal Chemistry Office (4569 CCL). The book must be returned at the end of the course to receive your grade. The class will be graded on the satisfactory/unsatisfactory scale system. In the alternate months, guest lectures will present information regarding various aspects of research in the COP as well as various resources available to researchers at the COP and the entire campus. It is also possible that during the year, senior students from the different disciplines/departments will present short seminars regarding their PhD research projects. You will be issued a permission to enroll in the course as soon as it is available in Wolverine Access. You will also be given access to the course C-tools site which will have the monthly schedule, location, and assignments.

RESEARCH ROTATIONS

In order to help students in their choice of a mentor and research group, and to gain understanding of the breadth of research in the Medicinal Chemistry program, all new graduate students are required to register for semester-long lab rotations in both the Fall and Winter terms. This is done in the form of the course, Medicinal Chemistry 573 (see Curriculum section). New students are expected, as soon as possible, to arrange meetings with individual Medicinal Chemistry faculty members in order to choose a lab in which to fulfill the Med Chem 573 requirement for the Fall term. Faculty interviewed, sign the Rotation Interview Form. This choice should be made after attending the faculty research presentations and by the end of the first week of the Fall term. In almost all cases, first-year students will elect to do their dissertation research in one of the two labs in which they have done rotations. The program does not require a
rotation in the lab prior to joining it; however, individual faculty may require a rotation. In special cases, students may make a request to the Medicinal Chemistry IDP Director to complete a third rotation during Spring term of their first-year before selecting a mentor. In all cases, first-year students must match with a mentor by the end of Spring term.

So that both faculty and students have equal opportunities for research rotations, there are a few rules. Eight (8) weeks or more of research undertaken by incoming graduate students during the Summer prior to the beginning of their graduate studies constitutes a “significant research experience” (SRE). An SRE performed under faculty within the Medicinal Chemistry IDP precludes first-year students from choosing the same lab for a formal (MC573) research rotation. The objective here is to allow all students equal access to faculty labs for rotations. For the Winter term rotations, you should approach faculty members that you are considering rotating with no earlier than November 15th to express your interest in their labs. Faculty have to wait until the first Friday in December before they can officially sign off on a winter rotation request, in order to allow all students to interview faculty for Winter term rotations.

Students are encouraged to spend as much time as possible in their rotation labs, even when not actively working on their projects. This will help the students become acclimated to the program and to the research environment. Senior students and Postdocs are valuable resources for first year students, not just for their rotation projects, but also for classes etc. The Med Chem program expects that students will spend at least 25 hours per week on the rotation work. Individual faculty members may set their own expectations. Students and faculty mentors should discuss and agree on the rotation expectations at the very beginning of the term.

At the end of each rotation, students prepare a report consisting of a title page (see Appendix 4 for example), introduction, results, discussion and conclusion sections, cited references, and a full experimental section. The report must be prepared independently by the student and is due on the last day of classes. The report is critiqued by the research mentor (who fills out an evaluation form and assigns a grade) and returned to the student. The faculty mentor also reviews the rotation evaluation with the student and both of them sign the evaluation form. The student will then revise the report based on the critique from the mentor. The revised report is due to the mentor by January 31st for Fall term rotations and May 31st for Winter term rotations. A copy of the final rotation report and the Rotation Evaluation Form, signed by the rotation mentor and student, are to be submitted to the Medicinal Chemistry office and are maintained in the student’s file. The student and rotation advisor should both keep copies of the evaluation form and the report.

Beginning approximately March 15th, students should discuss the possibility of joining a lab with prospective mentors. After April 1st, students may officially join labs by having their mentor sign their rotation/lab selection form. Students are required to complete their Winter term rotations.
CURRICULUM

The Medicinal Chemistry PhD academic program is divided into four tracks to allow students to customize their curriculum with courses specific to their area of research interest and yet maintain the commonality in the basic fundamentals of Medicinal Chemistry. Note: you must achieve no less than a “B” in each of the core medicinal chemistry courses (MedChem) in order to pass.

Track Course Requirements (credits in parentheses, track-specific courses in bold)

**First Year**

All Tracks: MedChem 660 (1)

### Biochemical Track (Bioc):

<table>
<thead>
<tr>
<th>Fall Term</th>
<th>Winter Term</th>
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<tr>
<td>MedChem 532 (3)</td>
<td>MedChem 533 or 534 (3)*</td>
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<td>MedChem 573 (3)</td>
<td>MedChem 573 (3)</td>
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<tr>
<td>Chem 540 (3)</td>
<td>Elective (1-3)</td>
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### Biophysical Track (Biop):

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<td>MedChem 573 (3)</td>
<td>MedChem 573 (3)</td>
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<tr>
<td>BiolChem 550 or ChemBio 501 (3)</td>
<td>Elective (1-3)</td>
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<td><strong>Biophysics 520 (3)</strong></td>
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### Bioinformatics Track (Bioinf):

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<th>Fall Term</th>
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<td>MedChem 573 (3)</td>
<td>MedChem 573 (3)</td>
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<tr>
<td>BiolChem 550 or ChemBio 501 (3)</td>
<td>Elective (1-3)</td>
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<tr>
<td><strong>Bioinf 527 (4)</strong></td>
<td><strong>Bioinf 575 (3)</strong></td>
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### Organic Track (Org):

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<td>MedChem 533 or 534 (3)*</td>
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<td>MedChem 573 (3)</td>
<td>MedChem 573 (3)</td>
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<tr>
<td>Chem 540 (3)</td>
<td><strong>Chem 541 (3)</strong></td>
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<td><strong>Chem 543 (2)</strong></td>
<td><strong>Chem 542 (3)</strong></td>
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*MedChem 533 and 534 are offered in the winter term, alternate years.*
Second-year (all tracks)

<table>
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<tr>
<th>Fall Term</th>
<th>Winter Term</th>
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<tbody>
<tr>
<td>BiolChem 550 or ChemBio 501 (3)(^1)</td>
<td>MedChem 533 or 534 (3)*</td>
</tr>
<tr>
<td>Chem 540 (3)(^2)</td>
<td>Elective (1-3)</td>
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<tr>
<td>Elective (1-3)</td>
<td>MedChem 990 (0-9)(^3)</td>
</tr>
<tr>
<td>MedChem 990 (0-9)(^3)</td>
<td>MedChem 740 (0.5 each, Fall and Winter)</td>
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\(^1\)For Organic Track.

\(^2\)For Biophysics & Bioinformatics Tracks. This could be taken in 1\(^{st}\) year and BiolChem 550 or ChemBio 501 in 2\(^{nd}\) year.

\(^3\)MedChem 990 (pre-candidacy research) is taken to fulfill the 9 credits per term minimum.

**Elective courses:** Elective courses in the student's area of interest are required by the Medicinal Chemistry IDP. The total number of elective credits needed by each track is as follows: 6 credits for Biochemistry Track, 3 credits for Biophysical Track, 0 credits for Bioinformatics Track, and 1 credit for Organic Track. Your advisor will help you choose among possible electives, which must be approved by the Medicinal Chemistry IDP Director. Some potential electives are listed in the appendix.

Third and Subsequent Years (all track)

All students who have been admitted to candidacy register for 8 credits of Med. Chem. 995 per term and may take one additional course (regardless of the number of credits) per term with no additional tuition fees (per Rackham guidelines).

Med. Chem. 995 (Fall and Winter, 8 credits)
Elective (option of 1 course per term)
MEDICINAL CHEMISTRY 740: Original Research Proposal

In addition to the courses listed in the Curriculum section, each student must prepare an original research proposal (ORP) in an area outside his/her dissertation research. This is done as a separate course, Medicinal Chemistry 740 (Med Chem 740), which must be completed prior to candidacy by the end of February of the Winter term of the second-year.

Two hallmarks of the PhD degree are the ability to engage in thorough independent scholarship, and to plan and conduct original research based on that scholarship. The ORP is designed to provide the student with the experience of researching a medicinal chemistry topic from the literature and then proposing novel studies to extend that work. The research topic will ideally be complementary to the student’s thesis research, i.e., not directly related, but relevant enough that increased knowledge in the area will add value to their thesis research. One overarching theme of medicinal chemistry involves the relationship of chemical structure with biological activity and function. Therefore, it is important that the proposal include some discussion of chemical structure. Medicinal chemistry research is a collaborative effort. It is important to be able to effectively work with others, to both give and receive constructive criticism and these are incorporated into MC 740. The evaluation of the proposal will focus on the following key aspects:

- depth and breadth of scholarship (45%)
- quality, organization and clarity of overall document (25%)
- feasibility of the ORP (10%)
- creativity of the ORP (10%)
- collegiality/working with peers (10%)

The general procedure is the following (details will be provided in the course syllabus):

- Students will register for MC 740 in their 2nd year.
- Prior to or at the beginning of the Fall Term, 2nd year students will meet with the Med Chem 740 Coordinator to review the guidelines and evaluation process.
- The Medicinal Chemistry IDP Director and Med Chem 740 Coordinator will assign a committee of three faculty members to evaluate the final presentation/defense. One committee member very familiar with the Medicinal Chemistry Program will chair the proceedings. The student’s advisor cannot be a member of the committee. The student and/or mentor are free to suggest committee members. (This committee will also serve as the student’s candidacy committee.)
- The student’s advisor can guide the student in the selection of an appropriate topic and can be available for limited consultation (as this is an independent proposal) throughout the proposal preparation process.
• After the student selects a topic, it must be submitted to their Med Chem 740 committee for approval. This should include a list of proposed specific aims and a brief (1 pg) description of the student’s own dissertation research.
• The committee must ensure that the topic is sufficiently distinct from the student’s own research area to fulfill the course criteria. If unacceptable, the committee will require the student to submit a new topic. They will also review the proposed specific aims and provide feedback for the student.
• The course will include lectures on Grant Proposal Writing that highlight the strategy and techniques of successful grant writing, arranged by the Med Chem 740 Coordinator.
• Each student will be assigned a “partner” from the class. Partners will critically review each other’s proposal drafts for clarity, accuracy, etc.
• A written proposal must be distributed by the student to his/her Med Chem 740 committee at least 2 weeks prior to the presentation/defense.
• The written proposal must take the form of an NIH R21 proposal using the following approximate page guidelines:
  • Title Page (1 page, see Appendix 4 for example)
  • Abstract (1/2 page)
  • Specific Aims (1 page)
  • Research Strategy (6 pages limit)
    ▪ Significance and Innovation (≤ 1 page)
    ▪ Background (2-3 pages)
    ▪ Approach (2-3 pages)
  • Bibliography (no limit)
• The format for references is based on JACS format, with the addition of the titles of the papers and inclusive page numbers (Smart, I. M.; Cool, U. R. Novel effects on a very interesting system. J. Am. Chem. Soc. 2008, 130, 253-259.)
• NIH guidelines for font (Arial 11 pt), single space, and margins (0.5” to 1” on all sides) are to be followed.
• The student should prepare a 45-50 minute oral presentation, using Powerpoint or similar presentation software that encompasses the entire proposal. The student should create attractive slides, clearly readable from the back of the room (avoid poor-resolution figures and tables and very small fonts), but the main objective of the presentation is to focus upon the content of the proposal and the development of oral presentation skills.
• The oral presentation should follow the NIH proposal format and be weighted accordingly, i.e., the number of slides for each section should be approximately proportional to the number of pages in the proposal.
• The student will present at least one practice presentation in front of the other Med Chem 740 students. Attendance by the other students at these practice sessions is mandatory, and each attending student will be required to provide a brief written evaluation of the proposal. Although the final Med Chem 740 grade will in most cases reflect the committee evaluation of each student’s presentation/defense, failure to participate fully in these practice sessions will have a negative impact on the final grade (see above grading guide).
The final Med Chem 740 presentations will be scheduled by the student and their committee with the assistance of the Med Chem 740 Coordinator, but must be completed before the end of February. Each student will present in a closed conference room in front of their Med Chem 740 committee. The committee will be free to interrupt at any time with questions, so a total of 90 min will be allotted for the entire presentation/defense.

Following the presentation, the student’s Med Chem 740 committee (all required to be present) will discuss the presentation/proposal, and the chair will draft a written summary evaluation. After approval by the rest of the committee, the evaluation will be submitted to the Med Chem 740 Coordinator. The evaluation summary will be given to the student’s advisor for discussion with the student. In addition to assigning a pass/fail grade, the committee’s evaluation will address the following:

- strengths and weaknesses of the written proposal
- strengths and weaknesses of the oral presentation and defense of the proposal
- identify any areas of the student’s preparation that are particularly strong and that are in need of improvement
- a recommendation for pass or fail grade

If, in the committee’s view, the student’s performance is unacceptable, then the Med Chem 740 feedback and the student’s entire file will be reviewed by the faculty at the soonest department meeting and a course of action (e.g., remedial work) will be determined by the faculty.

The student’s advisor (not involved in the grade assignment) will meet with the student, preferably within 1-2 weeks of the oral presentation, to discuss with the student the written summary of the committee evaluation and their grade. A copy of this summary, signed by the student and the mentor, is to be submitted by the student or the student’s advisor to the medicinal chemistry office and is kept in the student’s file. A copy should also be given to the Med Chem 740 Coordinator so that a final grade can be assigned. (Subsequently, the preliminary/candidacy exam committee will review this prior to the student’s candidacy exam and will probe to determine if any deficiencies have been remediated.)
CANDIDACY REQUIREMENTS

Once course work and other requirements (see below) are met, graduate students can be admitted into candidacy by the Rackham Graduate School, upon recommendation of the Medicinal Chemistry faculty. This marks the transition from a largely classroom-based experience to one focused on independent research. Under normal circumstances, it is expected that all graduate students complete the requirements for candidacy by the end of their second-year in the program.

Rackham Graduate School requirements for admission into candidacy include:

A. Faculty in the Medicinal Chemistry IDP determine the academic integrity of the degree in terms of requirements, achieving milestones, and completing the degree.

B. Rackham requires Ph.D. students to complete 18 hours of coursework in-residence during the pre-candidacy stage of their doctoral studies. That means they want you to take 18 credits worth of "real" classes here on campus. You may accumulate more than 9 credits of "in-residency" courses in a single term. Med Chem 990 does NOT count toward the "in-residency" credits.

C. At least 4 credits must be from a course in a “cognate” field.

D. In order to maintain "full-time" status, graduate students must enroll for a minimum of 8 credits in each of the Fall and Winter terms. You do NOT have to enroll for either the Spring or Summer terms.

E. You must maintain a cumulative minimum GPA of “B” (3.0 on a 4.0 point scale) or higher. The Medicinal Chemistry Program has established that a grade of “B” is the minimum passing for any of the “core” Medicinal Chemistry courses (see curriculum).

F. You must complete all Medicinal Chemistry course requirements.

G. Successful completion of the Candidacy Examination (see below).

If you follow one of our prescribed curricula, all of the above will be satisfied automatically.
CANDIDACY EXAMINATION

The candidacy meeting/examination is designed to evaluate the student’s preparedness for dissertation studies by examining the student’s knowledge in the fundamental scientific disciplines underlying the proposed Ph.D. research and their research skills by assessing their progress to date. Although many aspects of the exam may focus on the research proposal, this is not meant to be a dissertation committee meeting. Candidacy Committee Chairs are advised to focus the exam on the student’s preparation and readiness (including pertinent research skills) for embarking upon their dissertation research. The candidacy committee is expected to review the student’s Rotation Reports (MC 573) and MC 740 Evaluation. Any deficiencies or weaknesses identified in either of these benchmarks are to be explicitly probed in the candidacy exam.

The procedure is the following:

- The candidacy exam will take place between May 1st and July 31st.
- The candidacy committee will have been previously selected for the student’s Med Chem 740. Any necessary changes and an alternate must be approved by the Medicinal Chemistry IDP Director. The alternate attends the examination only if one of the three members is absent due to extenuating circumstances. The student’s faculty mentor also attends the examination, in an ex officio capacity, to advise the committee of the student’s overall progress but otherwise does not participate in the discussions and does not vote on the outcome. The Medicinal Chemistry IDP Director, or designee, will assign one committee member experienced in Medicinal Chemistry Preliminary Exams to chair the proceedings. Upon approval of the committee composition, the student consults with the committee to arrange a meeting for the candidacy defense.
- A written proposal for the student’s own thesis research is required and should be submitted by the student to the entire committee, and to the Medicinal Chemistry office, two weeks prior to the meeting date. The proposal should describe a research project in the broad area of Medicinal Chemistry. The student’s faculty mentor is responsible for guiding the preparation of this proposal.
- The written proposal must take the form of an NIH R21 proposal using the following format (approximate page guidelines):
  - Title Page (1 page, see Appendix 4 for example)
  - Abstract (1/2 page)
  - Specific Aims (1 page)
  - Research Strategy (6 pages limit)
    - Significance and Innovation (≤ 1 page)
    - Background and Progress Report (2-3 pages)
    - Approach (2-3 pages)
  - Bibliography (no limit)
- In addition to the proposal, copies of the student’s Med Chem 573 and Med Chem 740 evaluations will be distributed to the committee along with the
proposal. The student’s entire file, from the Med Chem office, will be available at the meeting for the committee to review. It is the responsibility of the student and/or the mentor to ensure that the evaluations have been distributed with the proposal to the committee and that the student’s file is available at the meeting.

- The candidacy meeting will take the form of an oral presentation and defense of the research proposal. The student may prepare a limited number (~25) of slides (usually a Powerpoint presentation) but will not be expected to rely entirely on visual aids to answer the questions put forth by the committee. The student should prepare an oral presentation of about 40 minutes. Given interruptions for questions and answers, it is expected that the exam will take no more than 2 hours.

- Immediately following the meeting, the committee determines whether or not to recommend advancement to candidacy. The committee’s evaluation and recommendation is then submitted to the Med Chem office on the Prelim/Candidacy Report Form and is kept in the student’s file.

- The Candidacy Committee Chair (not the student’s faculty mentor) shall be responsible for moderating the pre-candidacy meeting and preparing and submitting the Prelim/Candidacy Report Form and presenting it to the faculty at a faculty meeting where it will be reviewed and voted upon by the Medicinal Chemistry faculty.

- In the event that the committee deems a student’s performance unsatisfactory, the student may be granted a second attempt at the exam. In this case, this attempt must be made during the Fall term of the third year.
POST-CANDIDACY
EMBEDDED MASTER’S DEGREE

An "embedded master's" is a master's degree awarded "on-the-way" to a Ph.D. in the exact same program. An embedded master's is NOT required for completion of the Ph.D. degree. The decision to apply for an embedded master's rests with the student and is neither encouraged nor discouraged by the program. Upon advancement to candidacy, students may request to apply for an embedded master's. The student must notify the Medicinal Chemistry office that they wish to apply for an embedded master's degree. The office will process the request and then the student will receive notification from the department that they can log onto Wolverine Access Student Business and "Apply for Graduation".
(See: http://www.rackham.umich.edu/downloads/oard-embedded-masters-tip-sheet.pdf)

POST-CANDIDACY REQUIREMENTS

ENROLL in Med Chem 995 each term. Per Rackham guidelines, students may also elect to take one additional course (1 course regardless of the number of credits) each term.

THIRD YEAR SEMINAR: In each student’s third year of studies, they will present a public seminar to the IDP on their research project, encompassing background, goals, progress to date, and plans for the future. The student’s mentor will guide him/her in the preparation of this presentation. The seminars will be held in the Winter term of the student’s third year. The students' dissertation committee will meet to give the student feedback as soon as possible after the seminar, so all committee members should be present. A brief written summary of the feedback should be submitted to the Med Chem office by the student’s mentor and a copy shared with the student.

DISSERTATION COMMITTEE: A dissertation committee consistent with Rackham guidelines must be proposed within 2 months of admission to candidacy and must be approved by the Medicinal Chemistry IDP Director. The Dissertation Committee Meetings should be held during the Fall term of the fourth and subsequent years. The student will submit a written progress report to the committee for review at least 2 weeks prior to the annual committee meeting. The Dissertation Committee Meeting (DCM) Report Form is filled out by the student and advisor prior to the meeting. After the meeting, the committee summary is added to the form by the student’s faculty mentor, signed by both student and mentor and submitted to the Med Chem office and is kept in the student’s file.

DATA MEETING: 4-6 months before the final defense, a Dissertation Committee meeting is held to discuss the data generated and to identify any required, final
experiments. A Data Meeting Report Form (distinct from the DCM Form) is filled out by the mentor and a copy is submitted to the Med Chem office and is kept in the student’s file.

DISSERTATION DEFENSE: The defense includes a public seminar presentation, ideally included within the regularly scheduled Medicinal Chemistry seminar program. This public presentation is followed by a private session with the Dissertation Committee. The Dissertation Committee members are provided with copies of the dissertation at least 2 weeks prior to the defense. See the Rackham Website (http://www.rackham.umich.edu/dissertation_information/) for further administrative guidelines regarding the dissertation defense process and dissertation format instructions. See also Appendix 5 for logistical information about scheduling your defense.
APPENDIX 1 - COURSE DESCRIPTIONS: (required courses)

Medicinal Chemistry 532 (3 credits): Bioorganic Principles of Medicinal Chemistry. Prerequisites: Biochemistry 550 / Chem Bio 501 (or concurrent); Recommended: Chemistry 540 (or concurrent). A molecular/chemical approach to medicinal chemistry, emphasizing macromolecular targets of drug action.

Medicinal Chemistry 533 (3 credits): Survey of Medicinal Chemistry. Prerequisites: Medicinal Chemistry 532. A general survey of therapeutic agents in principal use today, with stress upon their origin, chemistry and mechanism of action.

Medicinal Chemistry 534 (3 credits): Modern Techniques in Drug Discovery and Development. Prerequisites: Medicinal Chemistry 532. A survey of methods used in contemporary pharmaceutical research including computational and combinatorial approaches, and high-throughput analysis of drug efficacy and metabolism.

Medicinal Chemistry 573 (3 credits): Investigations in Medicinal Chemistry. Prerequisites: none. A lab rotation course that allows the student to experience research prior to selecting a dissertation mentor.

Medicinal Chemistry 660 (1 credit): Responsible Conduct of Research and Scholarship (RCRS) in Pharmaceutical Sciences. (See detailed description above).

Medicinal Chemistry 740 (1 credit total, .5 credits per term): Original Research Proposal. The student presents an original research proposal on a topic distinct from, but related to his/her dissertation work (See detailed description above).

Medicinal Chemistry 990 (1-8 credits): Dissertation Research/Pre-candidacy. Prerequisites: Doctoral student status. Election for dissertation work by doctoral student not yet admitted to candidacy.

Medicinal Chemistry 995 (8 credits): Dissertation Research/Candidacy. Prerequisites: Advancement to candidacy. Election for dissertation work by doctoral student admitted to candidacy.
Bioinformatics 527 (4 credits): Introduction to Bioinformatics and Computational Biology. Prerequisites: Upper level or graduate level Statistics or concurrent enrollment in Statistics; Calculus I & II, Biochemistry, Molecular Biology, or Cellular Biology; or permission of instructor. This course introduces students to the fundamental theories and practices of Bioinformatics and Computational Biology via a series of integrated lectures and labs. These lectures and labs will focus on the basic knowledge required in this field, methods of high-throughput data generation, accessing public genome-related information and data, and tools for data mining and analysis. The course is divided into four areas: Basics of Bioinformatics, Computational Phylogeny (includes sequence analysis), Systems Biology and Modeling. There will be weekly homework, two take-home exams, and students will prepare and present group projects.

Bioinformatics 575 (3 credits): Programming Laboratory in Bioinformatics. Prerequisites: Some familiarity with computer programming is assumed. This course will introduce current software tools and information resources in bioinformatics. Topics will include rapid development programming languages (Python, Perl), relational databases (SQL), Java, exploratory data analysis in R and web services programming. The course will introduce computational biology applications (BLAST, BioConductor, Cytoscape and GenePattern). There will be a class project creating an information resource in genomics and molecular biology that will use these tools to retrieve bioinformatics data from multiple internet resources, build an integrated database and deliver web forms and graphical access. Grades will be based on programming exercises and participation in class discussions and cooperative development projects.

Bioinformatics 551 (3 credits): Proteome Informatics. (Elective Course) Prerequisites: The course is fundamentally interdisciplinary. Undergraduate Biochemistry and Calculus, or permission of instructor. Introduction to proteomics, mass spectrometry, peptide identification and protein inference, statistical methods and computational algorithms, post-translational modifications, genome annotation and alternative splicing, quantitative proteomics and differential protein expression analysis, protein-protein interaction networks and protein complexes, data mining and analysis of large-scale data sets, clinical applications, related technologies such as metabolomics and protein arrays, data integration and systems biology.

Biological Chemistry 550 (3 credits): Prerequisites: Biol. Chem. 415 or Biochemistry 451/452, or equivalent; or permission of instructor. This course covers protein structure, catalysis and kinetics.

Biophysics 520 (3 credits): Energetics, Interactions, and Dynamics of Biomacromolecules. Biological macromolecules such as proteins are at the basis of virtually all processes of life. These molecules are not the inert entities the pretty pictures suggest -- they interact with other molecules, they fold, they
catalyze reactions, they change their conformation, they move around. In this course we will try to share the excitement of understanding how these proteins really work -- in terms of energy functions, in terms of changes of conformation, in terms of kinetics and dynamics.

**Biophysics 521** (3 credits): Physical Methods for the Study of Biomacromolecules. This course gives background and applications of several physical techniques used in Biophysical research. General principles of spectroscopy will be explained. Macromolecular structure determination by X-ray diffraction and two-dimensional NMR will be treated in detail. IR, Raman, CD, EXAFS, and single molecule spectroscopy will be introduced.

**Chemical Biology 501 and 502** (3 credits, each): Chemical Biology. Two semester sequence in chemical biology focusing on the biological context of chemical reactions and on molecular level (chemical) explanations for biochemical phenomena.

**Chemistry 540** (3 credits): Organic Principles. Principles of chemical bonding, mechanisms of organic chemical reactions and stereochemistry. The important types of organic reactions are discussed. Basic principles and physical organic chemistry are emphasized; however, relatively little attention is paid to the scope and synthetic applications of the reactions.

**Chemistry 541** (3 credits): Synthetic Organic Chemistry. The scope and limitation of the more important synthetic reactions are discussed within the framework of multi-step organic synthesis.

CONSULT INDIVIDUAL DEPARTMENTS WEBSITES FOR DESCRIPTIONS OF ADDITIONAL COURSES
## APPENDIX 2 – Timetable of Deadlines

<table>
<thead>
<tr>
<th>Item</th>
<th>Students</th>
<th>Term/Month</th>
<th>Form</th>
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<tbody>
<tr>
<td>ACS Exams</td>
<td>1st Yrs</td>
<td>end of August</td>
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<tr>
<td>1st Year Evaluation</td>
<td>1st Yrs</td>
<td>end of Winter term</td>
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</tr>
<tr>
<td>MC 740 (ORP)</td>
<td>2nd Yrs</td>
<td>Fall/Winter, by end of February</td>
<td>Yes, Med Chem</td>
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<tr>
<td>Prelim/Candidacy Exam</td>
<td>2nd Yrs</td>
<td>May-July</td>
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<tr>
<td>3rd Year Seminar (serves as DCM)</td>
<td>3rd Yrs</td>
<td>Winter</td>
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<td>≥ 4th Yrs</td>
<td>Fall</td>
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<tr>
<td>Data Meeting</td>
<td>3-6 months prior to defense</td>
<td>as needed</td>
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<tr>
<td>Defense</td>
<td>graduating students</td>
<td>as needed</td>
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APPENDIX 3 - Medicinal Chemistry Academic Progress Form

Name ____________________ Date of last Relevant Degree/Major ________________________

Previous Degree/Institution __________________________________________________________

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Tracks:
- BIOCHEMICAL=Bc
- BIOPHYSICAL=Bp
- BIOINFORMATIC=Bi
- ORGANIC=O

573 Advisors: 1\textsuperscript{st} ____________, 2\textsuperscript{nd} ____________, 3\textsuperscript{rd} (optional)* ____________

Milestones

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<td>Adv. to Candidacy</td>
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<td>Third Year Seminar</td>
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Dissertation Committee Members

Chair: ______________________

______________________

______________________

______________________

Coursework

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GPA by Term

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Candidacy Proposal

Title of proposal
Your Name
Medicinal Chemistry Program
University of Michigan, Ann Arbor
Date of meeting
Place of meeting

Committee:
Prof. XXXX (Chair)
Prof. YYYY
Prof. ZZZZ
Prof. AAAAA (Ex officio, mentor)

Note: Use similar format for MC 573 reports and MC 740 proposal. Page number document.
APPENDIX 5 - Guidelines for Scheduling Oral Dissertation Defenses

1. Links to Guidelines on Rackham Website:
   - [http://www.rackham.umich.edu/current-students/dissertation/defense](http://www.rackham.umich.edu/current-students/dissertation/defense)

2. Flyer & Website Information

Due at least 30 days before defense, to be e-mailed to Sarah Lloyd, sarloyd@med.umich.edu

Information needed:
- Date
- Time
- Location
- Title

3. Booking Room for Oral Defense

To reserve a room for oral defenses send an e-mail with the requested room, date, start time and end time to:
- College of Pharmacy or CC Little, email: cop.facilities@umich.edu
- Rackham (if no rooms are available in the COP): [http://www.rackham.umich.edu/rackham-building/room-scheduling/scheduling-guidelines#who-may-schedule](http://www.rackham.umich.edu/rackham-building/room-scheduling/scheduling-guidelines#who-may-schedule), e-mail: RackhamScheduling@umich.edu.
- Chemistry (If your advisor is in Chemistry Dept.) e-mail: chemreservations@umich.edu
- Life Sciences Institute (If your advisor is in LSI) e-mail: LSIreservations@umich.edu

4. Program Book (Yellowbook)

Due two weeks prior to your defense, please e-mail information to Sarah Lloyd, sarloyd@med.umich.edu

Information needed:
- Your name as you would like it listed
- Photo image (mugshot)
- Title
- Abstract
- Publications
- Presentations
- Committee Member Names
- Future plans
- Anything else you want included in the yellowbook.