

## BIOLOGY/BIOTECHNOLOGY DEGREE PROGRAMS

(May 1, 2005)

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### Biology/Biotechnology Graduate Programs Committee:

Students applying to the Departments of Biology or Chemical Engineering that express interest in pursuing a biotechnology-related focus for their graduate degree would have their applications reviewed by a Biology/Biotechnology Graduate Programs Committee. This Committee would consist of at least two representatives from each Department. This committee would recommend appropriate applicants for consideration for entrance to the program. These applications would be forwarded from the 'home' department (e.g., biology or chemical engineering) to the Committee for review and approval, and subsequently back to the 'home' department for processing.

Degree Title: Biology/Biotechnology

### I. Course Work M.S. Degree

#### A. Entrance Requirements:

GRE Scores (general)

TOEFL scores as required by the Graduate School of Arts and Sciences for non-English speakers

Courses Required:

- 1 year calculus
- 1 year physics or equivalent engineering
- 1 year organic chemistry or 1 semester organic chemistry plus 1 semester physical chemistry
- 1 course in general genetics
- 1 course in biochemistry
- 1 course in cell biology or cell physiology
- 1 course or demonstrated competency in computer use

Students lacking courses in biochemistry, general genetics or cell biology must take Biology 152 (Biochemistry), Biology 41 (Genetics) or Biology 46 (Cell Biology) for a letter grade, but without graduate credit, in the first year after admission.

B. Advisory Committee - Upon matriculation, each student will be assigned a three member advisory committee.

C. Course Requirements: 8 courses are required.

1. Biochemistry and Cellular Metabolism (Bio 152) or Biochemistry I (Bio 171); students who have taken one or two semesters of Biochem as undergraduates may substitute Medicinal Chemistry (Chem 157) or Metabolic and Cell Engineering (ChBE 167) with preapproval by their committees.
2. Molecular Biology (Bio 105); students who have taken Molecular Biology as undergrads may substitute Comp 150 (Computational Biology/Genomic Sequences), ChBE/BME 162 (Molecular Biotechnology) or Bio 195 or 196 with preapproval by their committees.
3. Molecular Biology Seminar (Bio 185 or 188), Topics in Inflammation (Bio 177) or Topics in Molecular and Cell Biology (Bio 243) or preapproval for Bio 195, 196.
4. Chemical Engineering - Biochemical Processing Projects Lab (ChBE 168) or Recombinant DNA Techniques (ChBE 163/Bio)

- 5&6. Two of the following: Biochemical Engineering (ChBE 160), Protein Purification (ChBE 161), Cell, Microbial Culture (ChBE 166), Metabolic and Cell Engineering (ChBE 167) or Biomaterials & Tissue Engineering (ChBE 164) (one elective for research masters)
- 7&8. Two electives from biology courses with graduate credit (one elective for research masters) or from other Departments or the Medical School with preapproval of Advisory Committee. Examples include Microbiology (Bio 106), Developmental Biology (Bio 103), Immunology (Bio 104), Neurobiology (Bio 134), Folding of Biomolecules (Phy 193)

## II. Research (Thesis) M.S.

A. Entrance Requirements - as above

B. Advisory/Thesis Committee - Upon matriculation the student will be assigned a three member Advisory/Thesis Committee.

C. Course Requirements - 6 courses required - see prior list.

D. Committees - The Advisory/Thesis Committee will advise the students until a thesis topic is chosen. One additional external thesis committee member can also be added. To ensure progress and quality of work and advising, students will meet every six months with their committee.

E. Research - Thesis work will normally be carried out on campus. For students selecting an extramural research option, the work done extramurally must be open for public discussion, presentation and timely publication. The thesis must consist of work done after admission to the program and will be planned with, and approved by, the advisory/thesis committee. A student who does extramural research must have an extramural advisor who agrees to meet with the committee every six months.

F. Thesis Examination - The student will pass an oral thesis examination upon approval of the thesis by the committee. This examination will cover the thesis topic and related material. Students can request committee approval to retake the examination if they fail the first time.

## III. Ph.D. Program

A. Entrance Requirements - same as for M.S. students.

B. Course Requirements - Courses are recommended based on Advisory/Thesis Committee input and would be selected from the same list as for M.S. thesis program.

C. Committees - As earlier for the M.S. however, the committee will expand to four members before the written qualifying examination. Students must meet with their committees at least once every six months. The members must represent a mix from biology, chemical engineering or other suitable disciplines. For the thesis defense an external examiner will be appointed to the committee.

D. Student Rotations - A research rotation is an opportunity to explore a new area of Biology/Biotechnology, to learn new techniques, and to become acquainted with some of the research ongoing in the field. All students are expected to do at least two rotations. Three rotations can be done if the student begins in the summer after admission, or if a rotation is begun at the start of the first semester. If a student on entering has already picked a lab for thesis research, one of the required rotations can be in that lab. Under special circumstances, with committee consent, students can use one of the following options as one rotation: complete a research-based graduate level course at an established institution, or

work as a research assistant with a principal investigator outside of Biology/Biotechnology. We want students to start and end rotations in synchrony so that a critical mass of students can report on rotations at the same time. Therefore, there will be three dates: December 10, April 1, and September 15 for reporting on recently completed rotations. Each rotation will last about 10 weeks. Then, using the closest date listed above, the student will give an oral report to a group consisting of other students who have just finished a rotation, the sponsoring research mentors, members of the students' committees, and other interested persons. All rotations should be completed by the beginning of the fall semester of the student's second year.

E. Qualifying Examination. The examination will be given only if the student has satisfactorily completed at least two rotations.

E.1. Written Examination - The written examination tests a student's broad knowledge of those areas of biology/biotechnology that are related to the student's specialization. The exam will usually contain seven or eight questions of which the student must answer five. There may be alternatives for certain questions; others may be obligatory. At least four of the five questions answered will deal with material from courses or the student's background. Only one of the five questions can be taken directly from the immediate area of thesis or rotation research. The exam will be written by the student's Thesis/Advisory committee. It must contain several of the student's instructors. The committee can then change membership to a thesis committee after the written qualifying exam is completed. The exam committee will meet with the student and list the general topics that can be covered. The committee members will submit questions to the committee's head. These will be copied and circulated to the entire committee at a planning meeting. The committee will decide on the questions to be used. The student is given seven hours to write the exam; however, it should be planned by the committee so that most students can finish it within five hours. Each questions will be graded by two committee members. However, if needed, the second grader can be from outside the committee. The score for each question will be the average of the two grades. A passing grade is 70% of the exam's total points. The exam should be marked and the score told to the student within four working days of the date of the exam. At the time the exam is scheduled, the date and time for the graders to meet and discuss the scores should also be scheduled. The student should be told the final score but not the scores for each questions. However, the graders' comments on each question should be given to the student. The test is then returned to the student. The exam will be given on the second Monday after commencement in the student's second year, e.g., about 21 months after entry into the program. All students in a given entering cohort would take the exam on the same day. If the student's overall score is less than 70%, the committee will consider the quality of the answers given as well as the student's record including rotations, teaching assistantships, and courses in deciding if the student will be re-examined. The written re-examination, if needed, would occur the following September. The committee would clearly indicate the general topics covered on the re-examination. Re-examination can occur only once. Even with a passing score ( $\geq 70\%$ ) the committee can still require study or course work in certain areas.

E.2. Research Proposal - The purpose of the proposal is to make students thoroughly familiar with the theory behind the techniques that they will use: to give them a complete grounding in the literature, both current and historical, of their research field; and, most importantly, to get them to think about their research. The proposal is called a research proposal, not a thesis proposal. The proposal will cover the expected thesis area, but it is possible that the thesis will eventually be on another topic. The research proposal should consist of:

- Introduction and background including literature review
- Statement of specific question(s) asked
- Importance of these questions(s)
- Preliminary data (if any)

Proposed experiments and methods of data analysis

Literature cited

The proposal defense is also the time when the student can be examined orally about background and methods used in the proposed work. The proposal must be defended no later than the end of the student's fifth semester. If the direction of the thesis research changes significantly from what has been proposed, the student's thesis committee can request an additional written description of the proposed work. A trial or draft can be given to the committee for comments. The committee will meet with the student to comment on the draft. The final draft must be approved by four of the five committee members before the defense is scheduled. At the defense, the student presents the proposal orally and is then questioned about it. If the defense is not satisfactory, within four months, the student must be re-examined on those aspects of the defense indicated by the committee. Re-examination can only occur once.

F. Oversight of Graduate Student Progress - The Thesis/Advisory committee should meet with the student at least twice a year. If the student is presenting his or her work at a seminar session, all members of the student's committee should attend, and a committee meeting should be held within two weeks. After the seminar the student should schedule the meeting, but it is the committee head who is responsible that meetings are timely. Faculty are urged to be as flexible as possible so that the student can easily schedule the meeting. The chair of each student's committee will keep minutes of each meeting. Items such as course deficiencies, rotations completed or in progress, courses taken and those to be taken, research progress, exam scheduling, and work as a teaching assistant should be discussed. Before the minutes of the meeting are put into the student's folder, they should be circulated to all committee members for additions and/or corrections. The committee should give a copy of this to the student. Students involved in rotations or thesis research should submit research reports to their committees at least four days before each semi-annual meeting. These reports should be brief, not exceeding 500 words, excluding figures, tables, and literature cited. Figures can be simple and hand-drawn, but should be clear and easily interpreted. The student will be expected to provide original data at the committee meeting. The report should contain the specific aims of the work (for rotations, the limited aim of that period), approaches used, results obtained, and a brief discussion. The report should conclude with research plans for the next six months. If the student completed a rotation, the head of the lab in which the rotation was done should send a brief evaluation to the committee. In addition to the committee minutes and research reports, student's folder should also have a copy of the Graduate Progress Form, to be kept up to date by the student's advisor. This form is available in three formats: Ph.D., Research Masters, and Coursework Master's. At the end of the semester, an evaluation of the student's work as a T.A. should be completed by the supervising faculty member using a standard evaluation form. The evaluation is placed in the student's file. Before the beginning of the semester, all T.A.s should be given in writing a clear explanation of their duties and responsibilities by the faculty member in charge of the course. Students have the right to add comments to their files in response to the minutes of committee meetings. The Policy Committee will review each student's file every October, looking at committee minutes, transcripts, research reports, the progress form, etc. Initially, each student's file will be examined by one member of the committee. If that member has concerns about a student or the functioning of the student's committee, the student's file will be examined and discussed by the entire committee. The committee's concerns, if any, would be given in writing to the head of the student's committee.

Unsatisfactory Progress - Course grades must be B- or higher. In the event of a lower grade, the student's committee will decide if the course must be retaken. Overall grade point average must be at least 2.67. Unsatisfactory progress can also result from unacceptable or inadequate work as teaching assistants or in rotations and research, lack of progress in completing the qualifying procedurs, or academic dishonesty.

G. Extramural Ph.D. Program - The extramural program, in which students carry out their research at their workplace, is considered an exceptional route to the Ph.D. and not a normal alternative to the full-

time on-site pursuit of the degree. Course requirements for this program will be the same as above but with a stretched out timetable. However, all students are expected to complete the Ph.D. within six years. Degree work must be carried out following matriculation into the program. Students in this program and their extramural advisors must meet with their committees every six months. Students are required to attend the biotechnology seminar series and present their research yearly at these seminars. The research done must be open for public discussion, presentation and timely publication. Any 'residency requirements' established by the Graduate School will have to be met.