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*Last updated 3/26/2025

BOSTON UNIVERSITY SCHOOL OF MEDICINE PROGRAM IN PHARMACOLOGY & EXPERIMENTAL THERAPEUTICS

MA, PhD and MD/PhD DEGREE PROGRAMS

POLICIES AND PROCEDURES GUIDELINES

https://www.bumc.bu.edu/busm-pm/

The Department of Pharmacology, Physiology & Biophysics at the Boston University School of Medicine offers a graduate training program that leads to the MA, PhD and MD/PhD. degrees in Pharmacology & Experimental Therapeutics. Predoctoral students enrolled through the Department of Pharmacology, Physiology & Biophysics participate in this training program and students from other departments and programs are encouraged to join and acquire the expertise provided by this pharmacology offering. The training program is directed toward preparing students for future careers in pharmacologic research in academic, industrial and governmental settings. Advanced research in pharmacology requires an understanding of the principles of a broad range of disciplines.

The curriculum encompasses the interdisciplinary nature of this field and prepares students to study chemical interactions with biological systems on multiple levels, from the behavior of atoms in macromolecules to the effect of molecules on the behavior of organisms. A major focus of research training is in areas of molecular, cellular, and behavioral neurosciences, as well as cardiovascular and cancer pharmacology. Research facilities provide students with state-of-the-art opportunities for training in molecular genetics, bioinformatics, molecular modeling, electrophysiology, biophysical methods, biomedical engineering, psychophysical methods and other tools for elucidating the interaction of drugs with biological targets. A description of the research interests of faculty participants in the pharmacology training programs is provided on the Department/Biomolecular Pharmacology website.

Admissions Procedures: The procedures for admission to the graduate program in pharmacology are described on the website of the Division of Graduate Medical Sciences. Applicants must submit transcripts (GRE scores are not required), two letters of recommendation, and a statement of purpose. Interviews are required for applicants to the PhD and MD/PhD programs. Applications are reviewed by the Department's Admission's Committee for selection of interviewees. Following interviews, applicants are notified of admission's decisions by the Department Chair and the Associate Dean of the Division of Graduate Medical Sciences.

Registration: Students must register online each semester until completion of all requirements, including the thesis or dissertation. The first semester for incoming students is an exception as students are preregistered, based on the department's recommendation. At orientation students should check their registration and verify appropriate enrollment. Each semester thereafter, students should consult with their advisors, select courses, and register online. The access code required for registering is obtained from the Program Director after review of curricular choices, participation in training on responsible conduct of research, update of myIDP and other professional planning activities, as well as the scheduling of the per semester DAC meeting. Students must register for a total of 12 credits each semester to maintain full-time status; credits of Directed Research (GMS PM 931 fall, 932 spring) are added to formal course credits in even-numbered increments to reach the required 12 credits. For full-time status in the summer, students must upload an online form to the Division of Graduate Medical Sciences, entitled PhD Summer Research Status Form. This form is available at the Division's website GMS Forms https://www.bumc.bu.edu/gms/students/student-forms/.

Laboratory Rotations and Selection of Advisor: During the first year of study, students familiarize themselves with research projects of the faculty through laboratory rotations. The Department Chair

serves as advisor until a research supervisor is selected. Students register for two semesters of Laboratory Techniques in Modern Pharmacology (GMS 710), in which they complete three or four laboratory rotations of seven weeks each. This rotation experience provides exposure to a variety of experimental approaches in the study of pharmacology. Students are encouraged to select rotations in laboratories that approach problems from different perspectives, in keeping with the fundamental goal of providing a broad and more complete understanding of research strategies to address questions of pharmacological importance. Rotations are designed to be a teaching instrument and students are encouraged to obtain publication quality data. Each student submits a paper summarizing his or her research experience. Students receive a grade of Pass or Fail in GMS 710, based upon their performance in research rotations and the grading of their written reports. (1) By the end of the firstyear (approximately June 1st), students are expected to choose an area of research interest and match with an appropriate faculty advisor for their PhD research training. It is recognized that there may be extenuating circumstances that may require a student to change advisors. (2) If the student is switching advisors within their current Department/Program, they must consult with, and get approval from, the Program Director and Chair of their current Department/Program as well as the Associate Provost/Dean of GMS. If the student wishes to join a different Program, the current Chair/Director and the new Chair/Director, as well as the Associate Provost/Dean of GMS must approve the change and the Transfer Between Departments policy followed.

Professional Development Program: An important feature of the PhD program is the development of professional skills of each student and individualized planning of a career path. Students are expected to attend the Professional Development Events sponsored by the Division of Graduate Medical Sciences. The topics and PowerPoint presentations of these events are available <u>http://www.bumc.bu.edu/bumg/professional-development/</u>. Students are also expected to use the AAAS-sponsored career-planning tool, myIDP, available at <u>http://myidp.sciencecareers.org</u>/. Students should create a myIDP account early in the program, complete their first IDP shortly after the PhD qualifying exam, and refer to this tool more intensively after their progress report seminar when post-graduation planning should ensue in earnest. Students should also create an ORCID ID (https://sites.bu.edu/orcid/). Review of professional planning is one component of students' meetings with their Dissertation Advisory Committee each semester after passing the Qualifying Examination.

Industrial Internships in the Pharmaceutical Sciences: A capstone opportunity as part of the firstyear program is an internship in an industrial setting, which is expected of students in the Pharmacology Program. The internships are available during the summer after the first or second year through collaboration with Pfizer Inc., and Biogen, Inc., both located in Kendall Square, Cambridge, MA. Internships are generally 7 weeks in length for Pfizer and 10 weeks in length for Biogen. Students are provided a list of the available research areas and an opportunity to prioritize their choice. Students must sign Visiting Scientist agreements and are expected to provide feedback on their rotation experience.

Participation in Teaching: Students are encouraged to enhance their teaching skills by assisting as tutors, teaching assistants, and lecturers in the graduate, medical and dental course offerings of the department.

Curriculum: MA Degree Program

Students admitted for study through the Department of Pharmacology & Experimental Therapeutics are almost always doctoral candidates. Under unusual circumstances a student may obtain an MA degree. MA candidates are required to take a minimum of 16 credits of formal coursework and no more than 16 credits of laboratory research to earn 32 credits in total. Students are expected to consult with their advisors to plan the sequence of coursework that best suits their needs. Specific departmental requirements include regular attendance at departmental seminars and satisfactory completion of two advanced (800 level) pharmacology courses. Courses by other departments at Boston University may be substituted for advanced Department of Pharmacology courses with the approval of the student's advisor, the Graduate Education Committee (GEC), and the Department Chair. The MA degree requirements also include submission of a laboratory or library-based thesis prepared under the supervision of first and second readers. One of the readers must have a primary appointment in the Department of Pharmacology.

Generally, MA candidates take GMS FC 711,712,713,714 Foundations in Biomedical Sciences (FiBS); GMS PM 701 Molecular and Translational Pharmacology, GMS PM 702 Molecular Neurobiology and Pharmacology; one semester of GMS PM 810 Current Topics in Pharmacological Sciences; and GMS PM 801, 802 Systems Pharmacology & Therapeutics I and II. MA candidates are also encouraged to take a course in biostatistics.

After satisfactory completion of the first-year curriculum with a GPA of B (3.0) or higher, an MA candidate may submit a petition for transfer into the PhD program. This request should include the Division Change of Program Form, the student's BUSM transcript, a personal statement, and a letter of support from the proposed dissertation mentor.

Curriculum: PhD Degree Program

The curriculum for PhD candidates is designed to provide a broad-based foundation in pharmacology, as well as flexible opportunities to individually tailor a program that meets the individual student's background and research interests. Students are expected to consult with their advisors to plan a sequence of coursework that best suits their needs. Specific requirements include satisfactory completion of core courses (18 credits), a laboratory rotations course (4 credits), elective courses (6 credits minimum), and sixty-four credits in total for post-BA students and thirty-two for post-MA.

Elective courses should be chosen from those approved for the program (available at <u>http://www.bumc.bu.edu/busm-pm/programs/nigms/#PhD%20Curriculum</u>). Other courses may be substituted for already approved program electives with the permission of the student's advisor, the GEC and the Program Director.

During the first year of study, PhD candidates are expected to enroll in modules 1, 2, 3, 4 of Foundations in Biomedical Sciences (FiBS) course (GMS FC 711 Protein Structure, Catalysis and Interaction, GMS FC 712 Structure and Function of the Genome, FC 713 Architecture and Dynamic of the Cell, FC 714 Mechanisms of Cell Communication), as well as the foundational courses in pharmacology (GMS PM 701 Molecular and Translational Pharmacology, GMS PM 702 Molecular Neurobiology and Pharmacology (GMS PM 702 can be substituted with approved course in cancer or genetic such GMS PM MM 703 or GMS FC 715), and GMS PM 710 Laboratory Techniques in Modern Pharmacology). During their second year of study, students enroll in (GMS PM 801 and 802 Systems Pharmacology I, II and GMS PM 810 Current Topics in Pharmacological Sciences), and a course in biostatistics (GMS MS 700 Elementary Biostatistics) or equivalent. These courses provide both the necessary background study in the basic sciences and an introduction to the discipline of pharmacology. This subject matter is generally a prerequisite to more in-depth study in the advanced courses listed below.

Students who enter BU through BME or GPN and join the Pharmacology Training Program are expected to complete a curriculum that includes Molecular and Translational Pharmacology, Molecular Neurobiology and Pharmacology, Systems Pharmacology and Therapeutics I, II, as well as requirements and electives of their program of entry. Contained within this Handbook is a document describing in detail the full course requirements for GPN students who join Biomolecular Pharmacology.

Curriculum: MD/PhD Degree Program

The curriculum requirements for students in the MD/PhD degree program are 10 credits of advanced electives in pharmacology. Generally, students are expected to take GMS PM 701 and GMS PM 810 Current Topics in Pharmacological Sciences, which may be taken twice for credit. (For MD/PhD students GMS PM 701 and 702 are considered advanced electives.) Students generally enter the program after two years of the MD curriculum (MD/PhD students are advised not to take GMS PM 801 & 802 Systems Pharmacology & Therapeutics I & II, as much of the material in these courses is covered in the medical school curriculum.)

Qualifying Examination: The qualifying examination for PhD candidates consists of a written and oral examination. PhD candidates are expected to take the qualifying exam no later than the end of the second curricular year. MD/PhD candidates normally take the exam at the end of their first year of graduate studies. A Qualifying Examination Committee (QEC) of three faculty members from Boston University, including the student's major advisor, administers the examination. One out of the three members of the committee must be a primary faculty member in the Department of Pharmacology, Physiology & Biophysics. The chair must be at the rank of assistant professor or higher. In the exceptional case that a student's research advisor is not a full-time faculty member at Boston University, the advisor is expected to participate as a fourth member of the committee.

The written portion of the qualifying exam is in the form of a research proposal on a topic selected by the student in consultation with the QEC. The subject matter of the proposal is usually related to the topic of the student's thesis research but may be on a separate topic. The topic of the proposal must be substantially original; it must not duplicate projects previously proposed or assigned by the student's mentor. The student initially submits a statement of the topic area of the proposal to the QEC chair. The document describing the topic area should include a title, a (non-binding) hypothesis, a brief description of the type of system (*e.g.*, describing the transgenic mouse, cell line or primary tissue culture) and the measured outcomes. This abstract should ordinarily be one to two paragraphs. The chair circulates the proposal abstract to the other committee members and provides feedback within one week. If the proposal topic is not approved, the student should revise and resubmit within one week.

The proposal should include the following: rationale, hypothesis, aims, background/significance, research design, and methods. The research design section should include discussion of expected results and potential pitfalls. The proposal should be at least six pages, and not exceed ten pages, of single-spaced text (excluding references). The student may consult with faculty or other students regarding ideas and concepts, but the proposal must be written independently and must not be edited by the student's mentor or other students or faculty prior to submission to the QEC. The proposal should be prepared in anticipation of submission as a predoctoral fellowship application and will ordinarily follow guidelines for an NIH NRSA F30 or F31.

The criteria for evaluation of the written proposal include the following:

- 1. Significance: Will the subject matter have impact on the field?
- 2. Innovation: Is this original?
- 3. Rationale/Hypothesis: Are they clear, cogent and logical?
- 4. Aims:
 - a. Are they well defined?
 - b. Do they address the hypothesis?
- 5. Background: Does it display a comprehensive knowledge of the field and relevant literature?
- 6. Approach:
 - a. Are the experimental parameters defined (controls, dependent variables, independent variables, statistical considerations)?
 - b. Will the experiments achieve the aims?
 - c. How well are the expected results interpreted?
 - d. How well are potential pitfalls considered?
- 7. Methods: Is there a brief synopsis of methodologies with appropriate citations.

The final pass or fail evaluation is made by majority vote of the three members of the QEC. The QEC may also ask the student to revise the proposal to address deficiencies identified by the QEC before awarding a final pass on the written examination. If the QEC rules that the student has failed the written examination, the student is allowed one additional attempt to pass the written examination; the proposal can be a revision of the prior proposal or a new proposal on a substantially different subject. The student must pass the written portion of the qualifying examination in order to proceed to the oral portion. The deadline for submitting the second attempt at the written examination will be set by the QEC but is expected to be within three months.

The oral examination is usually taken about two weeks after passing the written portion. The oral portion of the qualifying examination is conducted by the QEC. The student should submit a CV to the QEC chair and be prepared to describe academic and research experiences at the beginning of the exam. The student is then examined by each member of the QEC. Questioning will assess the students grasp of the hypothesis, experimental design, and understanding of statistics.

Mock Qualifying Exam: In order to best prepare for the oral qualifying exam, all students are strongly encouraged to give a mock qualifying exam to a committee of fellow students. This student committee should consist of at least two senior students that have already passed their qualifying exams. It is up to the student to choose and organize the members of their own mock qualifying committee, though the department can help if needed. The student committee will run the mock exam and ask questions in a way that resembles the actual oral qualifying exam. Student volunteers participating as member of the committee should list this in their CV as it shows participation in leadership opportunities.

Pass/Fail Decision: After completion of the oral examination, each examiner separately evaluates the responses to his questions. The QEC will then discuss the candidate's overall performance. Each faculty member is then charged with the evaluation of the entire examination. The candidate shall be considered to have failed the examination if, in the opinion of two or more of the examiners, the <u>overall</u> performance was unsatisfactory. Students who fail the oral portion of the qualifying examination will be given only one additional opportunity to pass the oral portion of the examination. The QEC may also vote to award a conditional pass, which becomes a pass only after deficiencies have been corrected to the satisfaction of the QEC. Upon completion of the oral examination, the appropriate forms are signed and transmitted by the Academic Manager to the Division Office. Satisfactory completion of the oral examination.

Timeline for PhD Qualifying Examination (Spring Semester)

DATE	ACTION
January	Contact faculty to arrange participation on qualifying exam committee (QEC). QEC faculty composition - 3 faculty members: 1) the mentor 2) a primary faculty member in the Program in Pharmacology 3) a faculty member who is an expert in your field * One out of three members of the committee, including the chair, must be a primary faculty member in the Program in Pharmacology
1st Friday of February	Submit names of QEC faculty members on PhD tracking form for approval by the Program Director
3rd Friday of March	Schedule tentative date for oral exam in June/July
1st Friday of April	Submit topic area of written proposal to QEC Chair, who will communicate with other QEC members for approval
Мау	Assemble a mock oral qualifying committee with senior students
3-weeks Prior to Exam	Submit 6-page research proposal to QEC members. Format of the proposal should follow NIH NRSA fellowship application guidelines
2-weeks Prior to Exam	Students receive feedback from QEC members on the research proposal. Pass/Conditional Pass/Fail will be designated
June/July	Take oral qualifying exam

Dissertation Advisory Committee: Each PhD candidate enrolled in the Pharmacology program chooses a Boston University faculty member as advisor for the dissertation research project, preferably before the second curricular year. The student and advisor designate a Dissertation Advisory Committee (DAC) with the approval of the Program Director. The DAC must include at least five members. The advisor is always a member of the Committee. At least three members must have primary appointments at Boston University and two must have primary appointments in the Department of Pharmacology, Physiology & Biophysics. The committee must also include one member who does not have a primary appointment in the department and preferably is from outside Boston University and its affiliated hospitals. At least one member of the DAC must not be a collaborator on the dissertation project. The Chair of the Committee (at the rank of assistant professor or higher), who should be designated when the committee is formed, must have a primary appointment in the Department of Pharmacology, Physiology & Biophysics and must not be the advisor, First Reader or Second Reader. The First Reader of the dissertation must have a primary appointment at Boston University and is usually the advisor. The Second Reader should be identified as soon as possible, preferably before the progress report seminar. The form entitled "Request for a Special Service Appointment in the Division" with accompanying CV must be submitted to the Division Office for all committee members who are not faculty in the Division of Graduate Medical Sciences.

The first meeting of the DAC takes place as soon as possible after the qualifying exam is passed, but no later than the end of the subsequent semester. The DAC must meet each semester thereafter. A meeting must have occurred, or been scheduled, in order to earn a Pass grade for Directed Research (GMS PM 931,2). At least three DAC members must attend each meeting. The student should be prepared to give a slide presentation on his or her progress. The DAC members will meet briefly without the student prior to each DAC presentation for input from the advisor. At the completion of each meeting a summary will be prepared by the Chair, using the DAC Meeting Report form. The report will be reviewed with the student prior to submission to the GEC. The Chair includes in the report reference to discussion with the student about professional planning and updates of myIDP.

Requirements of the Division of Graduate Medical Sciences: Students are urged to be aware of the requirements and deadlines of the Division of Graduate Medical Sciences, regarding the dissertation, submission of the dissertation proposal/outline, abstract, final oral examination schedule, and diploma application. The following items should be obtained from the Division Office or website that has GMS Forms <u>http://www.bumc.bu.edu/gms/students/student-forms/</u>.Some of these items or forms have been included in this Handbook for convenience, including a memo that the Registrar sends to students nearing program completion.

- 1. Research Guide for the Writers of Theses and Dissertations
- 2. Request for a Special Service Appointment in the Division (due at time of Abstract Approval)
- 3.* Dissertation Outline Approval Page
- 4. Graduation Calendar
- 5. PhD Dissertation Abstract Approval (due one month prior to defense)
- 6. Final Oral Examination Schedule for the PhD (due two weeks prior to defense)
- 7. Diploma Application for the Degree of Doctor of Philosophy (due November 1 for January graduation, February 1 for May graduation)

*The dissertation proposal/outline required by the Division should be in the form of an outline that will reflect the anticipated Table of Contents of the dissertation and help serve as an organizing guide in the writing of the manuscript. Students are encouraged to refer to examples of approved Abstracts and Table of Contents for dissertations that are included in this Handbook. Both the outline and abstract

must be approved by the Advisor and the Program Director, prior to approval by the Division. Careful attention should be paid to the required formatting of the title, author, etc.

Setting a Defense Data: It is required that students will have a first-author (or co-first author) research manuscript, prepared under the supervision of their thesis advisor, submitted for publication prior to scheduling their thesis defense. Under extenuating circumstances, a student may request a waiver of this requirement to the GEC with the support of the dissertation mentor and DAC.

Dissertation Document: The PhD candidate prepares a dissertation that documents the accomplishment of original independent research of significance to the pharmacological sciences. The research is expected to have met publication standards of peer-reviewed journals in the candidate's area of specialization. A draft of the dissertation, approved by the advisor, is submitted to the Second Reader. After revision, the dissertation should be submitted to all DAC members in preparation for the

Pre-Defense Approval: The goal of the Pre-Defense is for DAC members to review the written thesis document to ensure it is completed to an appropriately high standard, to provide feedback for revision prior to the formal Dissertation Defense, and to approve the timing of the Dissertation Defense date. The student should provide their completed thesis document to the DAC at least 4 weeks prior to the defense date. The pre-defense review must then be completed at least two weeks before the defense date. Failure to distribute the required materials at least four weeks prior to the defense date may result in rescheduling of Dissertation Defense date.

Dissertation Defense and Submission: With the approval of the committee, the PhD candidate arranges the date for the formal dissertation defense. The availability of each committee member should be verified, since all five members must be in attendance. The appropriate forms must be submitted to the Division Office prior to the defense, as indicated above. The Academic Manager should be notified so that a notice of the oral defense can be prepared and distributed and the conference room reserved. The dissertation defense begins with a 50-minute seminar presentation by the candidate. After the presentation, students and faculty in attendance are given an opportunity to ask questions. Only following questions should students present slides that acknowledge friends and family, and these acknowledgements should be brief (less than 5 minutes). Each DAC member is then accorded an opportunity by the chair to ask questions and raise issues in closed session. At this time the committee must specifically approve the content and wording of the title and abstract. Once all DAC members have completed their inquiries, the candidate is excused from the room, and the committee decides whether the student has passed the examination. The total time of the examination, including the student presentation but not the deliberations, should not exceed three hours. The DAC then determines a mechanism to ensure that required changes in the dissertation are completed; a decision is made regarding the signing of the approval pages, which may occur at this time. The DAC Chair completes the Division form, which indicates the outcome of the defense. The student is then informed of the outcome. The student is responsible for making required revisions in the dissertation. Students should anticipate that additional questions and issues are likely to arise during the oral dissertation defense and should plan on devoting one or more weeks to final revisions of the PhD dissertation following the defense. Two final revised and approved copies of the dissertation must be submitted to the Division and one copy to the department before the forms that indicate completion the PhD requirements will be submitted by the department to the University. The student will consult with the Administrative Manager to arrange for printing and binding three copies of the dissertation, one for the Pharmacology library, one for the advisor, and one for the student. The student should provide unbound copies of the thesis to other members of the Dissertation Committee, if requested.

Time to Degree:

PhD students have a maximum of seven (7) to complete their degree. Post-master's candidates have a total of five (5) academic years. Students may petition for additional time to the Associate Provost and Dean of Graduate Medical Sciences in cases of extenuating circumstances. See policy <u>here</u>.

Training in Responsible Conduct of Research:

Formal training on scientific integrity and issues of ethical principles in research is a required component of the curriculum. Boston University School of Medicine sponsors a series of lectures, seminars and workshops devoted to the responsible conduct of research. The Program in Responsible Conduct of Research is organized by the RCR Education Advisory Committee and implemented through the Boston University and Boston Medical Center Office of Research Compliance. To a very large degree, the topics addressed by this program match those identified by Public Responsibility in Medicine and Research, the American Association of Medical Colleges and the National Institutes of Health. This program, which was instituted in 1991, has covered a wide range of issues concerning the responsible conduct of research including, but not limited to, data acquisition, management, sharing and ownership, mentor/trainee responsibilities, publication practices and responsible authorship, peer review, collaborations, human subjects, laboratory animals, research misconduct and conflict of interest. The series is offered periodically throughout the academic year to provide an ongoing dynamic forum for the exchange of ideas. Detailed information is provided at: http://www.bu.edu/orc. Students must complete online instruction and four workshops, preferably in the first two years of the program. Attendance at one workshop per year is encouraged once all four have been completed.

Rigor and Reproducibility of Scientific Research:

Students are expected to acquire skills in experimental design and analysis, replication of experimental findings, and critical analysis of the validity of experimental approaches to enhance the rigor of their work and its potential reproducibility by other investigators. Publications addressing deficiencies in these aspects of scientific research are posted on the program website within Resources and are discussed in several courses in the curriculum. Students will be expected to consider these issues as part of the critique of publications in the course Current Topics in the Pharmacological Sciences.

Misconduct and Grievance Procedures:

GMS places a high priority on the appropriate treatment of its community and affiliated members and provides a mechanism for both open and confidential resolution of complaints from students. Information on how to report misconduct including harassment, discrimination, academic issues, faculty complaints, disability discrimination, employment issues, etc. can be found on our <u>Report Misconduct webpage</u> and through the resources below.

Equal Opportunities Office : <u>https://www.bu.edu/eoo/</u> Office of the Ombuds: <u>https://www.bu.edu/ombuds/</u> Appropriate Treatment in Medicine Policy: <u>https://www.bumc.bu.edu/camed/student-affairs/atm/</u>

Satisfactory Academic Progress:

Students in the Pharmacology & Experimental Therapeutics program must make satisfactory academic program (SAP) according to GMS policy and guidelines which are available <u>here</u>. It should be noted that students enrolled in the PhD program in Pharmacology are expected to maintain a GPA of B (3.0) or higher. If a student cannot maintain a B average, he/she will be considered for a terminal MA degree at the end of their second year in graduate school. Course credit for marks below B- will not be awarded in accordance with University policy, and the course, if a program requirement, must be repeated. Students can petition the GEC to opt out of a required course due to hardship. Petitions to opt out must include an alternate course with strong justification for the choice of that alternate course. For students enrolled in the MA program, petitions for transfer to the PhD program in Pharmacology require a minimum GPA of B in the first-year curriculum.

Research Presentation Skills:

Trainees have multiple opportunities to develop their oral skills in the presentation of research findings. The first opportunity occurs at the end of the laboratory rotations course where they receive feedback on an oral presentation. This training is followed by presentations at meetings of the Graduate Student Forum, a student-organized seminar series. The Graduate Student Forum is run by a committee of pharmacology graduate

students that not only organize the events but also administer an anonymous survey from the attendees to help each presenter determine what may have worked or did not work during their presentation. Presentations range from 10 minutes to 50 minutes. After beginning their thesis research, students also routinely present their findings at laboratory meetings and in the student seminar series.

Student Seminar Series: This seminar series was implemented to enhance student research presentation skills and improve student and faculty awareness of program research. Students receive training on giving clear and effective scientific talks, focused on their thesis research, to a large and diverse scientific audience. Each PhD candidate is expected to give an annual research presentation beginning in their second year. Standard student seminars are 15-20 min followed by 5 min of discussion. Each seminar session includes two or three student presenters. Students and faculty are encouraged to provide constructive feedback to the speaker on presentation skills and style. Students who are scheduled to give their Dissertation seminar in the same calendar year are not required to give a student seminar.

GMS Research Symposium: Trainees are also expected to participate in interdisciplinary forums at the Medical School for the presentation and discussion of research such as the GMS Annual Symposium. This event provides trainees an opportunity to present research posters and give oral presentations.

Trainees are also expected to present their research findings at local, regional, and/or national research meetings. The Pharmacology, Physiology, & Biophysics Department supports these activities by providing a travel allowance to students who are first author on an abstract at a national meeting.

Evaluation of Student Progress:

The academic manager maintains a folder for each student that contains information (*e.g.*, course grades, completed DAC forms) to track student progress. The files can be used to assist faculty in writing letters of recommendation. Faculty are asked to report course grades for their advisees, as well as results of qualifying exams, etc., and to forward copies of correspondence pertaining to their students' academic status (*e.g.*, petitions, waivers) to the department office for inclusion in their files. The Academic Manager also monitors attendance of students at pharmacology seminars and, if necessary, reminds the students that their participation at seminars is required. Should a student request a leave of absence or an extension of time to finish the degree, a petition must be approved by the Advisor and the GEC before submission to the Department Chair and the Division of Graduate Medical Sciences.

Program GEC:

The GEC is comprised of faculty members and graduate student representatives. The GEC reviews matters that relate directly to the training program as it is described above and to make recommendations to the Department Chair. When the agenda of a meeting specifically includes discussions of individual students, the graduate student representatives are excused from the entire meeting or portions of the meeting. The program strives to ensure the success of every PhD student. Students have the option to petition the GEC for a waiver/postponement of certain program requirements in cases of extenuating circumstances or hardship.

Program Course Offerings

Molecular and Translational Pharmacology I

GMS PM 701 Farb, Kumaresan, staff, 2 credits, fall semester

Description: This course provides an integrated sequence of interactive teaching sessions designed to educate students in the fundamental principles of pharmacology with an emphasis on modern translational approaches for drug discovery. Basic principles of pharmacokinetics, pharmacodynamics and pharmacogenomics, the properties of drug targets, and the chemistry of natural products, small molecules and proteins will be emphasized. Translational topics will include an in-depth considerations of systems-level effects of target-drug interaction, macromolecular modeling for drug design, and nanotechnology methods for drug delivery.

Molecular Neurobiology and Pharmacology

GMS PM 702 Farb, Kumaresan, staff, 2 credits, spring semester

Description: This course introduces the student to the principles of pharmacology in the context of neurobiology. Emphasis is placed on translational pharmacology and the application of pharmacology to therapeutics, particularly to neurological disorders.

Laboratory Techniques in Modern Pharmacology

GMS PM 710, Russek, staff, 2 credits each, fall and spring semesters

Description: Supervised laboratory rotation emphasizing modern research techniques in molecular, cellular, and behavioral pharmacology. Problems of collection, summary, and interpretation of data are addressed. These sessions are designed to give the student an impression of the techniques and scientific niche unique to each laboratory and provide an opportunity to determine the choice for dissertation research training. Students are expected to generate a well-conceived project that can be accomplished in seven weeks with the P.I. A short, journal-style research report must be submitted to the P.I. and then the Course Manager.

Systems Pharmacology and Therapeutics I

GMS PM 801, Wolozin, 2 credits, fall semester

Description: Lectures and discussions on the major classes of pharmacological agents, with special attention to molecular, cellular and physiological mechanisms of therapeutic effects. This course is taught by faculty from the Pharmacology Department and other departments of BUSM. The material expands upon principles discussed in the first-year pharmacology courses. The course focuses on the agents for neurologic diseases.

Systems Pharmacology and Therapeutics II

GMS PM 802, Sabino, 2 credits, spring semester

Description: This course provides students with an overview of current therapeutics and provides a forum for discussion of developing new therapeutic strategies and for solving problems with current pharmacologic approaches. Major classes of pharmacological agents are reviewed, with special attention to molecular, cellular, and physiological mechanisms of therapeutic and adverse effects. This course is taught by faculty from the Pharmacology Department and other departments of BUSM. The course focuses on cardiovascular, endocrine, antimicrobial, anti-inflammatory and antineoplastic pharmacology.

Current Topics in Pharmacological Sciences

GMS PM 810, Cottone, 2 credits, spring semester

Description: Given in conjunction with the weekly seminar program of the department, students present and discuss research papers with the visiting scientist working on the cutting edge of pharmacology. This required course can be taken a second time as an elective. This course provides a unique opportunity for discussion between the students and visiting seminar speakers. Students present the speaker's work to the visiting scientist and classmates prior to the formal seminar. This

class is especially useful for developing critical thinking skills and presentation styles. This venue also provides an opportunity to discuss with leading scientists their strategies for ensuring rigor in their experimental work and reproducibility of their research results.

Directed Study/Research in Pharmacology

GMS PM 931,2, Staff, variable credits

Description: This Pass/Fail course represents the training accomplished in the research laboratory. Following completion of the qualifying exam, a passing grade requires a meeting with the DAC during the semester. The research advisor provides the evaluation for grade assignment. Registration in this course should be used in conjunction with other courses to gain a total of 12 credits, necessary for full-time status.

Technical and Professional Skill Workshop (TPSP)

This workshop held during the spring semester of the second year to help pharmacology students prepare for the qualifying examination. This workshop focuses on the development of skills in preparing research proposals, including use of appropriate experimental design and statistical analysis. An objective of the workshop and the qualifying examination is to enhance student skill in preparing predoctoral fellowship applications to external funding agencies including the NIH and maximize the likelihood of awards.

Electives in Pharmacological Sciences

Translational Genetics and Genomics

GMS FC715, Fisher, Feng, and staff, 2 credits, spring semester

Description: We will discuss exciting recent advances in human genetics and genomics, with illustrative examples of their translation into improvements in diagnosis and treatment of patients. We will also discuss ethical and societal challenges of this rapidly evolving field. Our course is aimed at first or second year PhD students, and will be taught by faculty in a variety of departments through traditional lectures and discussion sections. Students will be evaluated on their ability to explain the translational research process and demonstrate how individual research findings build on one another to move a field forward to ultimately impact patient care.

Cancer Biology and Genetics

GMS PM/MM 703, Flynn and Ganem, 2 credits, fall semester.

Prerequisite: Consent of instructor.

Description: This course covers topics in tumor biology including: tumor progression, invasion, and metastasis; viruses, immunodeficiency, and cancer; chemical carcinogenesis; signal transduction; anti-oncogenes and familial cancer syndromes; apoptosis and cancer; cell cycle control; DNA repair; principles of cancer therapy; immunotherapy of cancer; anti-angiogenesis therapy; and modern molecular diagnostic techniques.

Behavioral Pharmacology

GMS PM 820, Cottone, Kumaresan, and Sabino, 2 credits, spring semester.

Prerequisite: Consent of instructor.

Description: Focuses on the mechanisms and sites of action of drugs that influence the brain, with an emphasis on therapies for neurological and psychiatric disorders as well as drugs of abuse. Behavioral models of diseases affecting the brain also will be defined and critiqued.

Drug Discovery and Development

GMS PM 881, Kasaian, Farb, and Pfizer scientists, 2 credits, fall semester

Description: This course addresses the discovery and development process for small molecule and protein drug products and features lectures from scientists participating in industrial drug discovery. Topics include target identification and validation, lead optimization and selection of drug candidates

for clinical testing, and the objectives and design of clinical trials. Students will gain experience in IND preparation.

Other Elective Courses for the Program in Biomolecular Pharmacology

Students should discuss elective courses with the Program Director if they wish to take a course not on this list.

GMS FC 717 Physiology of the Specialized cell (3cr) GMS FC 715 Translational Genetics and Genomics GMS MI 720 Statistical Reasoning for the Basic Biomedical Sciences (3 cr) (expected to change to FC 720 in 2018) SPH BS 704 Introduction to Biostatistics (3 cr) GMS AN 704 Experimental Design and Statistics (3 cr) GMS MS 700 Elementary Biostatistics (2 cr) GMS AN 810 Systems Neurobiology (4 cr) GMS AN 811 Cognitive Neuroscience (4 cr) GRS MA 665/666 An Introduction to Mathematical Models & Data Analysis in Neuroscience (2 cr) GMS BY 760 Foundations of Biophysics and Structural Biology (4 cr) GMS BY 771 Biophysics of Macromolecular Assemblies (4 cr) GMS BY 772 Nuclear Magnetic Resonance Spectroscopy in Biology & Biochemistry (2 cr) ENG BE 560 Biomolecular Architecture (4 cr) ENG BE 561 DNA and Protein Sequence Analysis (4 cr) ENG BE 565 Molecular Biotechnology (2 cr) ENG BE 568 Systems Biology of Human Disease (4 cr) ENG BE 726 Fundamentals of Biomaterials (4 cr) ENG BE 727 Principles and Applications of Tissue Engineering (4 cr) GMS BI 776 Gene Targeting in Transgenic Mice (2 cr) GMS BI 777 Techniques in Biochemistry, Cell, and Molecular Biology (2 cr) GMS MS 710 Transdisciplinary Addiction Science (2 cr) GMS MS 783 Molecular Basis of Neurologic Disease (2 cr) GRS NE 741 Neural systems: Functional circuit analysis (4 cr) GRS NE 742 Neural systems: Cognition and Behavior (4 cr) CAS CN 510 Principles and Methods of Cognitive and Neural Modeling (4 cr)

Biomolecular Pharmacology Seminars

All Pharmacology graduate students are required to attend the Pharmacology seminar series held throughout the fall and spring semesters. In addition, students must enroll in at least one semester of Current Topics in Pharmacological Sciences. In this course, the guest seminar speaker attends student presentations of research paper(s) related to the speaker's research. This course has proven to be highly successful in providing students with essential background to the seminar speaker's work and thereby preparing the students to participate actively in the programmatic seminar.

Outline of Graduate Studies in Pharmacology M.A. and PhD Degree Program

Year	Semester	Course Name/ Activity Description	Course No.	Credit Hours
1 Fall Protein Structure, Catalysis		Protein Structure, Catalysis and Interaction	GMS FC 711	3
		Structure and Function of the Genome	GMS FC 712	3
		Molecular & Translational Pharmacology	GMS PM 701	2

		Laboratory Techniques in Modern Pharmacology Directed Research in Pharmacology Fall Seminar Series	GMS PM 710 GMS PM 931	2 Variable
	Spring	Architecture and Dynamic of the Cell Mechanisms of Cell Communication Molecular Neurobiology and Pharmacology Laboratory Techniques in Modern Pharmacology Directed Research in Pharmacology Spring Seminar Series	GMS FC 713 GMS FC 714 GMS PM 702 GMS PM 710 GMS PM 932	3 3 2 2 Variable
	Summer	Research (Industry Internship)		
2	Fall	Systems Pharmacology & Therapeutics I	GMS PM 801	2 Variable
L		Directed Research in Pharmacology Fall Seminar Series	GMS PM 931	Variable
		Taskalasi ad Desfassianal Okilla in Dhamaasalama	GMS PM932	
	Spring	Systems Pharmacology & Therapeutics II	GMS PM 802	2
		Electives Current Topics in Pharmacological Sciences Directed Research in Pharmacology Spring Seminar Series	See App II GMS PM 810 GMS PM 932	Variable 2 Variable
	Summer	Research (Thesis for M.A. Degree)		
2		Electives		Variable
3	Fall	Directed Research in Pharmacology & DAC Meeting Fall Seminar Series	GMS PM 931	Variable
	Spring	Directed Research in Pharmacology & DAC Meeting	GMS PM 932	Variable
	Oping	Spring Seminar Series		
1 & 5		Participation in Teaching	CMS PM 021 022	Variable
TUU		Pre-Defense of Dissertation PhD Dissertation Defense		64 for PhD

Outline of Graduate Studies in Pharmacology MD/PhD Degree Programs

Year	Semester	Course Name/ Activity Description	Course No.	Credit
				Hours

1	Fall	Molecular & Translational Pharmacology	GMS PM 701	2
		Electives		Variable
		Fall Seminar Series		
		Directed Research in Pharmacology	GMS PM 931	Variable
	Spring	Molecular Neurobiology and Pharmacology	GMS PM 702	2
		Current Topics in Pharmacological Sciences	GMS PM 810	2
		Electives		Variable
		Directed Research in Pharmacology Spring Seminar Series	GMS PM 932	Variable
	Summer	PhD Written & Oral Qualifying Exams		
	Fall	Electives	See App II	Variable
2		Directed Research in Pharmacology Fall Seminar Series	GMS PM 931	Variable
	Spring	Electives	See App II	Variable
		Participation in Teaching (optional) Directed Research in Pharmacology & DAC Meeting Technical and Professional Skills in Pharmacology Spring Seminar Series	GMS PM 932	Variable
	Summer	Research		
3 or 4	Fall	Directed Research in Pharmacology & DAC Meeting Participation in Teaching (optional)	GMS PM 931	Variable
		Fall Seminar Series Progress Report Seminar & DAC Meeting		
	Spring	Spring Seminar Series Directed Research in Pharmacology Pre-Defense of Dissertation & DAC Meeting	GMS PM 932	Variable
		PhD Dissertation Defense & Celebration		32 for PhD

* Students should register each fall and spring semester for 12 credits in total to achieve full-time status. In addition to courses, students should register for GMS PM 931 (fall) or GMS 932 (spring) to reach this 12 credit total. Enrollment in GMS 931,2 must be for an even number of credits.

Pharmacology Courses

First Courses in Pharmacology

GMS PM 701	Molecular & Translational Pharmacology (Fall)
GMS PM 702	Molecular Neurobiology and Pharmacology (Spring)
GMS PM 710	Laboratory Techniques in Pharmacology
Advanced Courses in Pharmacology	
GMS PM 801	Systems Pharmacology & Therapeutics I (Fall)
GMS PM 802	Systems Pharmacology & Therapeutics II (Spring)
GMS PM 810	Current Topics in Pharmacological Sciences*
GMS PM 820	Behavioral Pharmacology (Neuropsychopharmacology)
GMS PM 843	Pharmacologic Intervention in Inflammatory Responses
Research	
GMS PM 931, 932	Directed Research in Pharmacology

* This course can be used twice to satisfy the departmental requirement for elective courses: (6 credits for PhD candidates, 6 credits for MD/PhD candidates, 4 credits for M.A. candidates).

Committee on Graduate Education

- Dr. Neil Ganem (Chair): nganem@bu.edu (appointed 2014)
- Dr. Shannon Fisher: <u>shanfish@bu.edu</u> (appointed 2018)
- Dr. Rachel Flynn: <u>rlflynn@bu.edu</u> (appointed 2021)
- Dr. Venetia Zachariou: vachar@bu.edu (appointed 2023)
- Dr. Weiming Xia: wxia@bu.edu (appointed 2023)

Petitions should be submitted to the Program Director Dr. Rachel Flynn (<u>rlflynn@bu.edu</u>) and chair of the GEC, Dr. Neil Ganem (nganem@bu.edu)

Fair Expectations for Graduate Students at Boston University School of Medicine

- 1. Institutional Commitment
- 2. Quality of Training
- 3. Mentoring
- 4. Career Development
- 5. Code of Conduct

1. Institutional Commitment

Pre-doctoral training at Boston University School of Medicine (BUSM) includes both didactic course work in a focused area and an apprenticeship in which the graduate student trains under the supervision of one or more investigators who are qualified to fulfill the responsibilities of a mentor. The Division of Graduate Medical Sciences (GMS), home of the graduate programs at the BUSM supports the assertion that a positive mentoring relationship between the pre-doctoral student and the research advisor is a critical component of the student's preparation to become an independent and successful research scientist. In keeping with the AAMC compact between graduate students and their primary mentors, the Division of GMS recognizes that for those individuals who pursue a biomedical graduate degree there is the strong expectation to take responsibility for their own scientific and professional development. Faculty who advise students are expected to fulfill the responsibilities of a mentor, including the provision of scientific training, guidance, instruction in the responsible conduct of research and research ethics, and financial support. The faculty advisor also performs a critical function as a scientific role model for the graduate student. In concert with students' training, the Division of GMS provides oversight for the length of study, program integrity, stipend levels, benefits (including health insurance), grievance procedures, and other matters relevant to the education of its graduate students.

2. Quality of Training

Our goal is that individuals enrolled in GMS programs should be trained to independently formulate meaningful hypotheses, design and conduct interpretable experiments, adhere to good laboratory practices, analyze results critically, understand the broad significance of their research findings, and uphold the highest ethical standards in research. This is accomplished through programs offering relevant course offerings, research opportunities, including clear guidelines for performance assessment and close monitoring and guiding of graduate students through the course of their study. Training in career skills include critical thinking, grant preparation, scientific writing, presentation skills, working with others collaboratively, the responsible conduct of research and numerous other topics.

3. Mentoring

Effective mentoring is critical for graduate school trainees as they begin their scientific careers. Faculty mentors should dedicate substantial time to graduate students to ensure their development in areas of scientific, developmental, and professional development. Faculty mentors should foster a relationship of mutual respect with graduate students, encouraging their individual development, offering constructive criticism as well as praise. As an exemplary role model, the mentor also serves as a primary influence in providing an example of high ethical standards. In essence, the faculty mentor is a role model who will not only help prepare the student to become a successful scientist, the mentor will help shape the student to also become an effective mentor to future graduate students.

4. Career Development

Graduate students must have training experiences of sufficient breadth to ensure that they are prepared to pursue a wide range of professional career options in academia, industry, government and research careers. A series of formal and informal venues should exist to assist students in their career exploration and professional development.

5. Code of Conduct.

The following commitments will form the basis for our code of conduct in the Division of GMS for both students and graduate faculty.

Commitments of Graduate Students

• I acknowledge that I have the primary responsibility for the successful completion of my degree. I will be committed to my graduate education and will demonstrate this by my efforts in the classroom and the research laboratory. I will maintain a high level of professionalism, self-motivation, engagement, scientific curiosity, and ethical standards.

• I will meet regularly with my research advisor and provide him/her with updates on the progress and results of my activities and experiments.

• I will work with my research advisor to develop a thesis/dissertation project. This will include establishing a timeline for each phase of my work. I will strive to meet the established deadlines.

• I will work with my research advisor to select a thesis/dissertation committee. I will commit to meeting with this committee at least annually (or more frequently, according to program guidelines). I will be responsive to the advice of and constructive criticism from my committee.

• I will be knowledgeable of the policies and requirements of my graduate program, graduate school, and institution. I will commit to meeting these requirements, including teaching responsibilities.

• I will attend and participate in laboratory meetings, seminars and journal clubs that are part of my educational program.

• I will comply with all institutional policies, including academic program milestones. I will comply with both the letter and spirit of all institutional safe laboratory practices and animal-use and human-research policies at my institution.

• I will participate in my institution's Responsible Conduct of Research Training Program and practice those guidelines in conducting my thesis/dissertation research.

• I will participate with my mentor in applying for grant funds to support the research in the laboratory in which I work, and when appropriate, myself. I realize that my participation in the research laboratory is supported by funds for my stipend as well as supplies and materials used in my research, and that regular applications for the financial support of my laboratory are required for the support of laboratory colleagues, my laboratory resources, and myself. To the best of my ability, I will partner with my mentor in preparing research results and the proposed research plans for these applications of my own for the support of my stipend, realizing that this is not only an important research career training opportunity, but that it is required for the success of the laboratory in which I work.

• I will be a good lab citizen. I will agree to take part in shared laboratory responsibilities and will use laboratory resources carefully and frugally. I will maintain a safe and clean laboratory space. I will be respectful of, tolerant of, and work collegially with all laboratory personnel.

• I will maintain a detailed, organized, and accurate laboratory notebook. I am aware that my original notebooks and all tangible research data are the property of my institution but that I am able to take a copy of my notebooks with me after I complete my thesis/dissertation.

• I will discuss policies on work hours, sick leave and vacation with my research advisor. I will consult with my advisor and notify fellow lab members in advance of any planned absences.

• I will discuss policies on authorship and attendance at professional meetings with my research advisor. I will work with my advisor to submit all relevant research results that are ready for publication in a timely manner prior to my graduation.

• I acknowledge that it is primarily my responsibility to develop my career following the completion of my doctoral degree. I will seek guidance from my research advisor, career counseling services, thesis/dissertation committee, other mentors, and any other resources available for advice on career plans.

Commitments of Mentors

• I will be committed to the mentoring of the graduate student during this early phase of their research career. I will be committed to the education and training of the graduate student as a future member of the scientific community.

• I will be committed to the research project of the graduate student. I will help to plan and direct the graduate student's project, set reasonable and attainable goals, and establish a timeline for completion of the project. I recognize the possibility of conflicts between the interests of externally funded research programs and those of the graduate student, and will not let these interfere with the student's pursuit of his/her thesis/dissertation research.

• I will be committed to meeting one-on-one with the student on a regular basis.

• I will be committed to providing financial resources for the graduate student as appropriate or according to my institution's guidelines, in order for him/her to conduct thesis/dissertation research.

• I will be knowledgeable of, and guide the graduate student through, the requirements and deadlines of his/her graduate program as well as those of the institution, including teaching requirements and human resources guidelines.

• I will help the graduate student select a thesis/dissertation committee. I will assure that this committee meets at least annually (or more frequently, according to program guidelines) to review the graduate student's progress.

• I will lead by example and facilitate the training of the graduate student in complementary skills needed to be a successful scientist, such as oral and written communication skills, grant writing, lab management, animal and human research policies, the ethical conduct of research, and scientific professionalism. I will encourage the student to seek opportunities in teaching

• I will expect the graduate student to share common laboratory responsibilities and utilize resources, and be accessible, encouraging, and respectful. I will foster the graduate student's professional confidence and encourage critical thinking, skepticism and creativity.

• I will not require the graduate student to perform tasks that are unrelated to his/her training

program and professional development.

• I will discuss authorship policies regarding papers with the graduate student. I will acknowledge the graduate student's scientific contributions to the work in my laboratory, and I will work with the graduate student to publish his/her work in a timely manner prior to, and if necessary after the student's graduation.

• I will discuss intellectual policy issues with the student with regard to disclosure, patent rights and publishing research discoveries.

• I will encourage the graduate student to attend scientific/professional meetings and make an effort to secure and facilitate funding for such activities.

• I will provide career advice and assist in finding a position for the graduate student following his/her graduation. I will provide honest letters of recommendation for his/her next phase of professional development. I will also be accessible to give advice and feedback on career goals.

• I will provide for every graduate student under my supervision an environment that is intellectually stimulating, emotionally supportive, safe, and free of harassment.

Other Resources: GMS Handbook

PhD program's data profile

Shown are PhD profiles including a brief description of the program, and five-year (or more) trend data on: applications and offers, selectivity, entering cohort size, sex and ethnicity demographics, attrition rate, cumulative completion rate, median time to degree, and five- and ten-year out graduate employment

Oral Qualifying Sample Questions

The student will briefly summarize their project (5-10 min). The committee will then ask them scientific questions about the proposal. Faculty will be testing the student's general knowledge of the field of the proposal and ability to think in a rigorous, scientific manner. While asking these questions, the faculty will weave in questions related to the proposal to test the student's general knowledge of pharmacology. Sample questions of general pharmacological knowledge are shown below:

1. Pharmacodynamics:

Drug X inhibits activity of the receptor you are studying. Draw curves for the effects of the following types of compounds on receptor activity and explain how their potency is evaluated:

Competitive antagonist

Noncompetitive antagonist

Partial agonist

2. Pharmacokinetics:

Drug X is metabolized by CYP3A4 in the liver and has a plasma elimination half-life of 12 hours.

How many maintenance doses would be required to reach steady state levels? How does the dosing interval influence the steady state levels?

How might hepatic disease affect the plasma elimination half-life, and why might renal disease affect the pharmacokinetics as well?

How would doubling the dosing rate affect a) the plasma elimination half-life, b) the steady state level, c) the volume of distribution? What assumptions are you making to answer the question?

3. Receptor dynamics

What receptor mechanisms may contribute to clinically observed tolerance to opioid agonists.

4. Statistics

Note: The student will have proposed experiments that entail collection of data to test one or more hypotheses.

What type of statistical analysis is appropriate for summary and interpretation of data from your proposed experiments?

What is the difference between a one-way and a two-way ANOVA? Explain the meaning of 'interaction' in a two-way ANOVA.

What is the difference between standard error and standard deviation. Under what circumstances would you be more interested in SEM? When would you be more interested in SD?

5. Systems Pharmacology: Sympathetic nervous system

Through what central and peripheral receptors does the sympathetic nervous system regulate blood pressure? What are some medications that act on these receptors?

6. Systems Pharmacology: Anti-microbial agents

What is the mechanism of action of beta-lactam antibacterial agents, and what are the causes of resistance?

7. Systems Pharmacology: Anti-neoplastics

What are the advantages and disadvantages of targeted anti-neoplastic agents such as kinase inhibitors compared to conventional cytotoxic agents such as DNA alkylators

PhD Timeline

Form/Action Item:	Deadline:	Form Available:
Finalize Dissertation Advisory Committee DAC Members and submit Special Service Appointments to Division Office	At least one year before Final Oral Defense	http://www.bumc.bu.edu/gms/files /2012/09/PhD-Special·Service Appointment.pdf)
as needed		
Dissertation Prospectus Outline approved by First and Second Readers and Department Chair due in the Division Office	Middle of the semester prior to the one in which you intend to graduate*	http://www.bumc.bu.edu/gms/files /2011/10/Dissertation- Prospectus- Outline-Approval Page.pdf
Diploma Application due in the Division Office	Beginning of the semester in which you intend to graduate*	http://www.bumc.bu.edu/gms/files /2012/09/DIPLOMA APPLICATON PHD MD PHD Feb 2014 TAD.pdf
Complete dissertation due to First Reader	Six weeks before Pre- Defense	
Complete dissertation approved by First Reader due to Second	Three weeks before Pre- Defense Meeting	
Complete dissertation to rest of DAC	Two weeks before Pre Defense Meeting	
Hold Pre-Defense Meeting with all DAC Members	At least three weeks prior to the Final Oral Defense	
Dissertation Abstract approved by First Reader and Department Chair due in the Division Office for review and approval	At least three weeks prior to the Final Oral Defense	http://www.bumc.bu.edu/gms/files /2012/01/PhD·Dissertation· Defense-Abstractv1RE.pdf
Schedule of Final Oral Examination due in the Division Office with one printed copy of the approved abstract	At least two weeks prior to the Final Oral Defense	http://www.bumc.bu.edu/gms/files /2012/09/Schedule-of-Oral-Defense- updated-10-2013-TAD.pdf
Last date to hold Oral Defense	Two months before graduation*	
Dissertation format to be reviewed by Division Office	Email sent by Division Office with exact dates	http://www.bumc.bu.edu/gms/gat eway/students/phd/student- page/
Final Dissertation with signed Approval sheets due in Division	One to two months Before graduation*	Forms sent to Committee Chair by Division Office
Electronic version of Final Dissertation turned in to Department of Pharmacology,	Within two weeks of turning in Dissertation to Division Office	Pharm2@bu.edu

*Please refer to the Division of Graduate Medical Sciences website for specific dates for each semester. http://www.bumc.bu.edu/gms/files/2013/11/2014-Graduation-calendar.PhD.pdf

Course Requirements for GPN Students in the Biomolecular Pharmacology Training Program

GPN students who join the Biomolecular Pharmacology Program can take the pharmacology curriculum during years 1, 2 and/or 3. Pharmacology requirements fulfill 10 credits of the elective coursework requirement (12 credits) in the Graduate Program for Neuroscience (GPN).

A potential scheduling of pharmacology academic requirements (presented in bold lettering) in relationship to the GPN required curriculum is presented below. Dissertation research credits are not represented in this description and make up the 64 credits needed for partial fulfillment of the PhD. degree. There are 35 credits listed below that include core GPN and Pharmacology offerings, special training modules in computational neuroscience, and a year-long professional development class that emphasizes oral presentation skills, critical review of the literature and grant writing. There is also credit for clinical rounds that take place at the VA Hospital. Students can take additional academic credits as represented below by italicized "optional" coursework after consultation with their GPN advisors.

Year 1 Fall (12 cr)

GMS AN 810 Principles of Neuroscience I: From Molecules to Systems (4 cr)

GMS NE 500 Frontiers in Neuroscience (2 cr)

GMS NE 800 Laboratory Rotations (2 cr)

GMS PM 701 Molecular and Translational Pharmacology (2 cr)

GRS MA 665 Introduction to Mathematical Models & Data Analysis in Neuroscience (2 cr for

7-week module required, optional additional 2 cr module)

Year 1 Spring (10 cr)

GMS AN 801 Principles of Neuroscience II: From Systems to Mind (4 cr)

GMS NE 501 Frontiers in Neuroscience (2 cr)

GMS NE 801 Laboratory Rotations (2 cr)

GMS PM 702 Molecular Neurobiology and Pharmacology (2 cr)

Optional GPN elective (2-4cr)

<u>Year 2 Fall (9 cr)</u>

GMS NE 901 Clinical Rounds (1 cr)

GMS PM 801 Systems Pharmacology & Therapeutics I (2 cr)

GRS MA681 Accelerated introduction to statistical methods for quantitative research (4 cr)

GMS MS 783: Molecular Basis of Neurologic Diseases (2 cr) (Strongly suggested for required 2 credit GPN elective for all molecular neuroscience students)

Optional GPN elective (2-4 cr)

Year 2 Spring (4 cr)

Optional GMS NE 902 Clinical Rounds (1-cr)

Optional GPN elective (2-4 credits)

GMS PM 802 Systems Pharmacology & Therapeutics II (2 cr)

GMS FC 707 Physiology of Specialized Cells (2 cr)

List of Pharmacology Curriculum Requirements (10 credits total)

GMS PM 701 Molecular and Translational Pharmacology (2 cr, sem I)

GMS PM 702 Molecular Neurobiology and Pharmacology (2 cr, sem II)

GMS FC 707 Physiology of Specialized Cells (2 cr, sem II)

GMS PM 801 Systems Pharmacology & Therapeutics I (2 cr)

GMS PM 802 Systems Pharmacology & Therapeutics II (2 cr)

Other Requirements

In addition to the core coursework in neuroscience and the requirements to remain in good standing in GPN (<u>http://www.bu.edu/neuro/graduate/about-2/curriculum/core-courses/</u>) and GPN programmatic activities (that include the Neuroscience Retreat, Holiday Party, New Student Celebration, Distinguished Lectures, CSN seminar series, Neuroscience Graduate Student Seminar Series, GPN Recruitment etc), as a student specializing in neuropharmacology you are also expected to participate in the NIGMS biomolecular pharmacology training program by attending a minimum of 50% of their seminars, to be selected based on your interest.

A GPN/Pharmacology student who successfully competes for appointment to the NIGMS T32 Training Grant in Biomolecular Pharmacology is also required to complete a 7-week rotation at Pfizer or Biogen during the summer after their first year in GPN.

Program engagement also involves attendance at the Pharmacology holiday party and at least one additional major Pharmacology Social event. I also encourage you to participate once a year in the Pharmacology Student Seminar Series as it is a great opportunity for you to learn how to communicate your science to an interdisciplinary group and to receive constructive criticism from a great group of mentors and other graduate students.

Required Courses for Pharmacology Students Electing Neuroscience Pathway of Emphasis*

(10 credits)

1. GMS NE 700 Principles of Neuroscience

(4 cr) – Drs. Douglas Rosene (Anatomy and Neurobiology) and Jerry Chen (Biology) Tue, Thur 3:30-6:00pm – Fall semester

2. GMS PM 820 Behavioral Pharmacology

(2 cr) – Drs. Sabino, Cottone & Kumaresan Fridays 3:00-4:50pm – Spring semester

3. GMS NS 783 Molecular Basis of Neurologic Disease

(2 cr) – Dr. Carmela Abraham Thursdays, 3:00-4:50pm – Fall semester **OR**

GMS PM 843 Pharmacologic Intervention in the Inflammatory Response

(2 cr) – Drs. Tsuneya Ikezu and Susan Leeman Thursdays, 10:00-11:50am – Fall semester

4. (TBD) Computer Programming, Computational Neuroscience, or Biological Statistics course (2 cr)

*Students who elect this pathway of emphasis should consult with the Director of the Graduate Program in Neuroscience to coordinate these requirements with those for the Biomolecular Pharmacology Program.

Department of Pharmacology and Experimental Therapeutics Program in Biomolecular Pharmacology							
			PhD Di	issertation Tracking F	orm		
Name	lame:Matriculation Date:						
Disser	tation Advisor						
			Name	Signature	e Dat	e	
I.	QUALIFYING	EXAM (Advisor and	two Program faculty)			
	Committee	e :	1	Chair (Pri	imary Appt. De	ept., Asst Pro. Rar	nk and
above)						
			2	Advisor (E	Dept. or Progra	am)	
			3	Dept. or P	rogram Facul	ty	
	Approval:		Two memb third memb Program Di	ers must be from the Doper be a Program memb	epartment, an er from outsic	d it is encouraged le the Department	that the
	Dates:	Writter	າ:		Pass/Fail (notification sent to	Dept.)
		Oral:			Pass/Fail		
II.	DISSERTATI Advisory	ION (At 1	least two fac	culty with primary appoi	ntments in the Primary appt.	Dept. for DAC) Dept., Asst Pro. R	ank
	and above	e Commit	tee:	2. Advisor (Fir	st Reader)		
		3		Second Reade	ər		
		4		Internal Revie	wer		
		5		External Revi	ewer (Prefera	bly Non BU)	

Approval:

(PD)

A. Submission of First-authored Research Manuscript for Publication: _____ (Must occur prior to scheduling the Thesis Defense)

Approval:

(PD)

B. Pre-Defense Meeting and Approval for Scheduling

Defense*: Approval:

(PD)

*All necessary documents must be submitted and approved through the GMS online portal.

Program in Biomolecular Pharmacology Laboratory Techniques in Modern Pharmacology (GMS PM 710, 2 cr)

The Biomolecular Pharmacology Training Program includes registration in two semesters of the course Laboratory Techniques in Modern Pharmacology. Each semester entails completion of two 7-week rotations in laboratories of faculty members of the training program. **The student's responsibility consists of approximately 20 hours per week involvement in the research activities of the laboratory**. During the last week of the rotation, students must prepare a 3 to 6-page report written in the style of a research manuscript, with an introduction, materials and methods, results, conclusions and references. Sample lab reports are provided in the online student handbook. The report must be reviewed by the faculty advisor for the rotation, and corrections made as suggested. Submit the final version electronically by the deadlines below to the rotation advisor, Course Managers Drs. Russek and Flynn, and Academic Manager Licia Holman. A late report will result in a grade of Incomplete, and enrollment in the program will be in jeopardy.

Fall Semester:	Rotation 1 Advisor
Early September, Find rotation advisors	
Sept-Oct, Rotation 1	
Report due Nov	Rotation 2 Advisor
Nov-Dec, Rotation 2	
Report due Jan	
	Rotation 3 Advisor
Spring Semester:	
Jan-Mar, Rotation 3	
Report due March	
	Rotation 4 Advisor
March-April, Rotation 4 (optional)	
Report due May	

Graduate Student Forum

Graduate Student Forum (GSF) is an opportunity for graduate students in the Biomolecular Pharmacology Training Program to interact and develop professionally. GSF is a student-only space (i.e., no faculty are present) that is organized by two Pharmacology student co-chairs. The main goals of the forum are to present one's research and receive constructive feedback from peers, to learn about peers' research, and to socialize and hone professional skills. Presentations are mainly focused on the students' current thesis research. However, a main goal of GSF is to provide practice science communication, and so a large body of work is not necessary. GSF is a great environment to foster and encourage questions from students about each presentation.

The following guidelines were based on an annual survey of all pharmacology program PhD candidates, and we believe they will significantly add to the environment of constructive peer review.

- 1. GSF is held during the academic year, with three dates in the Fall semester and three dates in the Spring semester, depending on the number of presenters.
- 2. GSF will be held on Fridays and lunch will be provided.
- 3. Students are required to present twice before graduating.
- 4. Two presentations will be held per date.
- 5. Twenty-five minutes is allocated per presentation with an additional five minutes for questions.

Anonymous questionnaires will be handed out at the beginning of the forum in order to give constructive feedback to presenters.

Financial Aid for Students

Students admitted to the PhD program of the Department of Pharmacology & Experimental Therapeutics are provided information about the specific offer of financial aid in the letter of admission from the Department Chairman. Ordinarily, students admitted to the PhD program are provided financial aid for the first year in the form of full tuition scholarship, activity fees, health insurance, and a 10-month stipend. Students must be covered by health insurance and are offered the election of a BUSM policy or a waiver if there is proof of coverage by an alternative plan. The yearly premium is included in the financial aid award for predoctoral students. Financial aid for first-year students is administered through the Division of Graduate Medical Sciences.

Continuation of the financial aid award is contingent upon satisfactory academic accomplishment in formal coursework, in laboratory research, and a consistent record of attendance and participation at Department seminars and other related academic activities. Financial aid in the form of full tuition scholarship, activity fees, health insurance, and stipend almost always continues throughout the duration of predoctoral study. After the first year, financial aid is administered through the Department of Pharmacology & Experimental Therapeutics.

Stipend support following the first year of study comes from a variety of sources, most often the extramural grants of the research mentor, NIH institutional training grants, and individual NIH predoctoral fellowships. All students are strongly encouraged to apply for predoctoral fellowships from extramural sources such as NIH, NSF, the American Association of Cancer Research, the American Heart Association, and the Pharmaceutical Research and Manufacturers of American (PhRMA) Foundation. Workshops in the second year of the program are designed to provide training in preparing grant applications. This training will also provide the basis for preparation and submission of a research proposal as the written component of the PhD qualifying examination. Highly qualified students are eligible to formally apply for a 12-month appointment to the NIGMS Training Grant in Biomolecular Pharmacology. Please see 4b of the student handbook for the application process or visit our website for information listed under the NIGMS PROGRAM tab. This source of financial aid includes tuition scholarship, health insurance, stipend, travel, and laboratory supplies.

Guidelines for Registration, Health Insurance, and Financial Aid

Registration: Full-time students should register for 12 credits in each of the fall and spring semesters. Students must be registered in the semester during which they defend their dissertations. The financial aid to cover tuition charges is allocated by Sherill Ashe in the Division of Graduate Medical Sciences and comes from Division sources, NIH training grants and predoctoral fellowships.

Ordinarily, students do not register during summer semesters 1 or 2 unless they are defending their dissertation during that time. Government policy requires that FICA be withheld from the stipend during the three summer months, unless students are registered as full-time. (This policy does not apply to international students who have resided in the U.S. for less than 5 years.) If students wish to avoid FICA withholding, they can do so by submitting a form provided by the Division that allows for full-time status during the summer without incurring the cost of registering for research credits.

On matriculation, the stipend support is provided by the Division of Graduate Medical Sciences from University sources and continues for ten months. Subsequently, the source of stipend support will be determined by the faculty member who serves as the student's dissertation advisor or by appointment to a training grant.

Health insurance: Students must be covered by health insurance and are offered the election of a BU policy or a waiver if there is proof of coverage by an alternative plan. Students must submit a waiver form if they do not want the BU policy. Ordinarily, financial aid is provided for the yearly premium of the standard BU policy for students who elect that plan. Financial aid is not provided for coverage by other sources or for the additional premiums for family members. Students in the MD/PhD program must carry the plan for MD students while enrolled in the PhD program; financial aid is provided for the premium of the BUMC plan, but not other more-costly plans. For more information on health insurance plans offered by Boston University, refer to: <u>http://www.bu.edu/studentaccountingservices/resources/medical-insurance</u>.

Students should be familiar with the specific sources of their financial aid. Appointment to training grants may carry certain obligations as well as opportunities, and students should seek this information. For example, appointment to the Biomolecular Pharmacology Training Grant requires annual reporting of training accomplishments such as coursework, research training, and publications. References to sources of support should be provided in publications and in other documents such as the dissertation, and so students should seek this information on an annual basis. Current or past support from the Biomolecular Pharmacology Training Grant should be acknowledged by reference to NIGMS Grant 5T32GM008541.

Pre-Doctoral Fellowships

Ruth L. Kirschstein NRSA Fellowship

https://researchtraining.nih.gov/programs/fellowships

PhRMA Foundation Awards

http://www.phrmafoundation.org/

United Negro College Fund (UNCF)•Merck Graduate Science Research Dissertation Fellowships

http://umsi.uncf.org/applyonline/graduateinstructions

NSF Graduate Research Fellowship Program

http://www.nsfgrfp.org/

CDC Grants for Public Health Research Dissertation (R36)

http://grants.nih.gov/grants/guide/pa-files/par-07-231.html

ASPET Awards for Travel to Experimental Biology meetings and for Abstract Excellence

http://www.aspet.org/awards/

An extensive list of student funding opportunities is available at the following site:

http://www.medicine.virginia.edu/research/offices/research/home/find-page

Training in the Responsible Conduct of Research (RCR)

One key component of the Biomolecular Pharmacology training program addresses the principles of scientific integrity. The document below provides information about this educational component, which is required of all students. Students should refer to the accompanying document in this handbook that provides detailed information about the RCR training program for this upcoming academic year. New students should plan on completing the online instruction as soon as possible. Students are then encouraged to complete the four workshops, preferably by the end of the second year. After completion of all four workshops, students are expected to participate in one workshop a year until graduation. The Office of Research Compliance provides the Pharmacology Department with a record of student participation in these required phases of training.

Training in the responsible conduct of research is a critically important mission of the predoctoral Program in Biomolecular Pharmacology. Throughout predoctoral training students should consider the appropriate guidelines for ethical standards in experimentation, their interpretation, and use. During orientation students will receive information on institutional policies including "Policies and Procedures concerning Allegations of Misconduct in Scholarship and Research". Attendance at the faculty-led session on this topic is mandatory.

Formal training on scientific integrity and issues of ethical principles in research is a required component of the curriculum for graduate students in the sciences. The BU Program on Responsible Conduct of Research is implemented through the Boston University and Boston Medical Center Office of Research Compliance. To a large degree, the topics addressed by this program match those identified by Public Responsibility in Medicine and Research, the American Association of Medical Colleges and the National Institutes of Health. This program, which was instituted in 1991, covers a wide range of issues concerning the responsible conduct of research including, but not limited to, data acquisition, management, sharing and ownership, mentor/trainee responsibilities, publication practices and responsible authorship, peer review, collaborations, human subjects, laboratory animals, research misconduct and conflict of interest.

The RCR training includes online instruction and four discussion sessions. This educational activity is directed by Alan Fine, MD, Professor of Medicine, who is supported by the RCR Educational Advisory Committee. The RCR website at https://www.bu.edu/orc/training/responsible-conduct-of-research provides detailed information about this program. Faculty from the Biomolecular Pharmacology Training Program and other departments and programs at BU serve as facilitators at the four discussion sessions during the academic year. Each session includes a one-hour preparatory discussion among facilitators, followed by a two-hour training session with the students. Student attendance at training sessions is required, and attendance is recorded. Students receive email notification with information about the schedule and registration. Certificates are awarded to students after completion of the required series of training sessions to document compliance with Training Program and NIH requirements.

Additional resources are provided in this handbook to enrich students' understanding of responsible conduct of research. The NIH Office of Research Integrity text, "*ORI Introduction to the Responsible Conduct of Research*" by Nicholas Steneck, is available online at https://ori.hhs.gov/content/ori-introduction-responsible-conduct-research; the pdf is included in this handbook. A *Nature* article and two commentaries on scientific misconduct are also provided in this handbook. Students are expected to read all four documents as part of RCR study.

Related to these themes are mentoring relationships between students and faculty advisors. Students should read *Mentoring Guidelines* by Sally Koblinsky, provided in this handbook, which illustrates the challenges and opportunities of the student/mentor relationship.

Registration for Advanced Responsible Conduct of Research (RCR) Workshops Doctoral degree candidates and Post-doctoral researchers

ADVANCED RCR TRAINING: Doctoral candidates and post-doctoral researchers who have a RCR compliance requirement due to funding by an NIH training grant or an NSF research grant must complete the online Introductory (**Step 1**) & Intermediate (**Step 2**) RCR training modules before participating in the four Advanced RCR live workshops. Grant funded individuals, meanwhile, are required to complete **Steps 1** and **2** within 30 days of the start of funding and to complete all four live, advanced RCR workshops within two years.

All other doctoral and post-doctoral researchers who will be taking advanced RCR training, including those who are meeting a departmental mandate, they must also complete **Steps 1** and **2** before registering for the 4 workshops. Doctoral students should complete all four workshops by the end of their fourth year. Postdoctoral researchers are recommended to complete **Steps 1** and **2** as early as possible and commence the four RCR workshops in the semester in which online preparation is completed. We recommend completion of the four workshops at the rate of at least one per semester. **COMPLETING ONLINE STEPS 1** and **2**:

Step 1: Introductory RCR Principles

- 1. Log in to your Blackboard Learn homepage
- 2. Click on the second tab: All Blackboard Learn Courses
- 3. On the left-hand side of the All Blackboard Learn Courses page search for "RCR"

4. Select Introductory Responsible Conduct of Research (RCR) (Ongoing) from the list and follow directions

Step 2: Intermediate RCR Principles

1. Sign up for a CITI Account.

2. Affiliate with Boston University (please note that if you affiliate with Boston University Medical Campus through CITI, you will not be able to access the RCR course).

- 3. Click "Add a Course or Update Learner Groups"
- 4. Select "Responsible Conduct of Research (RCR Courses)"
- 5. Select "BU RCR Program for Doctoral candidates and Post-Docs: All Audiences"

YOU WILL RECEIVE AN ELECTRONIC DOCUMENT DIRECTING YOU TO REGISTER FOR ADVANCED RCR WORKSHOPS; REGISTRATION WILL OPEN MID-SEPTEMBER.

THE FOUR REQUIRED WORKSHOPS MAY BE TAKEN IN ANY SEQUENCE AND ON EITHER CAMPUS; EXACT DATES, LOCATIONS AND WORKSHOP TITLES WILL BE INCLUDED IN THE ELECTRONIC DOCUMENT

Oath of the Scientist

Medical students transition to their profession with the recitation of the Hippocratic Oath. However, no analogous oath has been widely adopted for students graduating with doctorates of philosophy (PhDs) in the various sciences.

Oaths taken upon entering a profession reflect a need to recognize the power and responsibility bestowed upon a graduate. It is then surprising that most scientists have escaped the privilege and duty of an oath. Scientists face tremendous ethical challenges, such as the development of human embryonic stem cells or tools of biological wars, to mention but a handful. An oath for scientists should include many of the same issues of professional identity and ethics that were addressed by Hippocrates, but should also pose additional matters pertinent to the sciences. Sir Joseph Rotblat proposed ethical

codes in science, highlighting the need for scientific oaths. Davis et al-offered a broad oath focusing on pride, integrity, and pursuit of knowledge.

We believe that a scientist's oath should reflect the professional activities inherent to being a scientist, be a pledge to responsible conduct, and embody commitments to help humanity and society at large. An effective oath should be inspiring without being confining. Such an oath should also emphasize the value and impact of PhD graduates on society. With this in mind, we have proposed and implemented at our medical school the following oath:

By accepting my Doctor of Philosophy degree, I earnestly assert that: I will

apply my scientific skills and principles to benefit society;

I will continue to practice and support a scientific process that is based on logic, intellectual rigor, personal integrity, and an uncompromising respect for truth; I will

treat my colleagues' work with respect and objectivity;

I will convey these scientific principles in my chosen profession, in mentoring, and in public debate;

I will seek to increase public understanding of the principles of science and its humanitarian goals;

These things I do promise.

Conceived by the faculty of the Division of Graduate Medical Sciences as articulated by Drs. Katya Ravid (Medicine and Biochemistry) and Benjamin L. Wolozin (Pharmacology and Neurology)