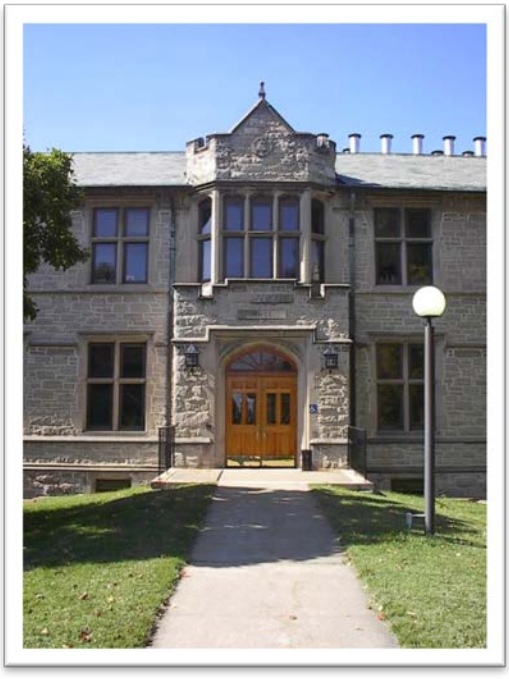
Biochemistry
University of Missouri

Biochemistry
Graduate Student Handbook

University of Missouri-Columbia

Revised July 2015



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Welcome to the Graduate Program of the Biochemistry Department at the University of Missouri-Columbia. You are one of a select group. Our entire department, faculty, staff and students, are ready to assist you through your graduate education to achieve your goal of becoming a professional scientist.

Our Graduate Program in Biochemistry emphasizes training in research and critical thinking. It is closely interwoven with the scholarly activities of the faculty. We study the biochemistry of life across the entire spectrum of living things, plants, animals and microorganisms. Our department has been a leader in interdisciplinary cooperation and collaboration throughout our University, and your graduate training will be strongly influenced by these interdisciplinary involvements.

The entire faculty is available for advice and consultation. Most academic questions and concerns should be posed first to the Graduate Education Committee, particularly the committee's Chair, Dr. Thomas Quinn (234A Schweitzer Addition). In addition, all members of the departmental faculty and staff are prepared to assist you or direct you to the appropriate individual. As Chair, I am available to discuss academic issues not resolved by other means. For issues of student and community life, your graduate student mentor is a good source of information, as is the very active Biochemistry Graduate Student Organization. Importantly, the department has an "Ombudsman", Dr. Linda Randall, who is available for confidential discussion with any member of the Department, faculty, staff or student about any difficult or uncomfortable situation. If you find yourself in such a situation, do not hesitate to have a confidential talk with Dr. Randall.

This graduate handbook contains a wealth of important and useful information. Get in the habit of referring to it as you progress in our graduate program. Good luck in this exciting and challenging stage of your life.

Gerald L. Hazelbauer
Professor and Chair

Ph.D. Degree

Prerequisites

- Biochemistry — At least one lecture course and one laboratory course, equivalent to Biochem 4270 or 4272 and 4974.
- Biological Sciences — One semester (e.g. general or microbiology)
- Physics — One year, equivalent to Physics 1210 and 1220.
- Organic Chemistry — One year with laboratory, equivalent to Chemistry 2100, 2110, 2130
- Calculus — One year, equivalent to Math 1500 and 1700.

Highly recommended courses

- Genetics or Molecular Biology — One semester, equivalent to Biology 2200 or 4976
- Biochemistry — Second semester of a lecture course, equivalent to Biochem 4272
- Quantitative Analytical Chemistry — One semester, equivalent to Chemistry 3200.
- Physical Chemistry — One semester of a course with a calculus prerequisite, equivalent to Biochem 4300 or Chemistry 3300.

A limited number of the courses listed above may be completed after acceptance as a graduate student. Any deficiencies must be completed in the first year of the graduate program. For example, it is recommended that students who have not completed a physical chemistry course take Biochem 4300, Physical Biochemistry, during the Fall semester of the first year.

Graduate Record Examination

The general examination is required and an advanced test is recommended.

TOEFL Exam

Students whose first language is other than English must take the TOEFL exam and score at least 620 on the paper version, 260 on the computer version, or 90 on the new version of the exam.

Research Rotations

To acquaint students with research laboratory settings, all incoming students participate in at least three research rotations during the first academic year. The purposes of rotations for the student include learning about laboratories of potential thesis advisors and exploring new areas of science. Thus, rotations in very different focus areas are highly recommended.

Each rotation is exactly eight weeks. Two rotations are performed in the first semester with the second rotation ending the Friday that classes end. The third rotation begins on the Monday two weeks before the Monday of Martin Luther King Day. For each of these two semesters, the student should register for 2 sections of one hour (each) Biochem 8450 (non-thesis research). Students should not register for more than 2 credits of Biochem 8450 in any one semester. The laboratory for the first rotation is determined during orientation week by discussion between the student, faculty and the Director of Graduate Studies (DGS). Second and third rotations are decided later in the semester after the student has had time to learn

about faculty members and their research, but at least one week before the end of the previous rotation. All rotations are chosen via discussions between the student and the faculty member and must be approved by the DGS. The faculty in whose laboratory the rotations are carried out will evaluate the student's performance and recommend letter grades for Biochem 8450. Faculty and students will provide the GEC with short written description and evaluation of the rotation within one week after the end of the rotation. Assessment of the student's performance is reflected in the assignment of grades (Biochem 8450 requires A, B, or C grading)

During a rotation, the student should perform as a full member of the laboratory. The student should have a desk and laboratory bench and a defined project supervised and guided by a member of the laboratory. One-half of the student's time and effort should be directed toward the rotation project, the other half toward course work. Since successful scientists usually work much more than 40 hours a week, the time of actual effort is typically greater. It is essential that you adopt a realistic work schedule that will allow you to complete your course work and perform laboratory research. The rotation laboratory should serve as an academic home and the student should participate in all usual laboratory activities, particularly weekly group meetings. The student should present an oral report about the research pursued to the host laboratory at the end of the rotation period. All members of the GEC are available for consultation at any time, should a difficult or awkward situation arise for anyone involved

. **Summer Research Opportunity**

Students are welcome to matriculate at the beginning of the summer term. A graduate student starting then will pursue full-time research for at least ten weeks that summer with a Biochemistry faculty member agreeing to supervise the research. The student will enroll in 4 credit hours of Biochem 8090 under the mentor and performance in the lab is reflected in an assigned grade (S/U); this does not qualify as a rotation. The student will still be required to do three laboratory rotations with the first starting at the beginning of their first semester. Students may return to the laboratory of their summer research experience for one of the three rotations.

Selection of Thesis Advisers

At the end of the third rotation students should identify a thesis advisor from the group of doctoral faculty having financial support for students. The choice of advisor is subject to final approval by the faculty member, the Director of Graduate Studies, GEC, and the department Chair. The student will receive credit and have a grade assigned for the fourth hour of Biochem 8450 by the advisor, reflecting the work performed with the thesis advisor during the second half of the second semester.

Coursework

Thesis Research (Biochem 9090)

Prior to successfully completing the Comprehensive Examination, nine credit hours per semester or four credit hours per summer are required to remain a full-time graduate student. If required classes do not total nine credit hours, Biochem 9090 should be used to reach the total. Following successful completion of the entire Comprehensive Exam, students should register for a minimum of two hours of thesis research (Biochem 9090) per semester (one in summer) to maintain "continuous enrollment." Students may need more than the minimum number of credit hours per semester to obtain the 72 credit hours required by the Graduate School for completion of the Ph.D. You must be registered every semester prior to and

including the semester in which you defend your dissertation. Zero-credit options are available; see the DGS.

Required Courses
During the first two semesters Ph.D. students are expected to complete Introductory Graduate Biochemistry I and II (Biochem 8240 Macromolecular Structure & Function and Biochem 8260 Systems Biochemistry), . Students must earn a B or A in each course. A C is unsatisfactory and the student must retake the course(s). Both required courses must be completed with a grade of B or better in order to remain a Ph.D. student in good standing. Only students in good standing may take the Qualifying exam. A grade of F in either of these two required courses will result in dismissal from the graduate program in Biochemistry, for lack of making "satisfactory progress". A student who has been dismissed has the right to appeal the dismissal to the department and Graduate Faculty Senate. Details on procedures for appeal to the department and Graduate Faculty Senate can be found at:
http://gradschool.missouri.edu/policies/progress/extension-appeal.php

Required additional Elective Coursework
A Ph.D. student must take a minimum of 7 additional hours of graduate science courses at the 8000 or 9000 level, and must earn a grade of B or better. Courses can be suggested or be required by the student's doctoral program committee. To satisfy the need for electives, students are encouraged to enroll in any of the following "pre-approved" Biochemistry courses towards their required 6 hours: Molecular Biology II / Biochem 9432 (4 hrs), Enzymology/Metabolism / Biochem 8432 (3 hrs) and Structural Biology and Molecular Association (9001) (2 hrs). Other Graduate level sciences courses may complete this requirement; please submit individual requests for approval by the GEC before enrolling.

Ethics Seminar
Ethical Conduct of Research (Biochem 8060, 1h), (or the equivalent offered in another department) is required of all Biochemistry graduate students. We recommend you complete this in your second semester (only offered in Spring).

Seminar (Biochem 9087, 4 credits total)
Students should enroll in Biochem 9087 during their first semester. Biochem 9087 in the Fall semester is designed to teach the fundamental techniques of oral presentation of scientific information, slide preparation, computer graphics, overhead preparation, etc. In addition, research compliance training (Chemical safety, Radiation safety) will be provided.

Students should take three additional semesters of Biochem 9087 in Spring semesters of years 3, 4, and 5. (A student may ask the DGS for permission to take 9087 in year 2 but this is not typical). In year 3, a student's second 9087 seminar is devoted to a presentation of their research. The third seminar should provide an update of research progress or a review of major journal papers in the student's research area. The fourth and final Biochem 9087 should be a practice for the dissertation defense. The student's thesis committee (Doctoral Program Committee, DPC) is expected to attend each of these presentations at the specific invitation of the student. A meeting with the DPC can often be conveniently arranged after the seminar presentation and serve as the required annual meeting.

Department Seminars

Students are required to attend all departmental seminars which are currently held Fridays at 1 pm in the Monsanto Auditorium of the Life Sciences Center.

Credit Hours
The Graduate School requires a minimum of 15 credit hours of course work at the 8000-level or higher (exclusive of research, problems and independent study experiences). The aforementioned core course work will fulfill 15 hours or more of this requirement. Ethics and Biochem 9087 (seminar) do not count towards the 15 credits. The student and his/her advisor in consultation with the student's DPC may decide upon additional courses. A minimum of 72 semester hours beyond the baccalaureate degree is required for the Ph.D. Within any limits imposed by the Graduate School or DPC, additional classroom graduate credit hours can apply to the requirement of 72 credit hours.

Residency
At least two nine-hour or three six-hour semesters must be completed in an 18-month period at MU to satisfy the residency requirement. All courses taken to satisfy the residency requirement must be MU courses approved for graduate credit and approved by the student's DPC.

Minimum Enrollment and Continuous Registration
Graduate students must maintain full-time status until they have passed both portions of the Comprehensive Exam. Full-time status is achieved by enrolling for 9 hours in Fall and Spring semesters and 4 hours during Summer term; students typically enroll in Biochem 9090 Research in order to complete their required hours.

Completion of the Comprehensive Exam admits a student to candidacy for the Ph.D. After the Comprehensive Exam has been passed, students must maintain continuous enrollment by registering in Biochem 9090 for at least 2 credit hours in Fall and Spring semesters and l credit hour in the summer. However, in order to meet the requirement for 72 hours of post-baccalaureate credit required by the Graduate School, students may need to enroll for up to 9 hours of Biochem 9090 per term to accumulate the 72 hours. Students may enroll in other courses in addition to 9090 and reduce the total 9090 hours taken, with approval of their Advisor. Failure to enroll in any semester terminates PhD candidacy by the Graduate School.

Financial Support

All Ph.D. candidates are provided with a graduate research assistantship from departmental or institutional sources for a maximum of twelve months of study. (As the University fiscal status changes, the departmental support may also be altered.) Special University and extramural fellowships may be used to supplement or extend this award. Laboratory rotations and the majority of the course work should be completed while students are supported by departmental sources. After departmental support, students will be supported by research grants, fellowships or other sources available to their mentors. A statement of employment agreement will be signed yearly.

Graduate Statement of Employment

I understand that I am obligated to be an enrolled graduate student each semester when employed as a Graduate Research Assistant at the University of Missouri. I understand that I am obligated to fulfill the duties my supervisor assigns and that continuing my assistantship is dependent on fulfilling those duties and my performance reviews, maintaining satisfactory performance in my courses and the availability of funding. I understand I must discuss additional employment at the University of Missouri with Dr. Thomas Quinn, Director of Graduate Studies and my mentor before accepting any other part-time employment. I also understand that I may not exceed a yearly average of 0.70 FTE and remain in a student title with all the benefits associated with that title.

I accept these conditions and the assistantship offer.

_____

Graduate Signature *Date*

_____

Chairman of Biochemistry *Director of Graduate Studies*

Fee and Fee Remission Program

Non-resident tuition and the resident education fees are waived. Student Activities Fees are paid by the student.

Doctoral Program Committee

The DPC membership is selected by the student's advisor in consultation with the student by the end of the second semester. In cases where matching of student with advisor is delayed, the DPC should be selected before one year has elapsed following the student's matriculation. After passing the Qualifying exam, the D1 form is submitted to The Graduate School to define the committee: http://gradschool.missouri.edu/policies/doctoral/requirements/d1.pdf

The DPC shall be composed of a minimum of four members of the MU graduate faculty. The DPC will include at least three members from Biochemistry faculty and an outside member from a different MU program. At least two of the DPC members besides the advisor must be MU doctoral faculty. Additional committee members with specialized expertise who do not meet the criteria for the MU graduate faculty or doctoral faculty may serve on a doctoral committee as a fifth or sixth member, with special permission of the GEC and Dean of the Graduate School. This committee will be responsible for advising the student throughout graduate study, for evaluation of the written and oral portions of the Comprehensive Examination, and for evaluation of the dissertation and the final defense.

First Doctoral Committee Meeting

The first meeting between the graduate student and his/her Doctoral Program Committee is informal. It should occur as soon as possible after the student has identified a mentor and by the end of the summer after the first academic year in order to fulfill Graduate School requirements for completing the D-1 and D-2 forms (Committee members and Plan of Study) within the first year. The purpose of this meeting is to introduce the scientific interests and goals of the student to the committee. As with all meetings between the student and the Doctoral Program Committee, the student should prepare a brief written document in advance of the meeting that summarizes the topics to be discussed. This document should be distributed to the committee members at least one week in advance of the meeting.

For the first committee meeting, the written document describes the student's "Plan of Study" and consists of two parts, the formal coursework to be taken by the student and the research project(s) to be undertaken by the student. The student should provide a list of graduate level coursework that has been completed to date, along with the grades received. The student should also provide a list of proposed courses and indicate how the formal course requirements of both the Department and the Graduate School will be met. The committee will review the completed and proposed coursework and, if necessary, suggest different or additional courses for the student consistent with the research interests of the student.

The second part of the document is a brief one- to three-page description of a projected Ph.D. research direction. At the first committee meeting, the student should describe this orally, including relevant scientific background. The committee will provide suggestions about the research direction.

At this meeting the Plan of Study / D-2 form should be completed. It is available on the

Graduate School website: http://gradschool.missouri.edu/policies/doctoral/requirements/plan-study-requirements.php

Teaching Experience

An important part of graduate education is learning to communicate effectively as a teacher.

One semester of teaching experience is a required component of both the M.S. and Ph.D. degrees. This requirement is typically performed in the second year of graduate study, although the Director of Graduate Studies may change this time frame to accommodate special circumstances. To facilitate the teaching experience students should enroll in Biochem 9001 (3 hrs) in semester of year 2 that they are assigned to teach. The teaching experience is a combination of discussion sessions with a coordinating faculty member as well as the classroom experience with students. The later usually involves assisting a faculty member in an undergraduate level course including (but not limited to) Biochem 4270 and Biochem 4272 and possible opportunities in Biochem 4974 /7274 (capstone laboratory course for senior majors). The Biochemistry Department offers a Zahler Fellowship for graduate students who are particularly interested in teaching as a career and wish to gain additional teaching experience (see Minor in College teaching and page 29 for info on Zahler Fellowship).

Up to three hours of graduate level-course credit will be earned for this year-long teaching experience (this does not count toward the 15 hours of class required but does count toward the 72 for graduation). In a semester the student is teaching, they should register for 3 credits in the 9001*3 course. Student TA's work in conjunction with a faculty who is instructor in an undergrad-level course. The faculty of the course will recommend a letter grade (A, B, C or F based on performance) to the DGS and provide the TA descriptive written feedback on a quarterly basis and a mid-semester, preliminary grade report. Students must satisfy this teaching requirement with a grade of "B" or better to remain in good standing as a graduate student in Biochemistry. The TA assignment and associated recitation meeting times have priority; any potentially conflicting classes the student is interested in can be taken in a future semester.

The University provides training to help students prepare for teaching and to expand their oral proficiency. All students (international or native English speakers) must participate in all of the Teaching Assistant (TA) orientation and training offered by the Biochemistry Dept (as part of 9001*3) and by MU (GATO, ONITA and/or WI courses) before the semester they are teaching begins, as partial fulfillment of the departmental teaching requirement.

Missouri requires that students whose first language is not English must demonstrate adequate oral proficiency before they can assist in teaching. Proficiency is demonstrated by passing the University oral proficiency examination, currently called the SPEAK test. A student must score 2 or better on the SPEAK test in order to qualify to serve as teaching assistant. *Failure to pass the oral proficiency examination by the end of the first year following matriculation may result in termination from the graduate program.* Students with poor oral proficiency, as evidenced by a score of '1' on the exam, may be required to enroll in a University English course.

Qualifier Examination, the "20 Question Exam"

Students who have passed both Graduate Biochemistry I and II courses with grades of B or better and are in good academic standing (cumulative GPA of 3.0 or better) should take the Qualifier Exam when scheduled in May or June at the end of their second semester. Students on academic probation because they have not passed one or both of the required courses in their first year must retake the relevant class and obtain a grade of B or better by the end of the second year. They will then take the Qualifier exam at the end of their fourth semester, in May or June. A student not passing the Qualifier on the first attempt may retake it in late summer, on the date that the Exam Committee Chair schedules. Failure to pass the Qualifier exam after two attempts will result in dismissal from the Ph.D. program but may opt for a Masters track.

The Qualifier Exam will be based upon a set of questions that may vary from year to year. Page 29 has the questions students answered in June 2015.

Purposes

1. To emphasize that all graduate students on their way to a PhD. should have of knowledge and understanding of the core of information that is the foundation contemporary biochemistry.

2. To provide a specific mechanism by which the faculty can assess that knowledge and understanding.

Background

Students should devote some time and energy their first two semesters to consideration of the core information and concepts that are the foundation of contemporary biochemistry. Through review and synthesis, that core knowledge should become a permanent store of information and ideas that a Ph.D. in biochemistry should master. This review and synthesis should be only one aspect of the student's activities during this time. The student will also be actively involved in formal course work and intensively involved in research. Research activity is ultimately the most crucial factor in evaluating performance as a graduate student, but core knowledge is critical to applying effectively the time and effort at the bench.

Scope

What is the core of information and concepts that a student is expected to have at their command? It is broadly defined by the subject matter contained in current textbooks (Voet and Voet; Stryer; etc.). The crucial items are generally those covered in core undergraduate and graduate courses in biochemistry. A biochemist should have some familiarity with all the major areas included in the texts and an active knowledge of the central subjects that are emphasized in a comprehensive introductory biochemistry course like our Biochem 4270-4272 (or 7270-7272) and in our core graduate courses.

What level of active knowledge is expected? The assay applied by this Department is the ability to provide a concise (10 minute) oral explanation of a given area or issue to someone who has the general background but may not have the specific knowledge. This requires not only knowledge of specific observations and facts but also the understanding of significance and implications that will allow distillation of the essence of a subject. This is what a good

teacher does when considering the specific subject in a class lecture. After two semesters in graduate school, a student ought to be able to do the same, beginning with the wider picture, emphasizing the fundamental principles and providing relevant and informative details.

There is no one correct way to do this, no one "right answer". The members of the examination committee are looking for evidence of knowledge and thoughtful understanding. Thus a good response is an individualized explanation, rather than rote presentation of someone else's distillation.

Format

1. Students should review and master the core material as part of their activities in the Fall and early Spring semesters.

2. Twenty questions that define the breadth of the core will be provided no later than the beginning of the matriculating semester as a guide for study. The questions are derived from suggestions by the faculty. We also welcome suggestions for or comments about questions from students.

3. The questions will come from four areas:
   I. Proteins and enzymes
   II. Metabolism
   III. Nucleic acids and gene expression
   IV. Supramolecular structure and cell biology

4. The core exam will be administered in May by a faculty committee. The composition of this committee will change annually and will consist of faculty members representing the general areas of biophysics, molecular biology and biochemistry.

   a. Each student will respond to three questions from the twenty listed, the first chosen by the student and the following two by the committee. Each question will be allotted a maximum of 30 minutes, making the entire core knowledge examination 1.5 hours long.
   b. For each question, the student will be given 10 minutes in which to address the subject. During those 10 minutes, interruption by faculty will be only for clarification. Following that time there will be 15-20 minutes for questions from the examining committee and responses from the student. The intent will be primarily diagnostic, to probe the breadth and depth of the student's mastery of core biochemistry. For this reason, although questioning will be based on the student's presentation, it may delve into related areas of core biochemistry.
   c. Over the course of questions probing breadth and depth, it is likely that a student will be unable to answer some questions. This is not unexpected and is not a significant fault if an appropriate level of basic knowledge and understanding of the area has been demonstrated.
   d. Because this is an examination of core knowledge and understanding, no notes or other aids are permitted.

Evaluation

1. Immediately after the 1.5 hour examination, the Examination committee will discuss the

student's performance and reach a consensus that will be conveyed to the student orally.

2. The student's demonstration of knowledge of core biochemistry will be judged to be either Satisfactory or Unsatisfactory

3. Students whose performance on the Qualifier Examination is deemed unsatisfactory have the option to take the exam a second time. This will be scheduled by the Examination Committee Chair, usually just before the start of the fall semester.

Comprehensive Exam

The Comprehensive Exam must be completed during the two semesters following a satisfactory performance of the Qualifier Exam and in any case no later than five semesters following matriculation. Failure to complete the exam on time will result in a mandatory meeting of the student and advisor with the GEC and may result in the student's dismissal from the Ph.D. Program. Comprehensive exams at the University of Missouri have both written and oral components that are evaluated independently. In the Department of Biochemistry, the written component is a research proposal. The oral component is the oral defense of the proposal and responses to questioning by the thesis committee with one GEC member present.

Students submit a written proposal in the current format of an NIH postdoctoral fellowship grant proposal to their faculty advisor for approval before submitting to their committee. After the advisor indicates the document is appropriate for consideration a hard copy must be given to each member of the DPC and the Director of Graduate Studies (DGS) a minimum of two weeks in advance of the exam. Within one week before the exam, any member of the student's DPC that does not find the document acceptable should contact the student, allowing the student time to revise the oral presentation accordingly or consider rescheduling the exam.

The format of an NIH postdoctoral fellowship is explained in the subsection on Format below. Sufficient information must be incorporated into the written proposal for the committee to make an evaluation of the proposed research plan. Although the advisor is expected to provide information, input and ultimately judge the document appropriate for consideration before it is distributed to the DPC, the student should independently write the proposal, develop the rationale for the design of experimental approaches and be prepared to defend it. The proposal does not represent a contract for research but is a description of a logical series of experiments designed to contribute to the body of scientific knowledge in a given discipline. It does not need to be limited to resources available to the faculty advisor but needs to be scientifically sound.

The voting members of the examination committee for the Comprehensive Exam will consist of the student's DPC (minus the advisor) with a member of the GEC serving as a non-voting chair of the Exam committee. While the advisor is expected to be present at the examination, he/she will not participate in the exam and cannot interject opinions or explanations. The advisor may voice an opinion or explanation after the student has finished the exam during discussion prior to the committee's vote.

For the comprehensive examination to be successfully completed, at least 3/4 of the examination committee must vote to pass the student; one dissenting vote is a "pass". If

circumstances warrant, the student may be given a "conditional pass" and will be allowed to retake or clarify portions of the written portion of the examination to demonstrate the expected level of comprehension. If a non-pass is decided, the committee may recommend further written work or remedial measures. The student who does not pass may re-write the entire proposal and undergo a second examination after at least 12 weeks have lapsed (as required by the Graduate School). Less than full committee approval on the second attempt may result in the student being dismissed or transferred to the M.S. program. In the latter event, readmission to the Ph.D. program requires the support and agreement of the GEC.

The oral defense of the written portion is the last part of the Comprehensive Examination. When both portions are successfully completed, the Biochemistry Department's version of the D-3 should be completed, signed by the exam committee, the DGS and forwarded to the Graduate School. http://www.biochem.missouri.edu/docs/biochem-d3.pdf

Format

The required format of the Comprehensive proposal is detailed in this excerpt from the current NIH PHS416-1 postdoctoral fellowship instructions. The Biochemistry Department at MU, however, has interests well beyond the public health mission of NIH.

Research Proposal Description: Project Summary

The *Project Summary* is meant to serve as a succinct and accurate description of the proposed work. State the application's broad, long-term objectives and specific aims, making reference to public benefits of the project. Describe concisely the research design and methods for achieving the stated goals. This section should be informative to other persons working in the same or related fields and insofar as possible understandable to a scientifically or technically literate reader. Avoid describing past accomplishments and the use of the first person.

*Following sections A through D are limited to **10 pages**.*

A. Specific Aims

List the broad, long-term objectives and the goal of the specific research proposed, e.g., to test a stated hypothesis, create a novel design, solve a specific problem, challenge an existing paradigm or clinical practice, address a critical barrier to progress in the field, or develop new technology.

B. Background and Significance

Briefly sketch the background leading to the present application, critically evaluate existing knowledge, and specifically identify the gaps that the project is intended to fill. State concisely the importance and public relevance, to health or agriculture for example, of the research described in this application by relating the specific aims to broad, long-term objectives.

C. Preliminary Studies

Use this section to provide a succinct account of preliminary studies that are pertinent to the proposal. When available, preliminary results can help your doctoral program committee to evaluate your preparedness and capability to conduct PhD research but such results are not required or necessary.

D. Research Design and Methods

Describe the research design, conceptual framework, procedures and analyses to be used to accomplish the specific aims of the project. Include how the data will be collected, analyzed, and interpreted. Describe new methodology and its advantage over existing methodologies. Describe novel concepts, approaches, tools, or technologies to be used. Discuss potential difficulties and limitations of the proposed procedures and alternative approaches to achieve the aims. As part of this section, provide a tentative sequence or timetable for the project.

Literature Cited

This section does not contribute to the page limit. List all literature references. Each must include the title, names of all authors, book or journal, volume number, page numbers, and year of publication. References should be limited to relevant and current literature. While there is no page limitation, be concise and select only those references pertinent to the proposed research.

Evaluation of Comprehensive Proposal

For the preparation of the proposal, the students are encouraged to use all the resources at hand including faculty and other students. Advisors should use the preparation of this proposal as an opportunity to mentor the student in the science proposed and in the formulation of a proposal. Detailed editing and exact outlining of the experiments are the responsibility of the student. The student will be evaluated on 1) writing skills, 2) deductive thinking, 3) inductive reasoning, 4) experimental design, and 5) knowledge of relevant literature, recent and past.

The proposal should be well organized, clearly written and logically presented. However, the ideas incorporated should form the basis for additional questioning to determine whether the student can identify significant biochemical questions related to his/her work and devise a logical experimental plan to address the issues. An understanding of basic biochemical principles should be demonstrated. The oral defense should likewise be delivered clearly and logically. Responses to questioning should be professional and appropriate for both particular issues of the research project and broader knowledge of biochemistry.

Standards of Academic Performance

Doctoral students must maintain an acceptable level of academic performance in order to remain in the program. When a student's GPA falls below 3.0, receives more than 2 C's in graduate courses, or spends two consecutive semesters on academic probation, he/she will be notified in writing that his/her performance is not satisfactory. Even if this is not the case, a student's DPC and/or advisor may decide that a student's research performance is not satisfactory. Unsatisfactory performance can result in dismissal from the PhD program. Students may elect to apply to the GEC to change to the M.S. program. Decisions regarding a student's standing in the Department are made by the GEC and can be appealed to the Department Chair, and then to the Graduate Faculty Senate Committee on Graduate Student Appeals.

Departmental Ombudsman

The position of "Ombudsman" originated in Scandinavian society. Note that in Swedish and other Scandinavian languages, the word "man" is without gender and equivalent to the

English “one”, as in “One should be diplomatic in these situations”. In many Scandinavian organizations, whether political, commercial or academic, there is an ombudsman who serves as an unbiased and confidential listener, gives advice and can take action if an individual so desires. An ombudsman can provide receptive channel for discussing difficult and awkward situations, council in times of tension or conflict, and effective action to resolve potentially volatile situations.

In the Department of Biochemistry, Dr. Linda Randall serves as Departmental Ombudsman. As part of her departmental service activities, she is available for confidential consultation and advice to all departmental personnel, students, staff members and faculty members about situations related to the Department or departmental personnel. She has many years of experience in this role, and been of substantial help in a range of difficult situations. Dr. Randall will not discuss issues brought to her as Ombudsman with anyone else or take any action unless the concerned individual approves.

You should be aware that Dr. Randall has a particular empathy with students, because she continues to work intensively in the laboratory, doing experiments constantly. Thus she is fully aware of the challenges of day-to-day experimentation and of life in a laboratory. For this reason, you should not hesitate to talk with her if you find yourself in need of a sympathetic ear and of unbiased and knowledgeable advice.

Dissertation Defense

Upon completion of dissertation research, and with the approval of his/her advisor and DPC, the student will prepare a thesis. He/she should adhere to the Graduate School Guidelines for thesis preparation (http://gradschool.missouri.edu/policies/thesis-dissertation/). Thesis defense involves a public research seminar followed by a closed meeting of the candidate with his/her DPC. Upon examination of the thesis and thesis research, the committee will vote to accept or reject the thesis. Submission of the final thesis to the Graduate School will be electronic. The D4 form must be completed and signed by all committee members. http://gradschool.missouri.edu/policies/doctoral/requirements/d4.pdf

Dissertation Preparation and Submission

The GEC of the Biochemistry Department recommends the following guidelines for preparation of dissertations and thesis:

- The standard requirements of the Graduate School at the website: http://gradschool.missouri.edu/policies/thesis-dissertation/guidelines/
- The Style Manual published by the Council of Biology Editors, Inc. for questions of punctuation, capitalization, and other matters of general style.
- The format of the *Journal of Biological Chemistry* (or the premier journal in the discipline of the research) for references with the full title and inclusive page numbers of the articles.
- All other matters of style to be at the discretion of the dissertation director.

These guidelines are intended to allow flexibility so that the dissertation research can be readily assimilated into publishable form.

Forms

The student is responsible for acquiring and filing the proper forms for submission to the Graduate School during the course of the program. These forms (D1 through D4) are available from the Graduate School, 210 Jesse Hall, and on the Graduate School website: http://gradschool.missouri.edu/policies/doctoral/requirements and links above.
Please use Biochemistry's modified version of the D3 form - http://www.biochem.missouri.edu/docs/biochem-d3.pdf

Timetable for students pursuing a Ph.D. starting in Fall 2015:

Date / Semester — **Courses / Forms**

Week of Aug 17th Welcome week and planned events – register for classes.

Aug. 23rd Last day to register for fall courses without a late penalty

Aug. 24th First day of class – should be registered for:
*Graduate Biochemistry I (8240) (4h) – Macromole Struc & Function
*Seminar 9087 (1h)
*Research Rotations 8450 (2x 1 hour each) – Lab Rotations #1 & #2
If no previous P-chem, then recommend Physical Biochemistry 4300

Oct., 2015 SPEAK test for international students (or Dec. 5, before finals, less optimal)

Oct. 20th Begin second rotation

Dec. 2015 Submit rotation reviews (to DGS) and annual report at:
https://gradschool.missouri.edu/policies/progress/annual-review/progress-system/index.php

Jan. 2016 MEET WITH GEC! – Jan 5 -7 2016.
All students must return to Columbia by 1/4/2016 for GEC meetings.

Jan. 18, 2016 Last day to register for Spring courses without a late penalty

Jan. 19, 2016 First day of class- should be registered for:
*Graduate Biochemistry II (8260) (4h)
Ethical Conduct of Research (8060) (1h)
*Research Rotation 8450 (2X 1 hour) -- Rotation #3 and home lab (or #4)
Other approved 8000-level science elective with permission:
Options: Structural Biol & Molec Assn (9001-x) or Molecular Biology II (9432, 4h)
(other classes with GEC permission before registering)
Choose adviser by March 15 or identify 4th rotation.
Choose members of Doctoral Program Committee (DPC) BEFORE Qualifying exam

Late May 20 Question Exam – Qualifying exam — D-1 form

April – Aug '16 Convene your DPC – informal meeting of 30 – 45 min. — D-2 form

Summer 2016 *Thesis Research (9090; 4h)

August 2016 * T.A. Training (ONITA or GATO) (register and attend relevant MU training)

Fall 2016 8000+-elective in biochemistry / approved science, e.g. Enzymology & Metabolism (8432) Teaching experience (FS15 or Sp16)

Dec. 2016 Submit annual report at: https://gradschool.missouri.edu/policies/progress/annual-review/progress-system/index.php

January 2017 MEET WITH GEC!

Spring 2017 Ethical Conduct of Research (8060, 1h) if not yet completed.
Teaching experience if not completed
8000-level biochemistry or science elective such as Molecular Biology II (9432)
Comprehensive Exam completed by Summer 2015 — D3 form

Summer 2017 *Thesis Research (9090; 4h if not yet passed Comps or ≥ 1h if passed Comps)

Fall 2017 *Thesis Research (9090; total 2h if passed Comps or 9h if not yet passed Comps)

Spring 2018, '19, '20 Seminar 9087 (1h)

Annual meeting required with Doctoral Program Committee by Spring semester end, submit annual report at: https://gradschool.missouri.edu/policies/progress/annual-review/progress-system/index.php

DEFENSE! — D-4 form

***Required courses and the number of Bchm 9090 research credit hours are added for the total number of credit hours**

M.S. Degree

Coursework

Required Courses - Both of the following two are required, with a passing grade of B or better:

– Intro to Graduate Biochemistry I: Macromolecular Structure & Function (4h)
– Intro to Graduate Biochemistry II: Systems Biochemistry (4h)

Seminar (Biochemistry 9087) (2h)

Research (Biochemistry 8450, 8090 or 9090, not to exceed 12 hours, see below)

One semester Teaching Assistantship (Biochem 9001) (3h)

Ethical Conduct of Research – (Biochem 8060) (1h)

Elective 1: 8000-level Biochemistry or science approved by graduate program committee such as:
Biochemistry 9432 (4h) - Molecular Biology II
Biochemistry 8430 (3h) - Physical Biochemistry
Biochemistry 8432 (3h) - Enzymology and Metabolic Regulation

Elective 2: Outside graduate level course or science approved by graduate program committee such as Biochemistry 9430 or 9432

Departmental Seminars - All students are required to attend departmental seminars.

Required Courses

M.S. students are expected to complete during the first two semesters, with passing grades of B or A, Introductory Graduate Biochemistry I and II (Biochem 8240 and 8260), also known as Macromolecular Structure & Function and Systems Biochemistry, respectively. Receipt of a grade of C in either of these courses is unsatisfactory, and the student must retake the course(s). Both required courses must be completed with a grade of B or above in order to remain an M.S. student in good standing. A grade of F in either of these two required courses will result in dismissal from the graduate program in Biochemistry, for lack of making "satisfactory progress". A student who has been dismissed has the right to appeal the dismissal to the department and Graduate Faculty Senate. Details on procedures for appeal to the department and Graduate Faculty Senate can be found at: http://gradschool.missouri.edu/policies/progress/extension-appeal.php

Ethics Seminar

Ethical Conduct of Research (Biochem 8060, 1 h), currently directed by Dr. Kathy Newton, (or the equivalent offered in another department) will be required of all Biochemistry graduate students.

Residency

Thirty hours of advanced study (7000 to 9000 level) are required. However, in Biochemistry, only 8000/9000 level courses count as advanced study. Fifteen of the thirty hours must be at the 8000 to 9000 level. Special research problems (Biochemistry 7085), Non-thesis Research 8450 and Thesis Research 8090 or 9090 can contribute only twelve hours to this total. The actual formal coursework requirement is eighteen hours. Twenty-four of the 30 h must be completed at MU. Continuous enrollment is not required, but access to University facilities does necessitate enrollment. Students must be enrolled the

semester the thesis is defended.

Financial support

Students may be supported by grant funds and extramural support. Departmental support is rare. Master's students may apply for departmental stipends by filing a written request in conjunction with his/her advisor. A recommendation will be made by the GEC to the departmental chair who will make the final decision. Support normally ceases 24 months after matriculation unless continuation is approved by departmental chair or the advisor (in the case of grant support).

Fees and Fee Remission

Non-resident tuition and the resident educational fee are waived for those students receiving at least partial (25%) support from any faculty or departmental sources. Graduate Students are responsible for paying all Incidental Student fees (computer, activity, recreation, & student health).

Teaching Experience

An important part of graduate education is learning to communicate effectively as a teacher.

One semester of teaching experience is a required component of both the M.S. and Ph.D. degrees. This requirement is typically performed in the second year of graduate study, although the Director of Graduate Studies may change this time frame to accommodate special circumstances. To facilitate the teaching experience students should enroll in Biochem 9001 (3 hrs) in semester of year 2 that they are assigned to teach. The teaching experience is a combination of weekly discussion sessions with the DGS and/or other faculty members as well as the classroom experience with students. The later usually involves assisting a faculty member in an undergraduate level course including (but not limited to) Biochem 4270 and Biochem 4272 but a very few opportunities for Biochem 4974 / 7274 (capstone laboratory course for senior majors).

Up to a total of three hours of graduate level-course credit will be earned for this year-long teaching experience (this does not count toward the 15 hours of class required but does count toward the 72 for graduation). In each semester the student is teaching, they should register for 3 credits in the 9001*3 course. Student TAs work in conjunction with a faculty who is instructor in an undergrad-level course. The faculty of the course will recommend a letter grade (A, B, C or F based on performance) to the DGS and provide the TA descriptive written feedback on a quarterly basis and a mid-semester, preliminary grade report. Students must satisfy this teaching requirement with a grade of "B" or better to remain in good standing as a graduate student in Biochemistry. The TA assignment and associated recitation meeting times have priority; any potentially conflicting classes the student is interested in can be taken in a future semester.

The University provides training to help students prepare for teaching and to expand their oral proficiency. All students (international or native English speakers) must participate in all of the Teaching Assistant (TA) orientation and training offered by the Biochemistry Dept (as part of 9001*3) and by MU (GATO, ONITA and/or WI courses) before the semester they are teaching begins, as partial fulfillment of the departmental teaching requirement.
Missouri requires that students whose first language is not English must demonstrate adequate

oral proficiency before they can assist in teaching. Proficiency is demonstrated by passing the University oral proficiency examination, currently called the SPEAK test. A student must score 2 or better on the SPEAK test in order to qualify to serve as teaching assistant. *Failure to pass the oral proficiency examination by the end of the first year following matriculation may result in termination from the graduate program.* Students with poor oral proficiency, as evidenced by a score of '1' on the exam, may be required to enroll in a University English course.

Standards of Academic Performance

MS students must maintain an acceptable level of academic performance in order to remain in the program. A student who has spent two consecutive semesters on academic probation will be notified in writing that his/her performance is not satisfactory. Alternatively, a student's thesis committee and/or advisor may also decide that a student's performance is not satisfactory. Unsatisfactory performance may result in dismissal from the MS program. Decisions regarding a student's standing in the Department are made by the GEC, and can be appealed to the Department Chair, and then to the Graduate Faculty Senate Committee on Graduate Student Appeals.

Thesis Defense

The candidate will defend his/her thesis research at the end of the second year. This involves a public research seminar followed by a closed meeting of the candidate with his/her thesis committee. Upon successful defense the committee will certify that the thesis is worthy of acceptance.

Thesis Committee Composition

Adviser
A second Biochemistry faculty member
A faculty member from outside the Biochemistry Department
The committee is assembled within the first year in consultation with and the approval of the research advisor.

Thesis Preparation and Submission

The Graduate Committee in the Biochemistry Department recommends the following guidelines for preparation of dissertations and theses:

- The Guidelines of the Graduate School :
  - http://gradschool.missouri.edu/policies/thesis-dissertation/guidelines/
- The Style Manual published by the council of Biology Editors, Inc., for questions of punctuation, capitalization, and other matters of general style;
- References formatted as per the Journal of Biological Chemistry (or a premier journal in the discipline) with full title and inclusive page numbers of the articles; and
- All other matters of style to be at the discretion of the Thesis Director/DPC.

These guidelines are intended to allow flexibility so that the dissertation research can be readily assimilated into publishable forms. Submission to the Graduate School is electronic.

Forms

The student is responsible for obtaining the proper forms from the Graduate School, 210 Jesse Hall, or from the Graduate School website:
http://gradschool.missouri.edu/policies/masters/requirements /
All candidates must be enrolled on the University of Missouri, Columbia Campus during the semester in which completion of the final oral defense is approved.

Appendix A
Department of Biochemistry
University of Missouri

ACADEMIC AND PROFESSIONAL HONESTY

The University of Missouri Graduate School states:

Academic honesty is essential to the intellectual life of the University. Students who use, or attempt to use as their own the answers, words, ideas or research findings of another person are guilty of academic dishonesty. In addition to such acts of cheating or plagiarism, any unauthorized possession of examinations, hiding of source materials, or tampering with grade records are acts of academic dishonesty specifically forbidden by University rules.

According to the MU Faculty Handbook, faculty are required to report to their departmental chair and the provost's office all acts of academic dishonesty committed by graduate and undergraduate students. In all such cases, the faculty member should discuss the matter with the student and then make an academic judgment about the student's grade on the work affected by the dishonesty and, where appropriate, the grade for the affected course. The decision as to whether disciplinary proceedings are instituted is made by the provost. Because of the importance of honesty to academic and professional life, acts of dishonesty by graduate students may result in suspension or dismissal from the University.

Graduate students also should be aware that most professional associations have codes of ethics. These codes vary considerably across fields, but tend to provide guidelines for a broad array of professional responsibilities including teaching, research and working with clients. Violations of a code of ethics can lead to negative sanctions by one's professional colleagues and the expulsion from the professional associations in one's field. Graduate students are encouraged to obtain copies of codes of ethics for their chosen profession from the director of graduate studies in their department or program."

A graduate student must maintain high standards of academic honesty throughout his graduate career, fully in class, teaching and research settings. Finding of academic dishonesty can result in a failing grade in a course and severe academic restrictions that can include probation, loss of PhD candidacy and immediate dismissal of the student from the graduate program.

An example of professional ethical standards required of scientific authors by a major commercial publishing house follows. Elsevier requires authors of papers in its journals to certify that the papers adhere to these standards:

- "be the authors' own original work, which has not been previously published elsewhere
- reflect the authors' own research and analysis and do so in a truthful and complete manner,
- properly credit the meaningful contributions of co-authors and co-researchers,
- be appropriately placed in the context of prior and existing research. "

The Biochemistry faculty endorses the principles of Academic and Professional Honesty above and expects graduate students to abide by them.

Appendix B
Department of Biochemistry
University of Missouri
FACULTY

CORE FACULTY
(*Doctoral Faculty)

***BEAMER, LESA,** Associate Professor. Ph.D. 1991, Johns Hopkins School of Medicine. Protein crystallography. (573) 882-6072. 105A Schlundt Annex.

***CORNISH, PETER,** Assistant Professor. PhD 2005 Texas A&M University. Dynamics and assembly of ribonucleoprotein complexes utilizing NMR and single molecule FRET. 573-882-0443 240 Schweitzer Hall.

***DEUTSCHER, SUSAN L.**, Professor. Ph.D. 1985, St. Louis University Medical School. Combinatorial approaches to cancer therapies; antibody-nucleic acid interactions and their role in autoimmune disease. (573) 882-2454. 234C Schweitzer Hall.

***EMERICH, DAVID W.,** Professor, Associate Chair and Director of Undergraduate Education. Ph.D. 1977, University of Wisconsin. Enzymology and physiology of biological nitrogen fixation and related metabolic activities in bacteria and plants. (573) 882-4252. 245A Schweitzer Hall.

***FOLK, WILLIAM R.**, Professor. Ph.D. 1970, Stanford University. Gene expression and DNA replication in eukaryotes and DNA tumor viruses; Expression of tRNAs in plants. (573) 882-4857. 202 Schlundt Annex.

***GUILFOYLE, THOMAS**, Professor. Ph.D. 1974, University of Illinois. Auxin control of plant transcription. Plant RNA polymerases. (573) 882-7648. 10 Schweitzer Hall.

***HANNINK, MARK**, Professor. Ph.D. 1987, University of California, San Diego. Biological and biochemical functions of cellular oncogenes, with emphasis on c-*rel*. (573) 882-7971. 440E Bond Life Sciences Center.

***HAZELBAUER, GERALD,** Professor and Chair. Ph.D. 1971, University of Wisconsin. Transmembrane receptors and sensory transduction; bacterial chemotaxis. (573) 882-4845. 117 Schweitzer Hall.

***HEESE, ANTJE**, Assistant Professor. Ph.D. 1997, Michigan State University. Role of membrane trafficking in plant innate immunity. (573)882-3831. 219 Schweitzer Hall.

***HENG, XIAO**, Assistant Professor. Ph.D. 2010, University of Maryland-Baltimore. NMR investigations of RNA structures, particularly from Hepatitis C and HIV-1, and their roles in regulation. (573) 882-3953.141 Schweitzer Hall

***HENZL, MICHAEL,** Professor. Ph.D. 1980, University of Wisconsin. Structure and function of calcium-binding proteins. Physiological function of the parvalbumins. (573) 882-7485. 11C Schlundt Annex.

***KOO, ABRAHAM,** Assistant professor, Ph.D. 2004, Michigan State University. Small molecule-mediated defense cell signaling during biotic stress responses and plant lipid metabolism. (573) 882-9227. 127 Schweitzer Hall.

LEE, CHRISTOPHER,. Assistant Teaching Professor. Ph.D. 2008. University of Missouri. Biochemistry Education. (573) 884-6881. 216 Schweitzer Hall

***LUBAHN, DENNIS B.**, Professor. Ph.D. 1983, Duke University. Biochemical genetics of the estrogen receptor. (573) 884-6781. 110A Animal Science Research Center.

MARTIN, MARK E., Associate Professor. Ph.D. 1985, University of Mississippi Medical Center. Eukaryotic gene expression; polyomavirus gene expression. (573) 882-5654. 11A Schlundt Annex.

***MAWHINNEY, THOMAS P.**, Professor. Ph.D. 1977, Albany Medical College. Analysis of exocrine secretions; development of analytical methodologies. (573) 882-2608. 4 Ag. Bldg.

***MCCLURE, BRUCE A.**, Professor. Ph.D. 1987, University of Minnesota. Gametophytic self-incompatibility systems in plants. Biochemistry of gene expression in plants. (573) 882-3932. 240A Bond Life Sciences Center.

***PECK, SCOTT**, Associate Professor. Ph.D. 1995, Michigan State University. Proteomics. (573)882-8102. 271H Bond Life Sciences Center.

PECULIS, BRENDA A., Associate Professor, Ph.D. 1991, Johns Hopkins University. Ribosome biogenesis, pre-rRNA processing; RNA metabolism and stability; RNA:protein interactions (573) 884-1424. 11B Schlundt Annex.

PENNELLA, MARIO,. Assistant Teaching Professor. Ph.D. 2005, Texas A&M University. Biochemistry Education. (573) 884-2762. 122 Bond Life Sciences Center

***PETRIS, MICHAEL,** Associate Professor, Ph.D. 1998, University of Melbourne, Australia. Regulation of copper transport and copper-transporting P-type ATPases in eukaryotes and prokaryotes. (573) 882-9685. 540D Bond Life Sciences Center.

***PHILLIPS, CHARLOTTE**, Associate Professor. Ph.D. 1987, North Carolina State University, Raleigh, NC. Biochemistry and genetics of collagen metabolism. (573) 882-5122. 135A Schweitzer Hall.

***QUINN, THOMAS P.**, Professor. Ph.D. 1988, St. Louis University Medical School. Radiopharmaceutical design; protein molecular modeling and molecular graphics. (573) 882-6099. 234A Schweitzer Hall.

***RANDALL, LINDA,** Professor. Ph.D. 1971, University of Wisconsin. Molecular chaperones in protein export and analysis of protein-protein interactions. (573) 884-4160. Stephens Hall.

***SCHMIDT, FRANCIS J.**, Professor. Ph.D. 1973, University of Wisconsin. Nucleic acid biochemistry; RNA processing; bacterial antibiotic resistance. (573) 882-5668. 103A Schlundt Annex.

***SIEGEL, MARCELLE,** Assistant Professor. Ph.D. 1999, University of California at Berkeley. Science Education. (573) 882-9248. 107 Schweitzer Hall.

SUMNER, LLOYD W., Arrives Jan. 1, 2016. Professor and Director of the University of Missouri Metabolomics Center. Ph.D. 1993, Oklahoma State University. Development and application of large-scale biochemical profiling with a personal emphasis on plant specialized metabolism. (573) 882-5486. 240D Bond Life Sciences Center.

***TANNER, JACK**, Professor. Ph.D. 1988, Brown University**,** Biochemistry. Protein Crystallography. (573) 884-1280. 211 Chemistry.

***THELEN, JAY**, Associate Professor. Ph.D. 1998, University of Missouri-Columbia. Proteomics of seed development and plastid differentiation. (573) 884-1325. 271G Bond Life Sciences Center.

***TIPTON, PETER A.**, Professor. Ph.D. 1987, University of Wisconsin, Madison. Application of tools and methods of modern mechanistic enzymology to enzyme systems. (573) 882-7968. 204A Schlundt Annex.

***TSIKA, RICHARD,** Professor. Veterinary Biomedical Sciences, Ph.D. 1987, University of California-Irvine. Transcriptional regulation of muscle genes; Transcription factors. (573) 884-4547. 440D Bond Life Sciences Center

***VAN DOREN, STEVE**, Professor. Ph.D. 1991, University of Illinois at Urbana-Champaign. Multi-nuclear, multi-dimensional NMR determination of protein structure. (573) 882-5113. 37A Schweitzer Hall.

***WALL, JUDY D.**, Professor, Ph.D. 1973, Duke University. Genetics and biochemistry of sulfate-reducing bacteria. (573) 882-8726. 214 Schweitzer Hall.

***WEISMAN, GARY A.**, Professor, Director of Graduate Admissions and Recruitment. Ph.D. 1982, University of Nebraska. Cell biology and nutrition; biochemistry and physiology of purinoreceptors; cystic fibrosis. (573) 882-5005. 540E Bond Life Sciences Center

***ZHANG, SHUQUN,** Professor. Ph.D. 1994, University of Texas, Austin. MAP kinases in plant defense responses. (573) 882-5837. 371G Bond Life Sciences Center.

***ZOU, XIAOQIN,** Assistant Professor. Ph.D. 1995, University of California, San Francisco. Computational Biology. (573) 882-6045. 117A Dalton Building.

JOINT FACULTY

(*Doctoral Faculty)

***BURKE, DONALD,** Associate Professor, Molecular Microbiology and Immunology. Ph.D. 1992, University of California-Berkeley. Biochemistry of ribozymes and RNA aptamers. (573) 882-8989. 471H Bond Life Sciences Center.

***CHEN, SHI-JIE,** Professor. Biological Physics, Ph.D. 1999, University of California, San Diego. Physico-chemical models and computational methods for molecular biology. (573) 882-6626. 302 Physics Building.

***GATES, KENT,** Professor of Chemistry. Ph.D. 1990, Northwestern University. Mechanisms of DNA damage by synthetic and naturally occurring antitumor agents, toxins, and mutagens. (573) 882-6763. 125 Chemistry Building.

***KING, GAVIN, M.** Assistant Professor, Ph.D. 2004, Harvard University. Single molecule biophysics. (573) 882-3217 318 Physics Building

***MIERNYK, JAN,** Research Molecular Biologist. USDA, Plant Genetic Research Unit USDA, Columbia, MO, Ph.D. 1980, Arizona State University. Protein targeting, co- and post-translational protein modification by phosphorylation, glycosylation, and acylation. (573) 882-8167. 108 Curtis Hall. [officially Adjunct, but operationally joint]

***ROBERTS, R. MICHAEL**, Professor Animal Sciences. D.Phil. 1965, Oxford University, England. Establishment and maternal recognition of pregnancy. Function and hormonal control of synthesis of secretory glycoproteins by the uterus and the early conceptus. (573) 882-0908. 240B Bond Life Sciences Center.

***SARAFIANOS, STEFAN,** Molecular mechanisms of drug resistance and inhibition of HIV, SARS, and other viral and bacterial pathogens. (573) 882-4338 471 Bond Life Sciences

***SHARMA, KRISHNA K.**, Professor Ophthalmology. Ph.D., 1983, University of Mysore, India. Structure-function of ocular proteases and peptide hydrolases; mechanism of cataract development. (573) 882-8478. EC 214 Mason Eye Institute.

***STACEY, GARY**, Professor Plant Pathology. Ph.D. 1981, University of Texas. Functional genomics of plant-microbe interactions and plant development. (573) 884-4752. 271E Bond Life Sciences Center.

PROFESSIONAL TRACK FACULTY

Instructional Track

FREYERMUTH, SHARI, Teaching Associate Professor, Assistant Dean for Academic Programs. Ph.D 1991, Duke University. Biochemistry Education. (573) 882-7643. 107 Schweitzer Hall

Research Track

ERB, LAURIE, Research Associate Professor, (Weisman Laboratory). Ph.D. 1993, University of Missouri. Molecular studies of nucleotide receptors. (573) 884-2065. 540F Bond Life Sciences Building.

HAGEN, GRETCHEN, Research Professor, (Guilfoyle Laboratory). Ph.D. 1978, University of Georgia. Control of gene expression by plant growth regulators. (573) 882-7300. 10 Schweitzer Hall.

MOONEY, BRIAN, Research Assistant Professor, Associate Director of Charles W. Gehrke Proteomics Center. Ph.D. 1996, University College Dublin, Ireland. Protein expression and assembly; Metabolic engineering. (573) 884-7374. 214 Bond Life Sciences Center.

MOSSINE, VALERI, Research Assistant Professor, (Mawhinney Laboratory). Ph.D. 1988, Institute of Physical chemistry, Acad. Sci. of Ukraine. Multivalent lactulose-amines as inhibitors of prostate cancer metastasis. (573) 882-2608. Room 4, Agriculture Building.

SIMONYI, AGNES, Research Associate Professor, (Sun Laboratory). Ph.D. 1988, University of Lorand Eotvos Hungary. Neuroscience. (573) 884-6178. 135B Schweitzer Hall.

WHITE, TOMMI., Assistant Research Professor. Associate Director Electron Microscopy Core Facility. Ph.D. 2007, University of Missouri. Electron Microscopy of biological specimens (macromolecular assemblies, viruses, bacteria and cells) with expertise correlative microscopy and cryo-electron microscopy. (573) 882-8304. W125 Veterinary Medicine Building

EMERITUS FACULTY

CAMPBELL, BENEDICT J., Professor Emeritus. Ph.D. 1957, Northwestern University. Medical Education. (573) 882-8797. M702 Medical Sciences Building.

MORRIS, ROY O., Professor Emeritus. Ph.D. 1958, University College, London. (573) 882-4845.

O'DELL, BOYD L., Professor Emeritus. Ph.D. 1943, University of Missouri. Biochemical and physiological functions of trace elements: Metabolism and bioavailability of trace elements. (573) 882-5197. 220 Eckles Hall.

POLACCO, JOSEPH C., Research Professor. Ph.D. 1971, Duke University. Plant cell genetics; assimilation of fixed nitrogen by legumes, Univ. Federal do Rio Grande do Sul Av. Bento Gonçalves.

RANDALL, DOUGLAS D., Professor Emeritus. Ph.D. 1970, Michigan State. Plant metabolism, plant signal transduction, protein kinases and phosphorylated proteins. (573) 882-4847. 223 Schweitzer Hall.

SUN, GRACE, Professor. Ph.D. 1966, Oregon State University. Receptor-mediated signal transduction pathways in cerebral ischemia; molecular mechanism of alcoholism. (573) 882-5377. 135C Schweitzer Hall.

Appendix C
Travel Award

DEPARTMENT/DIVISION OF BIOCHEMISTRY GUIDELINES FOR DEPARTMENTAL SUPPORT OF GRADUATE STUDENT TRAVEL

1. The Department of Biochemistry provides funds to support graduate student travel with the aim of enhancing research and training. This is to supplement the funds provided by the faculty advisor.

2. Departmental support will be awarded for travel for 1) attending a professional meeting at which the student is presenting a talk or a poster, 2) attending a professional training course, 3) collaborative research or 4) other purposes directly related to research and training.

3. All graduate students who successfully pass their comprehensive exam and are in good standing will have available to them up to $1,500 for travel. The intent of these Departmental funds is to encourage the students to attend several meetings; thus post-comprehensive exam students can apply for departmental support (up to $500-$1,000 per trip) to be used to attend 2 - 3 meetings approximately one year apart. Because travel costs are significantly higher to attend international meetings, requests for more than $1,000 will be considered, on a case-by-case situation. The request for additional funds must be justified by the student on the application.

4. Biochemistry funds should supplement funds provided by the advisor, thus each application must list the approximate funds contributed by the advisor and be signed by the advisor (electronic signatures on PDF documents are preferred). The MoCODE to which the funds for travel will be deposited must be provided. Funds are transferred to the MoCODE to which the travel will be charged.

5. The request process requires both completion of the application form and submission of the abstract of the work to be presented at the meeting. The application and abstract must be submitted a minimum of **45 days** in advance of the start of travel. "Late/last minute" requests may not be considered. Completed electronic application forms should be Emailed to **both** the DGS, currently Tom Quinn (quinnt@missouri.edu) for approval signature and to the departmental fiscal office, currently Joanne Brandkamp brandkampj@missouri.edu.

6. Decisions to fund applications are not competitive between students. However the amount and the frequency of the requests will be based on evaluation of the merits of the request by the Director of Graduate Studies in consultation, as necessary, with the departmental Chair and on the basis of available funds.

The electronic application can be found online at http://www.biochem.missouri.edu/docs/travel-support-application.pdf
http://ps.missouri.edu/dev/promo/

Biochemistry Department: 20 Questions
SPRING 2015

I. PROTEINS AND ENZYMES

1. What are the principles and patterns of protein structure? Utilizing features of the peptide bond and the principles of thermodynamics explain the origin of the two predominant secondary structures and of the three-dimensional organization of proteins.

2. Explain how X-ray crystallography and NMR spectroscopy are used to determine macromolecular three-dimensional structures. For each technique, describe 1) its underlying principles, 2) the nature of the data obtained, 3) how the data are used to provide information about structure and 4) the respective advantages and disadvantages.

3. Give an overview of biochemical mechanisms and cellular functions of regulated protein degradation via the ubiquitin-dependent proteasome pathway.

4. How does an enzyme increase the rate of a reaction? Describe three different mechanisms used by enzymes to enhance reaction rates.

5. Describe the concepts of binding of small molecules by proteins, including relevant equations. Explain the underlying thermodynamics. Distinguish dissociation constants, rate constants and rates. Outline one experimental approach for determining these parameters.

II. METABOLISM

6. Discuss the origins and roles of acetyl CoA in metabolism. How does acetyl CoA illustrate the principle of integrating diverse systems through shared chemical intermediates?

7. Explain the principles of chemiosmotic phosphorylation and thus how ATP is produced from the energy of chemical bonds or light. Describe key components and biochemical steps. Identify the similarities and differences for this process in respiration and photosynthesis.

8. What are the roles and significance of feedback inhibition and repression in metabolic regulation? Illustrate with two distinctly different examples.

9. What are the control points for glycolysis and the TCA cycle? Consider the irreversible steps and those that yield ATP.

10. Compare the reactions, energetics, cellular localization and control of fatty acid oxidation and biosynthesis.

III. NUCLEIC ACIDS AND GENE REGULATION

11. What are the principles and patterns of nucleic acid structure? Starting with the chemistry of nucleic acids, describe the basis for secondary and tertiary structure, considering both DNA and RNA.

12. Describe basic principles and mechanisms of transcriptional control. Consider similarities and differences between eukaryotes and prokaryotes.

13. Discuss the role of small RNA's in control of gene expression.

14. What are the biochemical steps and energetics of DNA replication? How is fidelity of the DNA maintained during this process?

15. What are the processing steps involved in converting a nuclear transcript into a mature mRNA? Describe the biochemistry of these reactions.

IV. SUPRAMOLECULAR STRUCTURE AND CELLULAR ORGANIZATION

16. What are the thermodynamic and biochemical principles of membrane organization and structure? How do the various components of the membrane interact and what are their respective roles?

17. Explain the condensation and organization of DNA into chromatin. Describe the biochemical processes by which chromatin structure regulates gene expression.

18. Outline the fundamental principles and biochemical processes used by transmembrane receptors to mediate response to environmental changes. Illustrate using two distinctly different signaling systems. For each, describe 1) the molecular components and the biochemical steps of 2) signaling, 3) signal amplification, 4) signal decay and 5) adaptation.

19. Outline the fundamental principles and processes used by active transport systems to concentrate a membrane-impermeable molecule against its concentration gradient. Illustrate using two distinctly different active transport systems. Describe the molecular components and the biochemical steps.

20. Explain the biochemistry and energetics of protein synthesis. Include descriptions of key components, their structures, functions and interactions.