Biochemistry and Molecular Medicine, Ph.D.

Degrees Offered

• Doctor of Philosophy
• Combined Degrees, Doctor of Medicine and Doctor of Philosophy

Nature of the Program

A major goal of the Biochemistry and Molecular Medicine Program is to foster ability for independent thought. To this end, our faculty cultivates an open, collegial relationship with one another and with our students. Close collaboration between scientists, the sharing of ideas, and open inquiry are critical components of our training plan.

The hallmarks of graduate training in biochemistry and molecular medicine are the emphasis placed on the use of the scientific literature in advanced coursework and on protecting time for laboratory research. In addition, students will have time for professional development through seminar presentation, attendance at national meetings, teaching opportunities, and seminar programs both within the department and throughout the Health Sciences Center.

This doctoral program focuses on the understanding of biology by exploring function of the molecular components of cells. The student’s ability for independent thought is critical in preparation for a career as an independent scientist. During the second year, specialized courses in biochemistry are offered as students continue their research projects. During subsequent years, students emphasize independent dissertation research, and a few formal courses may be taken. Completion of the Ph.D. degree is realized when the student successfully presents the research results to faculty of the graduate dissertation committee and program/department. Typically, four to five years are required to realize this goal. A fast-track option is available to West Virginia University undergraduate students who have excelled in undergraduate prerequisite courses relevant to biochemistry, and began their research in a Program member’s laboratory during their junior year.

Faculty research in the program can provide the student with training in multiple basic sciences areas including:

• Epigenetic regulation of chromatin structure and gene expression
• RNA processing
• Cell survival mechanisms
• Regulation of metabolism
• Proteosome function
• Cell proliferation and cell cycle regulation
• Cell adhesion
• Kinases and phosphatases in signal transduction and in cancer cell metabolism
• Oxidant-induced cellular stress
• Structural biology and structure/function relationships of macromolecules such as RNA and/or proteins
• Molecular genetics of visual and auditory development
• G protein-mediated signaling by retinal photoreceptors
• Molecular basis of age-related blindness
• Development and application of new magnetic resonance approaches to biomedicine

These research areas provide fundamental knowledge toward the normal health-state and aim toward the amelioration of important diseases: atherosclerosis, blindness, cancer, deafness, diabetes, and metabolic disorders.

FACULTY

CHAIR
• Visvanathan Ramamurthy - Ph.D. (Wesleyan University)

GRADUATE PROGRAM CO-DIRECTORS
• Roberta Leonardi - Ph.D. (University of Southampton)
• Aaron Robart - Ph.D. (University of Calgary)
PROFESSORS
- Yehenew Agazie - Ph.D. (University of Saskatchewan)
- Steven Frisch - Ph.D. (University of California-Berkeley)
- Valery Khramtsov - Ph.D. (Institute of Chemical Kinetics and Combustion)
- Qiang Ma - Ph.D. (Rutgers University)
- Vazhaikkurichi Rajendran - Ph.D. (University of Madras)
- Visvanathan Ramamurthy - Ph.D. (Wesleyan University)
- Mike Ruppert - M.D., Ph.D. (Johns Hopkins University)
- Michael Schaller - Ph.D. (McMaster University)
- Maxim Sokolov - Ph.D. (Weizmann Institute of Science)

ASSOCIATE PROFESSORS
- Michael Gunther - Ph.D. (Colorado State University)
- Roberta Leonardi - Ph.D. (University of Southampton)
- Jun Liu - Ph.D. (University of Oxford)
- Pete Mathers - Ph.D. (California Institute of Technology)
- Elena Pugacheva - Ph.D. (Russian Academy of Science)
- Andrew Shiemke - Ph.D. (Oregon Graduate Institute)
- David Smith - Ph.D. (University of South Florida)
- Peter Stoilov - Ph.D. (Friedrich Alexander University)
- Mark Tseytlin - Ph.D. (Russian Academy of Sciences)
- Scott Weed - Ph.D. (Yale University)

ASSISTANT PROFESSORS
- Wentao Deng - Ph.D. (University of Florida)
- Jinahai Du - Ph.D. (Peking University)
- Saravanan Kolandaivelu - Ph.D. (All India Institute of Medical Sciences)
- Aaron Robart - Ph.D. (University of Calgary)
- Michael Robichaux - Ph.D. (UT Southwestern)
- Bradley Webb - Ph.D. (Queen's University)

RESEARCH ASSISTANT PROFESSORS
- Alexey Ivanov - Ph.D. (Russian Academy of Sciences)
- Ezequiel Salido - M.D., Ph.D. (University of Buenos Aires)

TEACHING ASSISTANT PROFESSOR
- Marieta Gencheva - Ph.D. (Bulgarian Academy of Sciences)

Doctor of Philosophy

MAJOR REQUIREMENTS - STANDARD TRACK

A minimum GPA of 3.0 is required.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS 700</td>
<td>Scientific Integrity</td>
<td>1</td>
</tr>
<tr>
<td>BMS 701</td>
<td>Scientific Rigor and Ethics</td>
<td>1</td>
</tr>
<tr>
<td>BMS 702</td>
<td>Biomedical Lab Experience</td>
<td>2</td>
</tr>
<tr>
<td>BMS 706</td>
<td>Biomedical Research Methods</td>
<td>1</td>
</tr>
<tr>
<td>BMS 707</td>
<td>Experiential Learning for Biomedical Trainees</td>
<td>2</td>
</tr>
<tr>
<td>BMS 715</td>
<td>Molecular Genetics</td>
<td>3</td>
</tr>
<tr>
<td>BMS 720</td>
<td>Scientific Writing</td>
<td>2</td>
</tr>
<tr>
<td>BMS 747</td>
<td>Foundations for Contemporary Biomedical Research I</td>
<td>4</td>
</tr>
<tr>
<td>BMS 777</td>
<td>Foundations for Contemporary Biomedical Research 2</td>
<td>4</td>
</tr>
<tr>
<td>Journal Club</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>BIOC 785</td>
<td>Biochemistry and Molecular Biology Journal Club</td>
<td>1</td>
</tr>
</tbody>
</table>
### MAJOR REQUIREMENTS - FAST TRACK

A minimum GPA of 3.0 is required.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMS 700</td>
<td>Scientific Integrity</td>
<td>1</td>
</tr>
<tr>
<td>BMS 701</td>
<td>Scientific Rigor and Ethics</td>
<td>1</td>
</tr>
<tr>
<td>BMS 707</td>
<td>Experiential Learning for Biomedical Trainees</td>
<td>2</td>
</tr>
<tr>
<td>BMS 715</td>
<td>Molecular Genetics</td>
<td>3</td>
</tr>
<tr>
<td>BMS 720</td>
<td>Scientific Writing</td>
<td>2</td>
</tr>
<tr>
<td>BIOC 785</td>
<td>Biochemistry and Molecular Biology Journal Club</td>
<td></td>
</tr>
<tr>
<td>BIOC 796</td>
<td>Graduate Seminar</td>
<td>1</td>
</tr>
<tr>
<td>BIOC 797</td>
<td>Research</td>
<td>52</td>
</tr>
<tr>
<td>Advanced Graduate Course - select one of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOC 750</td>
<td>Protein Chemistry/Enzymology</td>
<td>4</td>
</tr>
<tr>
<td>BIOC 751</td>
<td>Advance Molecular Biology</td>
<td></td>
</tr>
<tr>
<td>CCB 701</td>
<td>Biochemical and Oncogenic Signaling</td>
<td></td>
</tr>
<tr>
<td>Advanced Graduate Course - select one of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCB 701</td>
<td>Biochemical and Oncogenic Signaling</td>
<td>3-5</td>
</tr>
<tr>
<td>BIOC 750</td>
<td>Protein Chemistry/Enzymology</td>
<td></td>
</tr>
<tr>
<td>PSIO 750</td>
<td>Graduate Physiology and Pharmacology 1</td>
<td></td>
</tr>
<tr>
<td>BIOC 751</td>
<td>Advance Molecular Biology</td>
<td></td>
</tr>
<tr>
<td>MICB 784B</td>
<td>Special Problems in Microbiology</td>
<td></td>
</tr>
</tbody>
</table>

Qualifying Exam

Candidacy Exam

Dissertation Defense

Total Hours: 76-78

### Seminars and Research Forum

Students will present three seminars during their graduate study. The first seminar is on a topic outside of the student’s research area. The second seminar is the public presentation of the dissertation proposal, which is the background and proposed research for the dissertation project. The third seminar is the public presentation of the dissertation defense.

### Journal Club
Students are required to enroll in Journal Club each semester. The course involves the presentation and discussion of current research papers and will help acquaint students with the variety of methods used in scientific research.

**Doctoral Research**

Students will conduct research with a dissertation mentor during time in the program. Students register for research credits each semester, and their performance is graded by their dissertation mentor.

**Qualifying and Dissertation Proposal/Ph.D. Candidacy**

The written qualifying exam is given at the end of the first year of study. The candidacy is completed in the second year of study. Admission to Ph.D. candidacy occurs following the successful defense of the dissertation proposal.

**Dissertation Defense and First-Author Paper Requirement**

Students are allowed to defend their dissertation when a minimum of one manuscript with the student as first author, based on dissertation research, is accepted in a peer-reviewed journal. The final examination for the Ph.D. degree consists of orally defending a written dissertation in a public seminar and then in private to the dissertation committee. Satisfactory performance in the oral defense will result in recommendation for granting of the Ph.D.

**Suggested Plan of Study***

<table>
<thead>
<tr>
<th></th>
<th>First Year</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMS 700</td>
<td>1 BMS 701</td>
<td>12</td>
<td>1 BMS 701</td>
<td>1 BIOC 797</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BMS 706</td>
<td>1 BMS 715</td>
<td>9</td>
<td>3 Qualifying Exam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMS 702</td>
<td>2 BIOC 785</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMS 747</td>
<td>4 BIOC 797</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMS 777</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Second Year</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOC 785</td>
<td>1 BIOC 785</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOC 797</td>
<td>4 BIOC 797</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Course</td>
<td>3 Advanced Course</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Third Year</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOC 785</td>
<td>1 BIOC 785</td>
<td>9</td>
<td>1 BIOC 785</td>
<td>1 BIOC 797</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BIOC 797</td>
<td>8 BIOC 796</td>
<td>2</td>
<td>8 BIOC 797</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Fourth Year</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOC 785</td>
<td>1 BIOC 785</td>
<td>9</td>
<td>1 BIOC 785</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOC 797</td>
<td>8 BIOC 797</td>
<td>3</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total credit hours: 87

*This is a suggested plan of study. Course sequences and length of time in program may vary depending on student and altered total credit hours.

NOTE: The graduate curriculum is finalized with a plan of study once the mentor and laboratory have been selected in the first year. The plan of study is developed by the graduate committee in consultation with the student. The courses listed above include the required and elective coursework necessary for the student to finalize his/her plan of study. When the student enters the laboratory of his/her doctoral dissertation mentor repetitive enrollments in research, seminars, and colloquia are typical and will determine total hours necessary for degree completion.
Major Learning Outcomes

BIOCHEMISTRY AND MOLECULAR MEDICINE

Students will:

- Identify and summarize the basic concepts of biochemistry and molecular medicine including: molecular genetics, protein structure and function, metabolism, cell biology and biophysics.
- Discuss, interpret and critique the research literature in biochemistry and molecular medicine.
- Demonstrate deep insight when discussing research in their specific field of study.
- Integrate broad, fundamental knowledge in the basic concepts of biochemistry and molecular medicine with detailed knowledge of the student’s specific field of study.
- Identify the major questions and gaps in their specific field of study. When challenged, be able to identify significant gaps in our collective knowledge of biochemistry and molecular medicine.
- Acquire, develop and use standard biochemical laboratory techniques as well as those necessary to successfully perform state of the art experiments in the student’s area of research.
- Design experimental protocols and conduct self-directed research that is well-controlled, rigorous and produces results with unequivocal interpretation.
- Conduct research to produce novel results that are presented at scientific meetings and published in peer-reviewed journals.
- Demonstrate oral, written and visual communication skills that result in clear and organized dissemination of material at a level appropriate for the audience.

COURSES

BIOC 531. General Biochemistry. 4 Hours.
PR: General chemistry, organic chemistry. (For pharmacy students: others by consent.) Consisting of the lecture portion of BIOC 705, this course is designed to be a general introduction to biochemical compounds, processes and concepts for students in the pharmacy program. Master's program students and others by consent. Four lectures per week.

BIOC 593. Special Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

BIOC 595. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

BIOC 650. Supervised Teaching. 1-6 Hours.
PR: Consent. Supervised college teaching of biochemistry.

BIOC 652. Journal Club. 1-6 Hours.
Discussions of recent important topics in scientific literature.

BIOC 690. Teaching Practicum. 1-3 Hours.
PR: Consent of chairperson. Supervised practice in college teaching of biochemistry. (Graded as S/U.).

BIOC 693. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

BIOC 697. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper, or equivalent scholarly project, or a dissertation. (Grading may be S/U.).

BIOC 698. Thesis or Dissertation. 1-6 Hours.
PR: Consent. This is an optional course for programs that wish to provide formal supervision during the writing of student reports (698), or dissertations (798). Grading is normal.

BIOC 699. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use the University’s facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department's 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is P/F; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.

BIOC 701. Biochemical and Oncogenic Signaling. 3 Hours.
This advanced course is designed for upper level graduate students. It will focus on the biochemical and oncogenic mechanisms of cellular signaling. Students will explore the experimental techniques required to understand the scientific literature in biochemistry and cancer cell biology. (cross listed as CCB 701).
BIOC 705. General Biochemistry. 5 Hours.
PR: General chemistry, organic chemistry. (For dental students.) General introduction to biochemical compounds, processes and concepts as part of the training for the practice of dentistry, including passage of the Dental Board Exam. Four lectures and one clinical correlation or small group discussion per week.

BIOC 730. Current Topics in Cell Biology. 3 Hours.
PR: Consent. Provides advanced graduate students an opportunity to independently study a focused area of cell biology in considerable depth with the guidance of a faculty member as tutor. Over the course of the semester, the student will scrutinize the primary literature covering a topic of interest and draft an original review of the topic, under the guidance of the faculty tutor.

BIOC 731. Current Topics in Cell Biology. 3 Hours.
PR: Consent. Provides advanced graduate students an opportunity to independently study a focused area of cell biology in considerable depth with the guidance of a faculty member as tutor. Over the course of the semester, the student will scrutinize the primary literature covering a topic of interest and draft an original review of the topic, under the guidance of the faculty tutor.

BIOC 750. Protein Chemistry/Enzymology. 4 Hours.
PR: Consent. Advanced topics in protein structure function relationships and enzymology. Emphasis is placed on emerging topics in the literature.

BIOC 751. Advance Molecular Biology. 4 Hours.
PR: Consent. A study of contemporary topics in molecular biology. This is an advanced seminar-style class using material from the current literature.

BIOC 785. Biochemistry and Molecular Biology Journal Club. 1 Hour.
(May be repeated for a maximum of 16 credit hours.) Guided reading and critiquing of the current scientific literature for graduate students in the Biochemistry and Molecular Biology Graduate Programs.

BIOC 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of biochemistry. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading will be S/U.).

BIOC 791. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

BIOC 792. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

BIOC 793. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

BIOC 796. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

BIOC 797. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U.).