BIOCHEMISTRY, MASTER OF SCIENCE (M.S.)

Program goal
The M.S. program in biochemistry prepares students for research-oriented careers in academia, government and biotechnology. The core of this degree program is an original independent research project under the supervision of a faculty adviser. The Department of Biochemistry and Molecular Biology has research efforts of international stature in several areas, including cellular and molecular signaling, tumor biology, structural biology, eukaryotic molecular biology, lipid and membrane biochemistry and molecular genetics, using state-of-the-art approaches in enzymology, genomics, proteomics and lipidomics.

While emphasizing independent research in biochemistry and molecular biology and training in the responsible conduct of research, the program also provides a background of courses designed to match the needs and interests of each student. The program is designed to provide students with the skills required to advance to positions as bioscience researchers/trainers in a broad spectrum of positions. The program provides a framework for the progressive development of a mastery of the current state of the subject matter of biochemistry, cell and molecular biology, as well as an ability to synthesize this information and apply this foundation to the identification of key areas of investigation and experimentation in bioscience.

The program relates the above framework to the development of the ability to design, implement and interpret experimental approaches which address the questions identified. In addition, the program will develop skills in the various means of communicating both the core of bioscience knowledge and the expression of experimental design, results and interpretation to a variety of potential audiences.

Student learning outcomes
1. Experimental design: Degree candidates will demonstrate the achievement of an appropriate level of competence in the ability to appraise, modify and/or create, and implement experimental protocols and to design and develop experiments.
2. Oral communication skills: Degree candidates will demonstrate the achievement of an appropriate level of oral communication skills with respect to the content, organization, logical flow, presentation and appropriate use of language incorporating the use of visual aids.
3. Written communication skills: Degree candidates will demonstrate the achievement of an appropriate level of written communication skill with respect to grammar, syntax, spelling and use of vocabulary to effectively present information including the use of figures, tables and citations.
4. General knowledge of science: Degree candidates will demonstrate an appropriate level of knowledge of the current elements of the biosciences as related to disciplinary specialization and a more detailed understanding of the individual area of scholarship, including an appropriate familiarity with the research literature and the ability to evaluate and critique publications.
5. Problem-solving skills: Degree candidates will demonstrate an appropriate level of skill in the identification and selection of meaningful problems to be addressed in bioscience research, including the ability to defend said identifications and to design and develop appropriate methods to solve said problems.

VCU Graduate Bulletin, VCU Graduate School and general academic policies and regulations for all graduate students in all graduate programs
The VCU Graduate Bulletin website documents the official admission and academic rules and regulations that govern graduate education for all graduate programs at the university. These policies are established by the graduate faculty of the university through their elected representatives to the University Graduate Council.

It is the responsibility of all graduate students, both on- and off-campus, to be familiar with the VCU Graduate Bulletin as well as the Graduate School website (http://www.graduate.vcu.edu) and academic regulations in individual school and department publications and on program websites. However, in all cases, the official policies and procedures of the University Graduate Council, as published on the VCU Graduate Bulletin and Graduate School websites, take precedence over individual program policies and guidelines.

Visit the academic regulations section for additional information on academic regulations for graduate students. (http://bulletin.vcu.edu/academic-reg)

Degree candidacy requirements
A graduate student admitted to a program or concentration requiring a final research project, work of art, thesis or dissertation, must qualify for continuing master’s or doctoral status according to the degree candidacy requirements of the student’s graduate program. Admission to degree candidacy, if applicable, is a formal statement by the graduate student’s faculty regarding the student’s academic achievements and the student’s readiness to proceed to the final research phase of the degree program.

Graduate students and program directors should refer to the following degree candidacy policy as published in the VCU Graduate Bulletin for complete information and instructions.

Visit the academic regulations section for additional information on degree candidacy requirements. (http://bulletin.vcu.edu/academic-reg/grad/candidacy)

Graduation requirements
As graduate students approach the end of their academic programs and the final semester of matriculation, they must make formal application to graduate. No degrees will be conferred until the application to graduate has been finalized.

Graduate students and program directors should refer to the following graduation requirements as published in the Graduate Bulletin for a complete list of instructions and a graduation checklist.

Visit the academic regulations section for additional information on graduation requirements. (http://bulletin.vcu.edu/academic-reg/grad/graduation-info)

Other information
School of Medicine graduate program policies
The School of Medicine provides policies applicable to all programs administratively housed in the school. Information on master’s programs is available elsewhere in this chapter of the Graduate Bulletin.
**Admission requirements**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Semester(s) of entry</th>
<th>Deadline dates</th>
<th>Test requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.S.</td>
<td>Fall preferred</td>
<td>Applications accepted through June; priority given to early applicants</td>
<td>GRE, MCAT or DAT</td>
</tr>
</tbody>
</table>

**Special requirements**

- MCAT or DAT acceptable in lieu of GRE for combined professional/academic degree programs.

Applicants to the Master of Science in Biochemistry program must meet all general admission requirements of the VCU Graduate School (http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements). In addition, applicants must meet the following requirements.

1. Organic chemistry (with a minimum grade of B)
2. Undergraduate biochemistry (not required but recommended)
3. Laboratory experience
4. GRE scores of at least 158 (verbal), 158 (quantitative) and 4.0 analytical

**Continuing for the Ph.D.**

Students who plan to eventually work toward the Ph.D. degree in biochemistry at VCU should apply directly to our Ph.D. program and forgo the master’s degree. Applicants who are unsure if they want to earn a Ph.D. and who wish to gain experience in biomedical research before making this decision will be well served by our M.S. program. Outstanding performance in our master’s program can help students gain admittance to a doctoral program at VCU or elsewhere. Master’s students wishing to gain admission to the Ph.D. program should submit the following documents to the graduate program director: (1) a letter making this request which should include justification for the request, career goals, name of proposed Ph.D. adviser and brief description of proposed Ph.D. research project, (2) VCU graduate transcript and (3) a letter of support from proposed Ph.D. adviser. Additional admissions requirements include (1) a grade of A in BIOC 691, (2) a grade of A in BIOC 505 (laboratory rotation), (3) a final score in the top 50 percent of scores in BIOC 503-BIOC 504 and (4) GRE scores of at least 158 (verbal), 158 (quantitative) and 4.0 analytical.

**Degree requirements**

In addition to the general VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-regs/grad/graduation-info), students in the M.S. in Biochemistry program must complete a minimum of 30 credit hours, including at least 24 didactic credit hours (exclusive of research credit hours).

Students in the M.S. program in biochemistry take courses designed for graduate students with an emphasis on research design and experimentation. During the first year of study, students pursue research rotations, take formal course work and become familiar with current research topics through seminars, discussion groups and lectures by distinguished scientists. By the end of the first year, students choose a faculty adviser and begin thesis research. Following completion of the research project and defense of the master’s thesis, graduates are equipped to participate in virtually any area of current biomedical research in the most prestigious laboratories. For more detailed information on the program, visit biochemistry.vcu.edu/education/masters/default.htm (http://www.biochemistry.vcu.edu/education/masters/default.htm).

M.S. students register for BIOC 690 and BIOC 691 for the duration of their tenure in the program. The core set of courses may be supplemented with elective courses offered by the Department of Biochemistry and Molecular Biology or other departments. Students are encouraged to take additional courses that relate to their personal projects. Electives may include courses in techniques in molecular biology and genetics, bioinformatics, statistics, immunology, microbiology, molecular genetics, mammalian physiology and advanced organic and physical chemistry, among others.

**Training in the responsible conduct of research**

All M.S. students are required to complete the following training in the responsible conduct of research:

1. OVPR 601, OVPR 602 or OVPR 603
2. Collaborative Investigator Training Initiative: an online course that provides training in human subjects research. The course must be completed during the fall semester of year two. Students must submit the certificate of completion before starting the spring semester of year two. Consult the following link to access the course: research.vcu.edu/human_research/citi_requirements.htm (http://www.research.vcu.edu/human_research/citi_requirements.htm)

3. Animal research training: Students are required to complete an online training course for the conduct of animal subjects research. The course must be completed during the fall semester of year two. Students must submit the certificate of completion before starting the spring semester of year two. Consult the following link to access the course: Research and Innovation website.

**Curriculum requirements**

**Required course work**

Students must take a minimum of 24 didactic credit hours from the following list of courses.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOC 503</td>
<td>Biochemistry, Cell and Molecular Biology</td>
<td>5</td>
</tr>
<tr>
<td>BIOC 504</td>
<td>Biochemistry, Cell and Molecular Biology</td>
<td>5</td>
</tr>
<tr>
<td>BIOC 505</td>
<td>Experimental Biochemistry (research rotation, typically taken in year one)</td>
<td>2</td>
</tr>
<tr>
<td>or BIOC 697</td>
<td>Directed Research in Biochemistry</td>
<td></td>
</tr>
<tr>
<td>BIOC 602</td>
<td>Physical Properties of Macromolecules and Enzymology</td>
<td>4</td>
</tr>
<tr>
<td>BIOC 604</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Take the following courses each fall and spring throughout the program</td>
<td>variable</td>
</tr>
<tr>
<td>BIOC 651</td>
<td>Biochemistry Journal Club (year two until program complete)</td>
<td>1</td>
</tr>
<tr>
<td>BIOC 690</td>
<td>Biochemistry Seminar</td>
<td>variable</td>
</tr>
</tbody>
</table>

Take one or both of the following (typically during year one) for a total of two credits.
IBMS 630  Critical Thinking
or BIOC 661  Critical Thinking

IBMS 600  Laboratory Safety  1

Select one of the following:  1

OVPR 601  Scientific Integrity
OVPR 602  Responsible Scientific Conduct
OVPR 603  Responsible Conduct of Research

1 Students will select modules from BIOC 602, typically year one, and BIOC 604, typically year two, to complete a total of four credit hours, at least one credit hour from each course.

2 One- to four-credit course in which students must register for the duration of their tenure in the program for a minimum of four credit hours.

Directed research
Directed research (minimum 6 credits):  variable

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOC 697</td>
<td>Directed Research in Biochemistry (to be taken each fall and spring semester)</td>
</tr>
</tbody>
</table>

Electives
(suggested but not required)

Select two credits from the following:  (2)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANAT 615</td>
<td>Techniques in Neuroscience and Cell Biology</td>
</tr>
<tr>
<td>BIOC 601</td>
<td>Membranes and Lipids</td>
</tr>
<tr>
<td>HGEN 501/BIOL 530</td>
<td>Introduction to Human Genetics</td>
</tr>
<tr>
<td>MICR 505</td>
<td>Immunobiology</td>
</tr>
<tr>
<td>MICR 605</td>
<td>Prokaryotic Molecular Genetics</td>
</tr>
<tr>
<td>MICR/BNFO 653</td>
<td>Advanced Molecular Genetics: Bioinformatics</td>
</tr>
<tr>
<td>PHTX 691</td>
<td>Special Topics in Pharmacology</td>
</tr>
</tbody>
</table>

Total graduate credit hours required (minimum) 30

Typical plan of study
Many students often end up taking more than the minimum number of hours required for a degree program. The total number of hours may vary depending upon the program, nature of research being conducted by a study or in the enrollment or funding status of the student. Students should refer to their program websites and talk with their graduate program directors or advisers for information about typical plans of study and registration requirements.

Graduate program director
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Program website: biochemistry.vcu.edu (http://www.biochemistry.vcu.edu)