INTEGRATIVE LIFE SCIENCES, DOCTOR OF PHILOSOPHY (PH.D.) WITH A CONCENTRATION IN BIOINFORMATICS AND GENOME SCIENCES

Program mission

The Ph.D. in Integrative Life Sciences is designed for students who want to conduct research that is integrative across multiple disciplines and that takes a systems approach to emerging research questions across the many fields that comprise the life sciences. Students may opt to work with faculty members from any department, center or institute across VCU campuses. The program provides the opportunity to conduct interdisciplinary research at multiple scales of study from the molecular to ecosystem levels with an emphasis on the concepts of systems biology and biological complexity.

Program goals

1. **Interdisciplinary knowledge and skills:** The core curriculum of the ILS program will effectively assist students in gaining understanding of modern systems biology along with training in the interdisciplinary skills and knowledge increasingly required for doing effective research in the life sciences. It will also foster progressive development of a mastery of the current state of the research in students' areas of interest as they seek to identify key focus areas for their integrative research.
2. **Research skills:** The mentored research component of the program, building on the core curriculum and interdisciplinary elective course work, will foster development of an ability to synthesize this learning and identify key focus areas for integrative research. It will support students as they learn how to design, implement and interpret interdisciplinary experimental approaches that will best address their research questions.
3. **Communication skills:** Students in the program will develop skills in both written and oral communication of life science knowledge, experimental design, results and interpretation to a variety of potential audiences.

Student learning outcomes

1. **Oral communication skills:** The candidate 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, as measured by rubric.
2. **Written communication skills:** The candidate 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, as measured by rubric.
3. **Experimental design:** The candidate 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, as measured by rubric.
4. **Problem-solving skills:** The candidate 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, as measured by rubric.
5. **Integrated knowledge:** The candidate will demonstrate an appropriate level of knowledge of the life sciences and a more detailed understanding of the disciplines most pertinent to their own interdisciplinary research areas, including an appropriate familiarity with the research literature and the ability to evaluate and critique publications, as measured by rubric.

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-regs)

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-regs/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-regs/grad/graduation-info)

Admission requirements

Degree:	Semester(s) of entry:	Deadline dates:	Test requirements:
Ph.D.	Fall (preferred)	Jan. 10	GRE
			International students require TOEFL, IELTS or equivalent

Note: All application components must be received by Jan. 10 to be competitive.

In addition to the general admission requirements of the VCU Graduate School (http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements), the Ph.D. in Integrative Life Sciences program requires graduation from an accredited college or university or its equivalent with a degree that is preparative for graduate-level study in the life sciences. Applicants should have a minimum GPA of 3.0 on a 4.0 scale, and scores on the Graduate Record Examination should exceed the 50th percentile in each category. For international applicants, satisfactory scores from a standardized test, such as the TOEFL (a minimum score of 100) or IELTS (minimum band scores of 7.0), must be submitted along with external evaluation of undergraduate transcripts from nondomestic educational institutions (see Graduate Admissions website (http://graduate.admissions.vcu.edu/apply) for further details).

The ideal applicant with a Bachelor of Science degree will have performed well in biology courses through cell and molecular biology and genetics; mathematics, including linear algebra and statistics; chemistry, including analytical and organic; physics; and computer science with significant programming skills, basic scripting languages (e.g., PYTHON and R) and an understanding of databases and database structures. A successful applicant with all of the above skills will be required to complete a core curriculum of 23 credits of didactic courses, 12 credits of appropriate electives and 30 credits of directed research (see B.S. to Ph.D. curriculum below).

Students with a previous master's degree in bioinformatics, an appropriate science or computational subject will be expected to have all of the prerequisite skills described above for the B.S. to Ph.D. option, plus a graduate-level understanding of basic molecular biology and metabolism, the major concepts in bioinformatics and a comprehensive understanding of the algorithms underlying major bioinformatics tools.

Letters of recommendation from three present or former professors, advisers or mentors qualified to evaluate the applicant's ability to engage in graduate research in the life sciences are required, as is a written statement from the applicant describing the applicant's research interests, motivation, research experience, education and goals for pursuing graduate study in this particular program, preferred research adviser(s), official transcripts from all past postsecondary educational institutions, official GRE scores, and current curriculum vita or resume. Applicants are **strongly** encouraged to contact potential research advisers prior to submitting application materials and to identify potential research advisers in their personal statements. Individuals who have identified a research adviser will be given preference for admittance and funding.

Degree requirements

In addition to general VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-regs/grad/graduation-info), students are required to complete course work in core and elective courses and to conduct significant research. All work toward the degree must be completed within eight years of the first enrollment.

1. **Credit-hour requirements:** Students pursuing the concentration in bioinformatics and genome sciences are required to earn a minimum of 50 (for M.S. to Ph.D.) or 64 (for B.S. to Ph.D.) graduate-level credit hours. At least one-half of the graduate credit hours presented for graduation must be at the 600 level or higher. No elective courses may be used for both M.S. and Ph.D. degrees.
2. **Grade requirement:** Degree applicants must achieve an overall GPA of 3.0 (B) with a grade of C in no more than one course. The GPA for graduation is based on all graduate courses attempted after acceptance into the program.
3. **Transfer/waiver credit:** Graduate-level VCU course work taken as a nondegree-seeking student or in a previous graduate matriculation for which a degree was never awarded may be evaluated to determine whether it can be used to fulfill degree requirements of this program in accordance with the VCU Graduate School transfer policy (http://bulletin.vcu.edu/academic-regs/grad/transfer-credit). Course work completed toward a previous degree can also be considered as a waiver of program core or elective course work requirements. In these cases, the requirement(s) are waived, and other course work or research credits can be used to make up credits needed toward the degree. A minimum grade of B is required for credit hours transferred or waived.
4. **Research adviser and committee:** Students should select a research adviser prior to matriculation, but no later than the end of the first semester. The research adviser may be chosen from among the many graduate faculty members from any VCU research unit. This research adviser is approved by the program director in accordance with the Graduate School bylaws. Students are required to form a research advisory committee that is headed by the research adviser and that consists of a minimum of four other members of the VCU graduate faculty. Individuals who are not graduate faculty members (i.e., individuals from another institution or industry) must apply to the dean of the Graduate School for temporary affiliate graduate faculty appointment. The significant areas of the student's research focus should be represented by the members of the research advisory committee. At least two members of the committee should have primary appointments in departments other than that of the research adviser, with one of those members being integrally associated with the student's research to foster the interdisciplinary intent of this degree program. Students should form their committees no later than the end of the second semester of study. This committee must be approved by the program director.
5. **Written and oral examinations:** Before admission to degree candidacy for the Ph.D. degree, students must successfully complete a comprehensive examination and a research proposal examination. The student's research advisory committee will administer both exams. Students should take the comprehensive exam upon completion of all required didactic course work, usually no later than the end of the fourth semester of study. It may be written or oral (or both) and will focus on material covered in core and selected elective

courses as well as fundamental knowledge relevant to the student's research field. Upon successful completion of the comprehensive examination and submission and acceptance of a written research proposal, students will take an oral examination that includes a defense of the proposed research project and other subject areas deemed appropriate by the committee. Students may retake the comprehensive and research proposal examinations only once each. Written evaluations of the examinations will be completed by research advisory committee members. These valuations are provided to the chair of the research advisory committee and to the program director for discussion with the student and for program assessment.

6. **Dissertation research:** The dissertation research project should represent a significant contribution to the body of knowledge in its field and should be deemed suitable for publication in refereed journals. The emphasis of the research conducted by students in this program should be on interdisciplinary research and incorporate two or more disciplines. Research projects may take advantage of the many research opportunities across the life sciences on both campuses. Students shall prepare a written dissertation describing the completed research using the format approved by the Graduate School. An oral defense of the dissertation, under the direction of the research advisory committee and open to the public, also is required. Written evaluations of the dissertation and the oral defense of the dissertation will be completed by research advisory committee members. These evaluations are provided to the chair of the research advisory committee and to the program director for discussion with the student and for program assessment. Upon successful completion of all degree requirements, students will graduate with the Ph.D. in Integrative Life Sciences.

Curriculum requirements

B.S. to Ph.D. curriculum

Course	Title	Hours
Core courses		
LFSC 630	Integrative Life Sciences Research	2
LFSC 631	Student Seminar in Integrative Life Sciences (one credit hour taken two semesters)	2
LFSC 690	Research Seminar in Integrative Life Sciences (one credit hour taken two semesters)	2
Scientific integrity		
OVPR 601	Scientific Integrity	1
or OVPR 602	Responsible Scientific Conduct	
or OVPR 603	Responsible Conduct of Research	
Advanced statistics, advanced mathematics or experimental design course		
BIOS/STAT 513	Mathematical Statistics I	3
or STAT 641	Applied Data Analysis	
Technologies course (recommended options; choice depends on student's specialty)		
BNFO 691	Special Topics in Bioinformatics (biological sequence analysis: methods and applications)	3
Additional required concentration courses		
BIOC 530	Biochemistry, Cell and Molecular Biology Module 1: Protein Structure and Function	2
BIOC 531	Biochemistry, Cell and Molecular Biology Module 2: Basic Metabolism	1
BIOC 532	Biochemistry, Cell and Molecular Biology Module 3: Central Dogma of Molecular Biology	1
BNFO 601	Integrated Bioinformatics	3
Recommended elective courses (based on research interest and approved by research advisory committee)		
Select a minimum of 12 hours from the following:		12
BIOC 504	Biochemistry, Cell and Molecular Biology	
BIOC 533	Biochemistry, Cell and Molecular Biology Module 4: Lipids/Membranes and Bioenergetics	
BIOL 516	Population Genetics	
BIOL 550	Ecological Genetics	
BIOL 591	Special Topics in Biology	
BIOL 606	Quantitative Ecology	
BIOL 650	Conservation Genetics	
BIOL 691	Special Topics in Biology	
BIOS/STAT 514	Mathematical Statistics II	
BIOS 524	Biostatistical Computing	
BNFO 591	Special Topics in Bioinformatics	
BNFO 592	Independent Study	
BNFO 601	Integrated Bioinformatics	
BNFO 620	Bioinformatics Practicum	
BNFO 621	Business and Entrepreneurship Essentials for Life Scientists	
BNFO 637	Networks Biology	
BNFO/MICR 653	Advanced Molecular Genetics: Bioinformatics	
BNFO 691	Special Topics in Bioinformatics	
BNFO 692	Independent Study	
CMSC 501	Advanced Algorithms	
CMSC 502	Parallel Algorithms	
CLSE 562	Advanced Systems Biology Engineering	
HGEN 501/ BIOL 530	Introduction to Human Genetics	
HGEN 614	Pathogenesis of Human Genetic Disease	
MEDC 541	Survey of Molecular Modeling Methods	
MEDC 670	Advanced Molecular Modeling Theory and Practice	
MICR 505	Immunobiology	
MICR 605	Prokaryotic Molecular Genetics	
MICR 616	Mechanisms of Viral and Parasite Pathogenesis	
MICR 618	Molecular Mechanisms of Bacterial Pathogenesis	
STAT 643	Applied Linear Regression	
Directed research (minimum 32 credit hours)		32

LFSC 697	Directed Research in Integrative Life Sciences	
Total Hours		64

For these students, the minimum total of graduate credit hours required for this degree is 64.

M.S. to Ph.D. curriculum

Course	Title	Hours
Core courses		
LFSC 630	Integrative Life Sciences Research	2
LFSC 631	Student Seminar in Integrative Life Sciences (one credit hour taken two semesters)	2
LFSC 690	Research Seminar in Integrative Life Sciences (one credit hour taken two semesters)	2
Scientific integrity		
OVPR 601	Scientific Integrity	1
or OVPR 602	Responsible Scientific Conduct	
or OVPR 603	Responsible Conduct of Research	
Advanced statistics, advanced mathematics or experimental design course		
BIOS/STAT 513	Mathematical Statistics I	3
or STAT 641	Applied Data Analysis	
Technologies course (recommended options; choice depends on student's specialty)		
BNFO 691	Special Topics in Bioinformatics (biological sequence analysis: methods and applications)	3
Recommended elective courses (based on research interest and approved by research advisory committee)		
Select a minimum of six hours from the following:		6
BIOC 504	Biochemistry, Cell and Molecular Biology	
BIOC 533	Biochemistry, Cell and Molecular Biology Module 4: Lipids/Membranes and Bioenergetics	
BIOL 516	Population Genetics	
BIOL 550	Ecological Genetics	
BIOL 591	Special Topics in Biology	
BIOL 606	Quantitative Ecology	
BIOL 650	Conservation Genetics	
BIOL 691	Special Topics in Biology	
BIOS/STAT 514	Mathematical Statistics II	
BIOS 524	Biostatistical Computing	
BNFO 591	Special Topics in Bioinformatics	
BNFO 592	Independent Study	
BNFO 601	Integrated Bioinformatics	
BNFO 620	Bioinformatics Practicum	
BNFO 621	Business and Entrepreneurship Essentials for Life Scientists	
BNFO 637	Networks Biology	
BNFO/MICR 653	Advanced Molecular Genetics: Bioinformatics	
BNFO 691	Special Topics in Bioinformatics	
BNFO 692	Independent Study	
CMSC 501	Advanced Algorithms	
CMSC 502	Parallel Algorithms	
CLSE 562	Advanced Systems Biology Engineering	
HGEN 501/ BIOL 530	Introduction to Human Genetics	
HGEN 614	Pathogenesis of Human Genetic Disease	
MEDC 541	Survey of Molecular Modeling Methods	
MEDC 670	Advanced Molecular Modeling Theory and Practice	
MICR 505	Immunobiology	
MICR 605	Prokaryotic Molecular Genetics	
MICR 616	Mechanisms of Viral and Parasite Pathogenesis	
MICR 618	Molecular Mechanisms of Bacterial Pathogenesis	
STAT 643	Applied Linear Regression	
Directed research (minimum 31 credit hours)		31
LFSC 697	Directed Research in Integrative Life Sciences	
Total Hours		50

For these students, the minimum total of graduate credit hours required for this degree is 50.

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
Brian C. Verrelli, Ph.D.
bverrelli@vcu.edu (bverrilli@vcu.edu)
(804) 828-6920

Additional contact
Regina Jefferson
Executive administrative assistant
lrjeffer@vcu.edu
(804) 827-1865

Program website: lifesciences.vcu.edu/academic-programs/phd-in-integrative-life-sciences (http://lifesciences.vcu.edu/academic-programs/phd-in-integrative-life-sciences)