MEDICINE, DOCTOR OF (M.D.)/ INTEGRATIVE LIFE SCIENCES, DOCTOR OF PHILOSOPHY (PH.D.) WITH A CONCENTRATION IN BIOINFORMATICS AND GENOME SCIENCES [DUAL DEGREE]

Graduate study in the Ph.D. in Integrative Life Sciences with a concentration in bioinformatics and genome sciences is a highly individualized undertaking and required course work represents only one component. Each student's program is tailored to meet his or her particular interests, with the primary emphasis on developing research skills and the capacity for independent scholarship and with the recognition that career goals for many M.D.-Ph.D. physician-scientists are distinct from those of most Ph.D. trainees.

Program goals

The objectives of this dual degree program are:

- Students in the M.D.-Ph.D. program in integrative life sciences will acquire the foundational skills to allow them, after further clinical specialty and postdoctoral research training, to become independent physician-scientists. Program graduates ultimately pursue careers in academic medicine, biotechnology and the pharmaceutical industry, research institutes, and government agencies as clinicians, scientists, educators and administrators.
- Students will gain a progressive mastery of concepts in life sciences and related disciplines, an understanding of the current state of research investigations in the field, an ability to synthesize information and apply foundational concepts to identify key areas for innovative investigation and experimentation, and the knowledge to design, execute and interpret experiments and publish studies that address the questions identified.
- Students will develop skills in various means of communicating core knowledge in the field and the details of experimental design, results and interpretation to a variety of potential audiences.

Among the many benefits offered by participation in the dual-degree program are the following:

- Students will have the foundation and training in life sciences and in medicine to conduct basic and translational research that will enable them to take bedside observations to the bench and the results of bench research to the bedside to advance both the underlying science and patient health.
- Students have the opportunity to participate in clinical research during the M4 year.
- Students with M.D.-Ph.D. training are highly competitive for positions in leading physician-scientist clinical training programs, faculty positions in academic medical centers, and are well-positioned to ultimately take on leadership roles in academic medicine, industry and government.
- Tuition, fees and a stipend are provided throughout both the medical and graduate phases of training.

The diplomas for this dual degree program are awarded simultaneously upon completion of the requirements for both degrees.

Student learning outcomes

The student learning outcomes described on the integrative life sciences Ph.D. program page (https://bulletin.vcu.edu/graduate/vcu-life-sciences/integrative-life-sciences-phd-concentration-bioinformatics-genome-sciences/) also apply to M.D.-Ph.D. students.

Admission requirements

To be considered for the VCU M.D.-Ph.D. program, prospective students must apply to the medical school through the American Medical College Application Service (https://students-residents.aamc.org/applying-medical-school/applying-medical-school-process/applying-medical-school-amcas/). Please designate "Combined Graduate/Medical Degree" on your AMCAS application. The deadline for application to the program for admission in the fall semester is listed on the AMCAS web site.

In rare situations when resources allow, students matriculated in the medical school class may be considered for admission to the M.D.-Ph.D. program, usually near the start of the M1 academic year. For additional details, see the M.D.-Ph.D. dual degree opportunities page (https://bulletin.vcu.edu/professional-studies/medicine/md-phd-opportunities/).

Degree requirements

The dual degree program is designed to allow students to complete the first two-years of medical school and the USMLE Step 1 examination (M1, M2) before undertaking graduate training (G1 and subsequent years). After successfully defending the Ph.D. dissertation, students complete the remaining clinical years (M3, M4) of medical training. Nevertheless, important aspects of dual degree training are integrated across the program. These include M.D.-Ph.D. specific graduate courses during M1 and M2 that supplement the medical curriculum and emphasize research and translational aspects of M.D. course topics and required M3 clinical rotations integrated into the graduate phase. Opportunities for research experience begin prior to entering the graduate phase (pre-matriculation and summers after M1 and M2), when students spend time working in several faculty laboratories of their choice. These laboratory rotations enable students to examine faculty research projects, experimental approaches and laboratory environments, and to select an area for specialization. After completing M2, students are required to take the USMLE Step 1 exam, followed by one or two required M3 clinical rotations lasting 6 to 8 weeks total. They then transition into graduate studies.

During the first year of graduate training (G1), students take graduate courses selected to optimize their training and devote time to independent research under the guidance of a faculty adviser. During G2 and subsequent years, most effort is devoted to independent research, as part of the course requirements are satisfied by the M1 and M2 M.D. curriculum (see below). On satisfactory completion of coursework, students must pass written and oral comprehensive examinations to qualify for degree candidacy. Candidacy examinations for the dual M.D.-Ph.D. are normally completed during G2. Following admission to candidacy, each student must conduct a substantial original research project, prepare a written dissertation, present their work in a seminar and defend it successfully in an oral examination. Department-sponsored seminars and other activities give students opportunities to discuss their research interests with visiting scientists and to present their research both internally at national professional meetings.

The Ph.D. component of training in integrative life sciences with a concentration in bioinformatics and genome science for M.D.-Ph.D. students normally takes at least four years to complete. Courses taken during the M1 and M2 years of medical school satisfy a number of course requirements, and additional courses are completed in the G1 year. M.D.-Ph.D. students, if eligible under NIH rules, are required to prepare and submit an NIH F30 predoctoral training grant application, which is usually based on the dissertation proposal defended during the comprehensive examinations. M.D.-Ph.D. students also are encouraged to submit predoctoral training grant applications to other funding sources. Acceptance of a peer-reviewed first-author (or co-first-author) manuscript in a scientific journal indexed in PubMed or Web of Science that is based on experimental research conducted during Ph.D. training (rather than a review, commentary, case note or similar publication) is required of all M.D.-Ph.D. students prior to returning to the M3 phase of medical school.

In addition to completing VCU School of Medicine requirements for the M.D. degree and the general VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-regs/grad/graduation-info/), students must complete a minimum of 64 credit hours for the Ph.D., including directed research.

Curriculum requirements for the M.D.

Based on the equivalent knowledge acquired by successfully completing MEDI 100, MEDI 150, MEDI 200, MEDI 250 during the M1 and M2 years, nine credits are satisfied (for BIOC 504[1], BIOC 530, BIOC 531 and BIOC 532). Courses taken to satisfy Ph.D. requirements do not satisfy M.D. requirements.

Course	Title	Hours
M1 year		
Fall semester (MEDI 100)		
Transition to Medical School		
Practice of Clinical Medical Bootcamp		
Molecular Basis of Health and Disease		
Principles of Physiology		
Principles of Autonomics and Pharmacology		
Immunity and Infection		
Foundations of Disease		
Practice of Clinical Medicine		
Patient, Physician and Society		
Population Health and Evidence Based Medicine		
Ultrasound		
Diagnostic Reasoning		
Geriatrics		
Spring semester (MEDI 150)		
Marrow (Hematology / Oncology)		
Movement (Musculoskeletal)		
Gastrointestinal		
Endocrine		
Reproduction		
Practice of Clinical Medicine		
Patient, Physician and Society		
Population Health and Evidence Based Medicine		
Ultrasound		
Diagnostic Reasoning		
Geriatrics		
IPEC 502	Interprofessional Quality Improvement and Patient Safety	1
M2 year		
Fall semester (MEDI 200)		
Cardiovascular		
Pulmonary		
Renal		
Neuroscience		
Practice of Clinical Medicine		
Patient, Physician and Society		
Population Health and Evidence Based Medicine		
Ultrasound		
Diagnostic Reasoning		
Geriatrics		
Spring semester (MEDI 250)		
Behavioral Sciences		
Practice of Clinical Medicine		
Step 1 Study		
M3 year		
Fall and spring semesters (MEDI 300)		
M3 Transition to Clerkships		
Internal Medicine Clerkship		
Surgery Clerkship		
OB/GYN Clerkship		
Pediatrics Clerkship		
Family Medicine Clerkship		
Neurology Clerkship		
Psychiatry Clerkship		
Ambulatory Clerkship		
Foundational Career Exploratory electives		
Patient, Physician and Society		
Population Health		
Telehealth		
M4 year		
Fall and spring semesters (MEDI 400)		
Transition to M4 - Clinical Concentrations		
Two acting internships, one ward and one critical care (four weeks each)		
Step 2 Clinical Knowledge exam		
28 weeks of clinical electives		
Up to 20 weeks of non-clinical electives		
Patient, Physician and Society		
Interprofessional Critical Care Simulations		
IPEC 561	IPE Virtual Geriatric Case	2
Transition to Residency		

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BIOC 504 is an elective option; it must be chosen to realize the full nine credits of course work satisfied by the M1 and M2 years.

Curriculum requirements for the Ph.D.

Based on the equivalent knowledge acquired by successfully completing MEDI 100, MEDI 150, MEDI 200, MEDI

250 during the M1 and M2 years, nine credits are satisfied (for BIOC 504[1], BIOC 530, BIOC 531 and BIOC 532). Students are required to take additional credits of M.D.-Ph.D.-specific courses listed below. M.D.-Ph.D. students should consult with the ILS-BSG program director.

Course	Title	Hours
Required core courses		
LFSC 630	Integrative Life Sciences Research	2
LFSC 631	Student Seminar in Integrative Life Sciences (one-credit course taken for two semesters)	2
LFSC 690	Research Seminar in Integrative Life Sciences (one-credit course taken for two semesters)	2
Additional required courses		
BIOS/STAT 513	Mathematical Statistics I	3
or STAT 641	Applied Data Analysis	
BNFO 691	Special Topics in Bioinformatics	2
IBMS 624	Research Reproducibility and Transparency	1
IBMS 651	M.D.-Ph.D. Journal Club (one-credit course, required fall and spring semester of M1)	2
IBMS 652	M.D.-Ph.D. Science and Disease	1
IBMS 653	M.D.-Ph.D. Research Seminar (0.5 credit course, required fall and spring of M1, fall of M2, and during G phase except in semester of defense)	2
IBMS 697	M.D.-Ph.D. Directed Research (three credits taken each summer following M1 and M2; satisfies six credits of LFSC 697)	6
OVPR 601	Scientific Integrity	1
or OVPR 602	Responsible Scientific Conduct	
or OVPR 603	Responsible Conduct of Research	
Additional required concentration courses		
BIOC 530	Biochemistry, Cell and Molecular Biology Module 1: Protein Structure and Function (satisfied by M1/M2 study)	2
BIOC 531	Biochemistry, Cell and Molecular Biology Module 2: Basic Metabolism (satisfied by M1/M2 study)	1
BIOC 532	Biochemistry, Cell and Molecular Biology Module 3: Central Dogma of Molecular Biology (satisfied by M1/M2 study)	1
BNFO 601	Integrated Bioinformatics	4
Elective courses		
Select 12 credit hours from the following or other courses as recommended by the graduate advisory committee and approved by the graduate program director:		12
BIOC 504	Biochemistry, Cell and Molecular Biology (suggested elective; satisfied by M1/M2 study) [1]	
BIOC 533	Biochemistry, Cell and Molecular Biology Module 4: Lipids/Membranes and Bioenergetics	
BIOL 516	Population Genetics	
BIOL 550		
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 620	Bioinformatics Practicum	
BNFO 621	Business and Entrepreneurship Essentials for Life Scientists	
BNFO 637		
BNFO 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	Microbial Physiology and Genetics	
MICR 616	Mechanisms of Viral and Parasite Pathogenesis	
MICR 618	Molecular Mechanisms of Microbial Pathogenesis	
STAT 643	Applied Linear Regression	3
Directed research		
LFSC 697	Directed Research in Integrative Life Sciences (variable credit course; six credits satisfied by IBMS 697)	32
Total Hours		**64**

[1] BIOC 504 is an elective option; it must be chosen to realize the full nine credits of course work satisfied by the M1 and M2 years.

The minimum number of graduate credit hours required for this degree is 64.

Plan of study timeline

The dual-degree program blends medical and graduate training supplemented with M.D.-Ph.D.-specific course work and opportunities during the medical (M) and graduate (G) phases of the curriculum that culminates in the simultaneous awarding of the M.D. and Ph.D. degrees. The timeline of medical and graduate training is as follows:

Year 1 (M1): Mostly preclinical medical course work, some research

- Preclinical medical courses
- M.D.-Ph.D. Journal Club (two semesters)
- M.D.-Ph.D. Seminar (two semesters)
- Research rotations (and pre-matriculation research opportunity)

Year 2 (M2): Mostly preclinical medical course work, some research and clinical rotation

- Preclinical medical courses
- M.D.-Ph.D. Science and Disease (one semester)
- M.D.-Ph.D. Seminar (one semester)
- Research rotations
- Preparation for USMLE Step 1
- Required M3 clinical rotation(s) (one or two, lasting six to eight weeks total)

Year 3 (G1): Graduate course work and research, some clinical experiences

- Graduate program course work
- M.D.-Ph.D. Seminar (two semesters)
- Directed research (begin dissertation research)
- Opportunities for clinical experience

Years 4-5 (G2-G3) and additional year if needed: Primarily research, some clinical experiences

- Ph.D. Qualifying Examination, admission to candidacy
- Submit NIH F30 fellowship application
- Directed research (completion of dissertation research)
- Graduate program course work
- M.D.-Ph.D. Seminar
- Required M3 ambulatory care rotation
- Publication of peer-reviewed first-author paper
- Dissertation defense

Years 6-7: M3-M4: Completion of clinical training, clinical research experience

- Clinical rotations
- Clinical and non-clinical elective
- Preparation for USMLE Step 2
- M4 Clinical research capstone project

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