

MEDICINE, DOCTOR OF (M.D.)/PHARMACEUTICAL ENGINEERING, DOCTOR OF PHILOSOPHY (PH.D.) [DUAL DEGREE]

Students in the M.D.-Ph.D. program in pharmaceutical engineering will capitalize on their boots-on-the-ground clinical experience to inform their research into improvements in drug formulation and delivery. During graduate training they 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 pharmaceutical industry, research institutes and government agencies as clinicians, scientists, educators and administrators.

The students will engage in a rigorous and cross-disciplinary educational experience that includes foundational and research area specific coursework be empowered with the necessary tools to formulate and answer hypotheses-driven research questions in collaboration with mentors that have special expertise; engage in professional development opportunities to effectively promote and disseminate their work; and be immersed in a research and innovation environment of excellence.

Program goals

The objectives of this dual degree program are:

- Capitalize on clinical training, experience, perspective, and insights with advanced training in the design and manufacturing of novel pharmaceutical therapeutics.
- Provide students with an integrated training program in which clinical training and graduate training are engaged throughout the training period to cross-fertilize these disciplines.
- Train students in cross-disciplinary and interdisciplinary science to recognize the need for a team-based approach to solving challenges related to the design and manufacturing of pharmaceutical products.
- Graduates will gain the necessary skills and scientific foundation to work in a team-based environment, cross-disciplinary and interdisciplinary science who recognize the need for a team-based approach to solving challenges related to the design and manufacturing of pharmaceutical products.
- Prepare students who will simultaneously work in clinical and research environments to work and innovate in areas that create medicines to improve human health including the pharmaceutical industry, medical nonprofits, universities and regulatory authorities.

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

- Students holding these degrees will be prepared to capitalize on their clinical training and experience to translate observations from clinical practice to advance novel approaches to developing effective pharmaceutical entities.
- Students will have the foundation and training in pharmaceutical engineering 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 pharmaceutical engineering Ph.D. program page (<https://bulletin.vcu.edu/graduate/school-engineering/pharm-eng-phd/>) 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 taken 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 six to eight weeks in 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 course work, 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 and at national professional meetings.

The Ph.D. component of training in pharmaceutical engineering for M.D.-Ph.D. students normally takes a minimum of four years to complete. Courses taken during the M1 and M2 years of medical school satisfy a number of elective course requirements, and additional elective 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. 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 (<https://bulletin.vcu.edu/academic-regs/grad/graduation-info/>), students must complete a minimum of 83 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 and MEDI 250 during the M1 and M2 years, 18 credits of Ph.D. requirements are satisfied (six credits of PESC 697, three credits of PESC 690 and nine credits of graduate-level open electives). 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

Curriculum requirements for the Ph.D.

Based on the equivalent knowledge acquired by successfully completing MEDI 100, MEDI 150, MEDI 200 and MEDI 250 during the M1 and M2 years, nine credits of electives are satisfied. Students also take one credit of IBMS 651 and one credit of IBMS 652 during the M1 and M2 years. Additionally, IBMS 697 fulfills six credits of PESC 697; and IBMS 653 satisfies three credits of PESC 690. Students are required to take additional credits of M.D.-Ph.D.-specific courses listed below.

Course	Title	Hours
Required courses		
PESC 605	Advanced Topics in Pharmaceutical Engineering I	3
PESC 607	Advanced Topics in Pharmaceutical Engineering II	3
PESC 609	Pharmaceutical Engineering Laboratory I	1
PESC 690	Pharmaceutical Engineering Seminar (satisfied by IBMS 653)	3
PESC 709	Pharmaceutical Engineering Laboratory II	1
Additional required courses		
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; satisfies two credits of PESC 690)	2
IBMS 697	M.D.-Ph.D. Directed Research (three credits taken summers after M1 and M2; fulfills six credits of PESC 697)	6
OVPR 601	Scientific Integrity	1
or OVPR 602	Responsible Scientific Conduct	
or OVPR 603	Responsible Conduct of Research	
Research area elective courses		
Select nine credits in consultation with the adviser and approved by the program directors.		9
Electives		
Satisfied by M1/M2 study		9
Research		
PESC 697	Directed Research in Pharmaceutical Engineering (six credits satisfied by M1/M2 study)	53
Total Hours		83

For students entering with a B.S., the minimum number of graduate credit hours required for this degree is 83.

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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Program websites: [medschool.vcu.edu/education/graduate/dual-degree/
mdphd/](https://medschool.vcu.edu/education/graduate/dual-degree/mdphd/) ([https://medschool.vcu.edu/education/graduate/dual-degree/
mdphd/](https://medschool.vcu.edu/education/graduate/dual-degree/mdphd/))

and pharmegr.vcu.edu/phd/ (<https://pharmegr.vcu.edu/phd/>)