

# MOLECULAR, CELLULAR AND INTEGRATIVE BIOSCIENCES

<b>Graduate Program Head</b>	Melissa Rolls
<b>Program Code</b>	MCIBS
<b>Campus(es)</b>	University Park (Ph.D., M.S.)
<b>Degrees Conferred</b>	Doctor of Philosophy (Ph.D.) Master of Science (M.S.) Joint M.D./Ph.D. with the College of Medicine
<b>The Graduate Faculty</b>	View ( <a href="https://secure.gradsch.psu.edu/gpms/?searchType=fac&amp;prog=MCIBS">https://secure.gradsch.psu.edu/gpms/?searchType=fac&amp;prog=MCIBS</a> )

The Intercollege Graduate Degree Program (IGDP) in Molecular, Cellular, and Integrative Biosciences (MCIBS) is designed to prepare researchers across an array of specializations in the biological sciences that share an emphasis on trans-disciplinary training, an approach that considers the whole organism and spans the continuum of understanding from fundamental mechanisms of action at the molecular/cellular level of discovery, to the function of the organism in its environment, with applications that enhance health and well-being. To achieve this goal, the IGDP in MCIBS serves as an umbrella portal for the entry and subsequent training of the next generation of researchers for academic, industrial, non-profit foundation, government, and other research entities in the biomedical sciences. Researchers will be trained across a wide range of specializations in the biological sciences that share the goal to elucidate mechanisms of action at the molecular, cellular, and organismal level, including disease.

The program currently offers educational and research emphasis areas in Cell and Developmental Biology; Immunology and Infectious Disease; Molecular and Evolutionary Genetics; Molecular Medicine; and Molecular Toxicology and Neurobiology, but is structured to remain contemporary with evolving or emerging fields within the biological/health sciences. Incoming students enroll in core courses of instruction covering basic biochemistry and molecular biology of cellular processes; ethics; and current research topics related to the diverse pathological mechanisms that underlie disease etiologies in humans and animals. In addition, students take specialized courses associated with one of the above programmatic emphasis areas or the option, as well as elective courses that complement and support their research interests and foci.

Calling upon the expertise of an extensive list of life science research faculty members representing an array of different departments across multiple colleges, the IGDP in MCIBS offers a unique opportunity to learn about and work in multiple bioscience disciplines. The MCIBS graduate program is supported by modern telecommunications facilities and equipment, and students not only explore new conceptual connections at the frontiers of research, but also engage in active group learning experiences and explore a variety of potential career opportunities before graduation.

## Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>). Requirements listed here are in addition to

Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies/>).

Review of completed applications begins December 1 of each year. Applicants to the Ph.D. program are considered for admission; the program does not admit applicants for the terminal master's degree. GRE scores are not required for admission.

Required application materials include:

1. Completed official Penn State Graduate School application (<http://gradschool.psu.edu/prospective-students/how-to-apply/>).
2. Paid, nonrefundable application fee (see Requirements for Graduate Admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/new-applicants/requirements-for-graduate-admission/>) for current fee).
3. Official transcripts from all post-secondary institutions attended (<http://www.gradschool.psu.edu/prospective-students/how-to-apply/new-applicants/requirements-for-graduate-admission/>).
4. Application for a U.S. visa (international applicants only).
5. Names and contact information, including business email addresses, for three references.
6. Statement of goals that pertain to the life sciences including motivation for pursuing a research doctorate; research experience and interests; and professional goals. The statement should include biological problems that are of interest to the applicant and how the applicant's past experiences have prepared him or her to pursue this research.
7. Successful applicants generally will have completed coursework in biochemistry, molecular and/or cell biology, physics, chemistry (organic and inorganic), and calculus and have a minimum 3.5/4.0 Jr./Sr. undergraduate grade point average.

The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) may be required for international applicants. See GCAC-305 Admission Requirements for International Students (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-305-admission-requirements-international-students/>) for more information.

Applicants to the MCIBS graduate program must have a minimum TOEFL score of 575 for the paper-based test, or a total score of 90 with a 21 on the speaking section for the Internet-based test (iBT). Successful applicants generally have a minimum score of 100 (with a 23 on the speaking section) on the Internet-based test.

## Degree Requirements

### Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies/>)

Master's students must take a minimum of 30 credits, described below. At least 18 credits in 500- and 600-level courses combined must be included in the program. A minimum of 24 credits in course work (400, 500, and 800 series), as contrasted with research, must be completed in the major program.

Code	Title	Credits
<b>Required Courses</b>		
MCIBS 590	Colloquium	2

MCIBS 591	Ethics, Rigor, Reproducibility and Conduct of Research in the Life Sciences	1
BIOL 893	Experiential Teaching in Biology	2
MCIBS 596	Individual Studies (for Research Rotations)	1
MCIBS/BIOL/ BMMB/VBSC 503	Critical Elements of Genetics and Molecular and Cellular Biology	4
MCIBS 592	Current Research Seminar	2
<b>Emphasis Areas</b>		
MCIBS offers curricular/research specializations in the following Emphasis Areas: Cell and Developmental Biology; Immunology and Infectious Disease; Molecular and Evolutionary Genetics; Molecular Medicine; Molecular Toxicology; Neurobiology. To complete an emphasis in any of these areas, students take a minimum of 9 credits of specialized course work and conduct original research associated with the respective Emphasis Area. The list of specialized courses that will count towards each Emphasis Area is maintained by the program office.		9
<b>Additional Course Requirements</b>		
Quantitative Foundation Course: A minimum of 3 credits in 400- or 500-level courses in a quantitative area such as statistics, genetics, bioinformatics, etc. (e.g., STAT 501 Regression Methods; STAT 502 Analysis of Variance and Design of Experiments; STAT 503 Design of Experiments; Population Genetics; etc.). The list of courses that will count towards the Quantitative Foundation requirement is maintained by the program office.		3
<b>Culminating Experience</b>		
MCIBS 600	Thesis Research	6
<b>Total Credits</b>		<b>30</b>

In addition, all graduate students in MCIBS are required to have one semester of teaching experience by serving as a teaching assistant (TA) in an undergraduate course (400-level or lower) in a bioscience-related field. Teaching assistant opportunities are arranged in consultation with the adviser and program chair.

Master's students must complete at least 6 credits of MCIBS 600, and up to 6 of the MCIBS 600 credits may be assigned a quality grade (A-F). In consultation with the adviser, the student must select a thesis committee of at least three members (including the adviser), write a thesis, and defend the thesis. The thesis must be accepted by the advisers and/or committee members, the head of the graduate program, and the Graduate School, and the student must pass the thesis defense. If all course credits and requirements are met, a student does not have to be registered for classes while writing and/or defending the thesis. Students must present their thesis in accordance with Graduate Council and Graduate School guidelines as described in the Thesis and Dissertation Guide: Requirements and Guidelines for the Preparation of Master's Theses and Doctoral Dissertations (<http://www.gradsch.psu.edu/index.cfm/current-students/thesis-and-dissertation-information/thesisdissertationguidepdf/>).

### Additional Requirements

All MCIBS graduate students must maintain a cumulative grade-point average of > 3.0 to remain in good academic standing. One or more failing grades (F) or a cumulative grade-point average below 3.0 will be considered evidence of unsatisfactory scholarship and may be grounds for dismissal from the program.

## Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies/>)

Ph.D. students must take a minimum of 24 credits, as described below. At least 18 credits in 500- and 600-level courses combined must be included in the program. A minimum of 24 credits in course work (400, 500, and 800 series), as contrasted with MCIBS 600, must be completed in the major program. A student's dissertation committee can require additional course work depending on the student's background and research plans.

Code	Title	Credits
<b>Required Courses</b>		
MCIBS 590	Colloquium	2
MCIBS 591	Ethics, Rigor, Reproducibility and Conduct of Research in the Life Sciences	1
BIOL 893	Experiential Teaching in Biology	2
MCIBS 596	Individual Studies (for Research Rotations)	1
MCIBS/BIOL/ BMMB/VBSC 503	Critical Elements of Genetics and Molecular and Cellular Biology	4
MCIBS 592	Current Research Seminar	2
<b>Emphasis Areas</b>		
MCIBS offers curricular/research specializations in the following Emphasis Areas: Cell and Developmental Biology; Immunology and Infectious Disease; Molecular and Evolutionary Genetics; Molecular Medicine; Molecular Toxicology; Neurobiology. To complete an emphasis in any of these areas, students take a minimum of 9 credits of specialized course work and conduct original research associated with the respective Emphasis Area. The list of specialized courses that will count towards each Emphasis Area is maintained by the program office.		9
<b>Additional Course Requirements</b>		
Quantitative Foundation Course: A minimum of 3 credits in 400- or 500-level courses in a quantitative area such as statistics, genetics, bioinformatics, etc. (e.g., STAT 501 Regression Methods; STAT 502 Analysis of Variance and Design of Experiments; STAT 503 Design of Experiments; Population Genetics; etc.). The list of courses that will count towards the Quantitative Foundation requirement is maintained by the program office.		3
<b>Total Credits</b>		<b>24</b>

### Teaching Experience

In addition, all graduate students in MCIBS are required to have one semester of teaching experience by serving as a teaching assistant (TA) in an undergraduate course (400-level or lower) in a bioscience-related field. Teaching assistant opportunities are arranged in consultation with the adviser and program chair.

### English Competence

Doctoral degree students are required to demonstrate high-level competence in the use of the English language, including reading, writing, and speaking, as part of the language and communication requirements for the doctorate. This will be assessed for both domestic and international students as part of the qualifying exam, which includes a reading and original writing component. Should deficiencies be identified at the qualifying examination, students will be directed into appropriate remedial activities, including additional English and communication courses. Competence must be formally attested by the program before the doctoral student's comprehensive examination is

scheduled. (Note: Passage of the minimal TOEFL or IELTS requirement does not demonstrate the level of competence expected of a doctoral degree candidate and for conferral of a doctorate from Penn State.)

### Qualifying Exam

All Ph.D. students in the IGDP in MCIBS must take a qualifying exam no later than the fall semester of the second year. The purpose of the exam is to ensure that students have mastered the core concepts necessary to proceed further towards the Ph.D. The exam consists of both written and oral components, and is based primarily on the students' ability to critically read, understand, and communicate the key findings of a current research paper selected from the literature.

### Dissertation Committee

Upon successful completion of the qualifying examination, the student in consultation with his/her adviser will, as soon as possible, select a dissertation committee. The committee must meet Graduate Council guidelines for the composition of dissertation committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>). This committee is responsible for supervising the academic program and monitoring the progress of the student towards his/her degree. It is the charge of this committee to assure that the student carries out a substantial piece of independent research and presents it as a dissertation.

### Comprehensive Examination

The Comprehensive Examination is administered and evaluated by the entire dissertation committee when the student has completed substantially all required course work, and is intended to determine the feasibility of the student's proposed research and the preparedness of the student to embark on his/her dissertation research. Students must be registered for classes (typically MCIBS 600) the semester they take this exam. The examination will consist of a written research proposal using an NRSA or NSF format, based upon the student's proposed dissertation research, and an oral presentation of the proposed research. The proposal must include a timeline for the completion of the work that will be considered in the feasibility of the work.

### Dissertation

All Ph.D. candidates must conduct original research and prepare a dissertation that makes a significant contribution of new knowledge, is presented in a scholarly manner, and demonstrates an ability on the part of the candidate to do independent research of high quality. The contents and conclusions of the dissertation must be defended at the time of the final oral examination. The dissertation must be accepted by the dissertation committee, the head of the graduate program, and the Graduate School, and the student must pass a final oral examination (the dissertation defense).

Students must present their dissertation in accordance with Graduate Council and Graduate School guidelines as described in the Thesis and Dissertation Guide: Requirements and Guidelines for the Preparation of Master's Theses and Doctoral Dissertations (<http://www.gradsch.psu.edu/index.cfm/current-students/thesis-and-dissertation-information/thesisdissertationguidepdf/>).

### Final Oral Examination

The final examination of the doctoral candidate is an oral examination administered and evaluated by the entire dissertation committee. It consists of an oral presentation of the dissertation by the candidate and a period of questions and responses. These will relate in large part to the dissertation, but may cover the candidate's entire program of study, because a major purpose of the examination is also to assess the general

scholarly attainments of the candidate. The portion of the examination in which the dissertation is presented is open to the University community and the public; therefore, it is expected that the examination will take place at University Park or the Hershey campus.

### Additional Requirements

All MCIBS graduate students must maintain a cumulative grade-point average of > 3.0 to remain in good academic standing. Furthermore, a Ph.D. student must have a 3.0 GPA to take the doctoral qualifying, comprehensive, and final oral examinations. One or more failing grades (F) or a cumulative grade-point average below 3.0 will be considered evidence of unsatisfactory scholarship and may be grounds for dismissal from the program.

## Joint Degrees

### Joint M.D./Ph.D. with the College of Medicine

Requirements listed here are in addition to requirements listed in GCAC-211 Joint Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-211-joint-degree-programs/>).

### Admission Requirements

Students interested in simultaneously pursuing an M.D. and Ph.D. degree must apply to the College of Medicine M.D. program using the national American Medical College Application Service (AMCAS) application system and indicate their intent to pursue the joint degree program. Admissions requirements and applications for admission for Penn State College of Medicine are available in the M.D. Program (<http://med.psu.edu/md/>) section of the Penn State College of Medicine website. The College of Medicine M.D./Ph.D. Admissions Committee reviews applications and evaluates applicants for acceptance into both the M.D. and Ph.D. program. Students not accepted into the joint degree program can be referred to either the M.D. or Ph.D. program, depending on their qualifications and interests.

After the review committee has accepted an applicant to the joint degree program, s/he must apply and be admitted to the Graduate School (<http://www.gradschool.psu.edu/prospective-students/how-to-apply/>) for admission to the graduate program. The general admission requirements for the Ph.D. degree are listed on the Admission Requirements tab. Additional admission requirements for the joint degree are listed below:

- Academic Achievement - Applicants to our program generally have very strong grades and MCAT scores. In recent years, successful applicants have an average GPA of 3.75 and MCAT scores of 33-34. Applicants are not required to take the GREs.
- Research Experience - We are especially interested in students with a strong and sustained background in research. Students who have spent 1-2 years after graduation conducting research are strongly encouraged to apply. Alternatively, in-depth research experience as an undergraduate can suffice.
- Recommendations - We are especially interested in receiving letters of recommendation from faculty with whom you conducted research and who can comment on your passion and potential for research.
- Goals - Applicants must be able to clearly articulate the reasons for pursuing the joint degree.
- International Students - All qualified students are eligible to apply regardless of citizenship.

### Degree Requirements

Students must fulfill all requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined

below. Degree requirements for the M.D. program are listed on the M.D. Program (<http://med.psu.edu/md/>) section of the Penn State College of Medicine website. Degree requirements for the Ph.D. degree are listed on the Degree Requirements tab.

During the first two years of medical school, the student conducts at least three research rotations. After successful completion of the first two years of medical school the candidate joins their dissertation lab in the MCIBS Graduate Program.

During the summer after the second year of medical school M.D./Ph.D. students take Step 1 of the United States Medical Licensing Examination (USMLE), which serves in lieu of the knowledge-based part of the qualifying examination for the MCIBS program. Successful completion of BMS 506A and BMS 506B, which is taken in the second year of medical school, with a grade of B or higher, meets the critical thinking and paper analysis requirement of the qualifying exam.

The Ph.D. committee of an M.D./Ph.D. student in the MCIBS program is formed upon entry into the dissertation laboratory. In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the committee must include at least two members of the MCIBS program Graduate Faculty and one M.D./Ph.D. steering committee member.

The MCIBS program will accept passing grades in the medical school courses SPM 711 (15 cr.) in lieu of 11 required credits for the MCIBS Core Required and Elective courses. The 11 required credits include:

Code	Title	Credits
<b>Required Courses</b>		
MCIBS 503	Critical Elements of Genetics and Molecular and Cellular Biology	4
MCIBS 596	Individual Studies	1
<b>Electives</b>		
BMMB 541	Molecular Biology of Animal Development	3
BMMB 542	Eukaryotic Cell Biology	3
<b>Total Credits</b>		<b>11</b>

Because students in the M.D./Ph.D. program are being trained to combine research and medicine, most likely in medical schools, the MCIBS requirement for exposure to undergraduate teaching is waived. M.D./Ph.D. candidates are not required to take BIOL 593 (2 credits) or to be teaching assistants. The Emphasis Area requirement and the Quantitative Foundation Course requirement are also waived.

In addition to taking the required courses MCIBS 590 (2 cr.), MCIBS 591 (1 cr.), and MCIBS 592 (2 cr.), elective courses are selected in consultation with the student's dissertation adviser and Ph.D. committee, with guidance from the MCIBS emphasis area course lists and program chair. 6 credits of elective courses will be selected.

The M.D./Ph.D. candidate prepares a written comprehensive examination in the format of a grant application and gives an oral presentation of this proposal to their Ph.D. committee.

A dissertation must be prepared and defended by each M.D./Ph.D. candidate, as described on the Degree Requirements tab. In addition, M.D./Ph.D. students must have *submitted* a first-author manuscript before defending their dissertation. Before returning to medical school, the doctoral dissertation must be accepted by the Graduate School.

The M.D./Ph.D. program requires that students have one first author peer-reviewed paper published based on their research accepted prior to completing medical school, and preferably accepted for publication prior to returning to the third year of medical school. At the discretion of the College of Medicine Vice Dean for Research and Graduate Studies, in consultation with the MCIBS Program Chair, the requirement for a first author publication prior to completing medical school may be waived. Examples of conditions that might warrant exemptions include:

- prolonged illness,
- mentor's relocation,
- mentor's reluctance to submit the student's work for publication,
- the student's project is published by another research group, or
- delays or challenges in the publication review process beyond the control of the student or dissertation adviser.

If a student decides not to return to medical school, or for some other reason is not able to complete the last two years of medical school, but they have successfully completed their Ph.D. dissertation and final oral examination and met all other degree requirements for the Ph.D. in MCIBS, they will be eligible to receive the Ph.D. The latter will be conferred after the student notifies the program that she/he wishes to withdraw from the M.D. program and completes all requirements for conferral of the Ph.D. degree.

## Minor

A graduate minor is available in any approved graduate major or dual-title program. The default requirements for a graduate minor are stated in Graduate Council policies listed under GCAC-600 Research Degree Policies (<http://gradschool.psu.edu/graduate-education-policies/>) and GCAC-700 Professional Degree Policies (<http://gradschool.psu.edu/graduate-education-policies/>), depending on the type of degree the student is pursuing:

- GCAC-611 Minor - Research Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-611-minor-research-doctorate/>)
- GCAC-641 Minor - Research Master's (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-641-minor-research-masters/>)
- GCAC-709 Minor - Professional Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-709-professional-doctoral-minor/>)
- GCAC-741 Minor - Professional Master's (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-741-masters-minor-professional/>)

## Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<http://gradschool.psu.edu/graduate-funding/>) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<http://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/>) set by The Graduate School.

## Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate

student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Molecular, Cellular, and Integrative Biosciences (MCIBS) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/mcibs/>)

## Learning Outcomes

1. **Know:** demonstrate knowledge of core principles and primary literature in their specialty area including comprehension of methods, results, and data analysis in the specialty area.
2. **Apply/Create:** demonstrate ability to design and carry out a major research project in the field, including synthesis of previous work in the field, and assembling new findings into a written work that advances understanding in the field.
3. **Think:** demonstrate ability to critically analyze work by others in their specialty area.
4. **Communicate:** demonstrate ability to convey scientific ideas and results in clear, concise and original writing as well as in formal oral presentations.
5. **Professional Practice:** demonstrate comprehension of and commitment to ethical standards in the discipline. Demonstrate the ability to teach key concepts.
6. **Teach:** demonstrate the ability to teach key concepts of the discipline to students.

## Contact

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<b>Program Website</b>	View ( <a href="https://www.huck.psu.edu/graduate-programs/molecular-cellular-and-integrative-biosciences/">https://www.huck.psu.edu/graduate-programs/molecular-cellular-and-integrative-biosciences/</a> )