Biomedical Science, PhD

The Biomedical Science Program optimizes students' mobility and their ability to explore several graduate programs during their first academic year before affiliating with a specific biomedical science subprogram—cancer biology, cell and developmental biology, experimental pathology (direct admit only), free radical and radiation biology, molecular medicine, molecular physiology and biophysics, or pharmacology.

Students thrive in a collaborative environment in which they explore subprograms by performing three research rotations in the laboratories of any of the biomedical science faculty, regardless of their departmental or program affiliation. Biomedical science students are advised regarding course selections, research rotations, and registration by a designated faculty academic advisor. Students can tailor their choice of electives based on their interests.

Following completion of the first year, it is expected that students will be able to select a research laboratory and subprogram affiliation. The specific subprogram students choose for thesis training determines their curriculum for subsequent years.

Core Curriculum

First Year, Fall

Course #	Title	Hours
One of these:		
BIOS:4120	Introduction to Biostatistics	3
PCOL:5204	Basic Biostatistics and Experimental Design	1
All of these:		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
Elective course(s)		

First Year, Spring

Course #	Title	Hours
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
PHAR:6504	Mastering Reproducible Science	1
Elective course(s)		

Admission

Applicants must have a baccalaureate degree from a regionally accredited U.S. college or university, or an equivalent degree from another country as determined by the Office of Admissions. They also must have an undergraduate grade-point average of at least 3.00. Applicants must meet the admission requirements of the Graduate College.

Appropriate preparation includes a one year, college-level course in biology, chemistry (inorganic and organic), and mathematics through calculus.

Learning Outcomes

Core Learning Outcomes

Students will:

- demonstrate expertise in foundational aspects of molecular and cellular biology, particularly in a human biomedical context;
- develop hypotheses and experimental methods that can be used to explore questions in molecular biology;
- apply knowledge of biomedical science to human disease through translational research paradigms;
- describe fundamental techniques, statistical methods, and core principles of rigor and reproducibility in biomedical science;
- describe the range of career pathways in the sciences for the biomedical PhD;
- develop proficiency in reading and interpreting scientific literature; and
- develop skills in written and oral communication of scientific work.

Cancer Biology

Students will:

- master foundational knowledge in cancer biology and demonstrate an in-depth knowledge in their area of emphasis;
- understand and apply the scientific method, design experiments and conduct research utilizing team-based collaboration, knowledge of current literature, and current laboratory methods;
- gain an appreciation of clinical management and therapeutic approaches to treat cancer;
- develop advanced skills in scientific writing and oral presentations in order to effectively communicate research progress and goals;
- exhibit and foster the highest ethical standards in the areas of education, publication, and scientific inquiry; and
- publish at least one first author paper and write a grant application.

Cell and Developmental Biology

Students will:

- master foundational knowledge in cellular and developmental biology;
- engage in designing and executing experiments to test scientific hypotheses;
- critically evaluate scientific findings;
- communicate scientific findings effectively to diverse audiences;
- exhibit and foster ethics in the areas of education, publication, and scientific inquiry; and
- become an effective teacher of the biological sciences.

Experimental Pathology

Students will:

- demonstrate subject matter expertise in basic cell and molecular biology, biostatistics/bioinformatics, and pathobiology/mechanisms of human disease;
- understand and apply scientific method allowing for the appropriate development and testing of hypotheses, problem solving, and utilization of current literature and contemporary laboratory approaches;
- understand and apply the need to conduct research using a team-based approach, including ongoing input from the thesis mentor/committee as well as peers within the laboratory and graduate program environment;
- understand and apply the key principles of carrying out research and interpreting results using the highest ethical standards; and
- acquire the ability to effectively communicate research goals, approaches and results using both written and oral means.

Free Radical and Radiation Biology

Students will:

- demonstrate comprehensive knowledge of foundational principals in free radical and radiation biology, a clear understanding of all free radical and radiation biology course material, and a thorough knowledge of the literature in their area of major emphasis;
- demonstrate a functional comprehension of scientific research, such as use of relevant literature, the formulation of a hypothesis, hypothesis testing, data interpretation, and the lucid presentation of the research in both written and oral form;
- acquire and develop classroom and laboratory teaching skills;
- acquire advanced scientific writing and communication skills competing at the national level for visibility in scholarly activities and funding opportunities;
- produce research results worthy of publication in high impact peer-reviewed journals relevant to the field of study; and
- participate in career development and networking activities at the local, regional, and national levels.

Molecular Medicine

Students will gain knowledge in:

- tracks for specialized coursework—demonstrate broad-base understanding of one of three tracks selected by students in their second year of studies (metabolic disorders, cardiovascular biology, or molecular and cellular medicine);
- oral and written presentation of scientific data—demonstrate proficiency in scientific writing as evidenced by external fellowship application requirement; organize, defend, and communicate ideas effectively in scientific oral presentations and settings; opportunities to present posters, full-length seminar presentations, short-form data blitzes, lay audience elevator pitches; comprehensive exam; on-topic or off-topic NRSA-style research proposal that is orally defended to a comprehensive exam committee comprised of subject-matter experts; scientific editing and research communication core; and service promoted to students to get one-on-one instruction in scientific editing, focused especially on grant writing;
- experimental design—instruction on experiment design provided by their mentor, experiences in the critical thinking course, and in the basic biostatistics and experimental design course;
- proficiency in research—three laboratory rotations before affiliating to lab, conduct research in a responsible and ethical manner, carry out an in-depth research project, and contribute intellectually and technically to all parts of its development, execution, and analysis; and
- professional skills development—journal clubs, course in critical thinking, and career development series.

Molecular Physiology and Biophysics

Students will:

- demonstrate a basic knowledge of physiology and biophysics that will serve as the foundation for the student's academic, scholarly, and research endeavors;
- exhibit the necessary practical, methodological, and technical expertise to perform original experimental work in an area of physiological research;
- gain professional skills required for successful academic or research-based careers, including skills in publishing, grant writing, presentation, and teaching; and
- acquire knowledge and respect for principles of biomedical research ethics.

Pharmacology

Students will:

- identify important research problems through development of subject matter expertise related to pharmacology, and critical evaluation of the current state of knowledge in that area of expertise;
- formulate valid and testable hypothesis and/or research questions, and then plan feasible experiments to address them;
- conduct, analyze, and interpret independent original research that contributes new knowledge to the field of pharmacology;
- effectively communicate research results to a range of audiences in both written and oral formats; and
- conduct all aspects of research and communication of results with the highest ethical standards.

Cancer Biology

The Doctor of Philosophy in biomedical science with a cancer biology subprogram requires a minimum of 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average of at least 3.00 to earn the degree.

Students enter the molecular medicine subprogram through the Biomedical Science Program. The Biomedical Science Program is designed to provide students maximum flexibility during the first year of graduate studies to take a course of study compatible with several programs while completing research rotations. At the end of the first year, students choose a subprogram affiliation. The cancer biology subprogram provides training in many areas of research—cell biology, genetics, immunology, and cell metabolism, among others—that are necessary to understand the complexities of cancer etiology and treatment.

The subprogram does not offer a master's degree. Cancer biology is affiliated with the Holden Comprehensive Cancer Center, which was founded in 1980 and has been designed

as a National Cancer Institute NCI-Designated Cancer Center since 2000.

The curriculum is a sequence of required and elective courses that provides students with advanced knowledge in current concepts related to molecular, cellular, and genetic processes that contribute to the development and treatment of cancer. It also provides specialized training in experimental methodology used to study cancer in a laboratory setting. Cancer biology prepares students for a variety of career paths in academic, clinical, and industry environments that deal with the study and/or treatment of cancer.

Students gain clinical exposure by shadowing oncologists. They are expected to have a solid background in chemistry, mathematics, and the biological sciences. They should have completed undergraduate coursework in introductory biology and chemistry, biochemistry, genetics, organic chemistry, physical chemistry, and calculus; and previous coursework in cancer biology is desirable. Deficiencies in a particular area, as determined by the Graduate Studies Committee, can be remedied by completion of appropriate courses.

Selection of a PhD mentor (thesis advisor) is normally finalized near the end of the spring semester of a student's first year of study. The deadline for selection is determined by the Biomedical Science Program.

Students are required to complete the core courses listed below prior to their comprehensive examination. Students who wish to take the comprehensive examination should first make arrangements in consultation with their mentor, the program director, and the Student Advisory Committee. The exam is typically completed during the second summer of study.

The PhD in biomedical science with a cancer biology subprogram requires the following coursework.

Core Cancer Biology Curriculum

Course #	Title	Hours
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	arr.
CBIO:7000	Clinical Connections	1
CBIO:7500	Crafting a Scientific Proposal	1
FRRB:7001/ PATH:7001	Molecular and Cellular Biology of Cancer	3
Elective		

Typical Curriculum

First Year, Fall

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	6
PCOL:5204	Basic Biostatistics and Experimental Design	1
Elective		3

First Year, Spring

Course #	Title	Hours
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	6
FRRB:7001/ PATH:7001	Molecular and Cellular Biology of Cancer	3
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
PHAR:6504	Mastering Reproducible Science	1

Second Year, Fall

Course #	Title	Hours
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	6
CBIO:7000	Clinical Connections	1
CBIO:7500	Crafting a Scientific Proposal	1
Elective		3

Second Year, Spring

Course #	Title	Hours
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	6
Elective		1

Additional Requirements

Laboratory Rotations

In order to gain more widespread experience in cancer biology research and to aid in selecting a laboratory home and thesis project, students perform three laboratory rotations prior to selection of a thesis advisor. Laboratory rotations are normally carried out in research laboratories of the cancer biology faculty. A rotation can be completed with a faculty member outside the cancer biology program with permission of the program director.

Three rotations, 12 weeks in length, begin in the fall semester of the first year. The goal of the rotations is to gain a comprehensive view of the mentor's research program, to gain exposure to experimental methods used in the mentor's lab, and to learn about the mentoring styles of faculty members.

Teaching

The cancer biology program does not require teaching. Students with an interest in teaching experience are encouraged to discuss their career plans with their mentor and/or the program director.

Publication Requirements

Students are required to have a minimum of one first-author publication in a peer-reviewed journal prior to graduation. The article must be formally accepted and be in-press status or published prior to graduation. A co-first-authored, peer-reviewed publication will count toward this requirement.

Comprehensive Examination

Students are eligible to take the comprehensive examination when they are in good academic standing as defined by the Graduate College—the student has completed all program core courses with a grade of at least B or have a non-letter grade of pass.

Written Examination

The comprehensive exam is on-topic, meaning the subject should be a student's current research being conducted in the mentor's lab. Students normally take the comprehensive exam during the second spring or summer of their enrollment in the program. They submit a written exam, if that is acceptable to the comprehensive examination committee, and then prepare for an oral examination.

Oral Examination

The purpose of the oral examination is to determine whether the student's written submission adequately represents the student's knowledge. A student may be queried on issues beyond the scope of the written proposal to allow the committee to determine the student's general depth of knowledge.

Final Examination

The thesis committee is selected by each student after the successful completion of the comprehensive examination. Students are eligible for their oral thesis defense after completing 72 s.h. of coursework, publication of at least one primary author manuscript or be in-press status, and with consent of the thesis committee. The procedures are the same as for the comprehensive examination.

Combined Programs

PhD/MD

Students may work toward the Doctor of Medicine degree and a PhD in biomedical science (cancer biology subprogram) in a combined degree program offered by the Graduate College and the Carver College of Medicine. Applicants must be admitted to both programs before they may be admitted to the combined degree program. See the Medical Scientist Training Program (Carver College of Medicine) in the catalog.

Cell and Developmental Biology

The Doctor of Philosophy in biomedical science with a cell and developmental biology subprogram requires 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average of at least 3.00 to earn the degree. They gain admission to graduate training laboratories in the Department of Anatomy and Cell Biology, Interdisciplinary Graduate Programs, or through direct admission into a specific laboratory.

The PhD in biomedical science with a cell and developmental biology subprogram requires the following coursework.

Core Cell and Developmental Biology Curriculum

Course #	Title	Hours
All of these:		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
ACB:6220/ MMED:6220/ MPB:6220	Mechanisms of Cellular Organization	3
ACB:6237	Critical Thinking in Biochemistry and Molecular Biology	1
ACB:6238	Critical Thinking in Genetics	1
ACB:6239	Critical Thinking in Cell Biology	1
ACB:6248	Critical Thinking in Development	1
ACB:6249	Critical Thinking in Cellular Physiology	1
ACB:6250	Critical Thinking in Scientific Writing and Presentations	1
PCOL:5204	Basic Biostatistics and Experimental Design	1

Typical Curriculum

First Year, Fall

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
PCOL:5204	Basic Biostatistics and Experimental Design	1
Elective course(s)		

First Year, Spring

Course #	Title	Hours
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
MMED:6260	Methods for Molecular and Translational Medicine	1

PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
Elective course(s)		

Second Year, Fall

Course #	Title	Hours
All of these:		
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
ACB:5206	Graduate Research in Cell and Developmental Biology	arr.
ACB:5224	Graduate Seminar in Cell and Developmental Biology	0-1
ACB:6220/ MMED:6220/ MPB:6220	Mechanisms of Cellular Organization	3
ACB:6237	Critical Thinking in Biochemistry and Molecular Biology	1
ACB:6239	Critical Thinking in Cell Biology	1
ACB:6248	Critical Thinking in Development	1
Elective (optional)		

Second Year, Spring

Course #	Title	Hours
All of these:		
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
ACB:5206	Graduate Research in Cell and Developmental Biology	arr.
ACB:5224	Graduate Seminar in Cell and Developmental Biology	0-1
ACB:6238	Critical Thinking in Genetics	1
ACB:6249	Critical Thinking in Cellular Physiology	1
ACB:6250	Critical Thinking in Scientific Writing and Presentations	1
Elective (optional)		

Electives

Elective course offerings change each year and are determined shortly before the semester begins. Examples of elective courses offered in the past five years that would be acceptable for students in the cell and developmental biology subprogram follow.

Course #	Title	Hours
BIOL:4333	Genes and Development	3
GENE:6150	Genetic Analysis of Biological Systems	3
MMED:6226/ ACB:6226/ MPB:6226	Cell Cycle Control	1
MMED:6227/ ACB:6227/ MPB:6227	Cell Fate Decisions	1
PCOL:6225	Growth Factor Receptor Signaling	1

Additional Requirements

Laboratory Rotations

The faculty advisor, along with the biomedical sciences program director, assists students in the process of selecting their initial laboratory rotation during the first year. The first of three 10-week rotations begins the first week of the fall semester. Students may choose any biomedical science program faculty member laboratory for the remaining two laboratory rotations, depending upon availability of positions and mutual interest of students and host faculty. Students have the option of joining the cell and developmental biology subprogram after their three rotations.

Teaching

Students are required to complete a teaching requirement (3 s.h.). They may teach in a combination of 1 or 2 s.h. courses, or one 3 s.h. course. Teaching requirements must be met prior to the final thesis defense and graduation. Most students meet the requirement in the third year after completion of the comprehensive exam. A student must earn a satisfactory report from the course director in order to receive credit for the teaching requirement.

Publication Requirements

It is expected that a student will have contributed as an author to at least one research publication. The publication must demonstrate primary authorship and be at the accepted phase of the publication process. The number of publications and their quality, content, and impact is established by the thesis committee.

Seminar Presentations

Students present their thesis research annually in the cell and developmental biology seminar series in a 30–minute presentation. Evaluation critique by faculty and students is provided.

Comprehensive Examination

The comprehensive examination must be taken before the fall semester of a student's third year.

Written Examination

A written proposal follows the form of a standard National Institutes of Health (NIH) R01 research grant and covers the area of the research proposed for the student's anticipated thesis dissertation. One aim area should be completely of the student's own design, with no input from the thesis advisor.

Oral Examination

The oral examination of the student's research proposal lasts approximately two to three hours. The exam begins with a brief student presentation on the proposed research project. Questions during the examination may come from the proposal, the thesis research, or other general areas of cell and developmental biology.

Thesis Defense

The five-member thesis committee serves as an advisory body for the preparation of the thesis. The candidate and the committee should meet yearly; however, the candidate, the thesis advisor, or the committee can request a meeting at any time. In the subultimate committee meeting, committee

members review the material that is expected to be incorporated into the thesis. The final draft of the thesis is due to the committee two weeks before the final examination. The final examination takes the form of a seminar presented to the program, with questions, comments, and discussion following. After the seminar, the candidate meets with the committee for the final thesis defense.

Combined Programs

PhD/MD

Students may work toward the Doctor of Medicine degree and a PhD in biomedical science (cell and developmental biology subprogram) in a combined degree program offered by the Graduate College and the Carver College of Medicine. Applicants must be admitted to both programs before they may be admitted to the combined degree program. See the Medical Scientist Training Program (Carver College of Medicine) in the catalog.

Experimental Pathology

The Doctor of Philosophy in biomedical science with an experimental pathology subprogram requires a minimum of 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average of at least 3.00 to earn the degree. The subprogram provides students with advanced knowledge of disease pathogenesis at the genetic, molecular, cellular, and systems levels. It also teaches cutting edge research skills enabling graduates to investigate the basis of disease and lay the foundation for novel and improved therapies.

The curriculum is a sequence of required and elective courses with the goal of providing students a foundation in current cellular and molecular biology, in-depth knowledge of disease pathogenesis, and specialty content in the area of their thesis work.

The experimental pathology subprogram only accepts direct admits at this time. All admitted students will have already identified a faculty mentor and laboratory upon entering the subprogram. Accordingly, students in experimental pathology do not perform rotations, but begin developing a thesis project with their mentor at the onset of their PhD training. Consistent with the direct admission policy, Medical Science Training Program (MSTP or MD/PhD) students may join the experimental pathology PhD subprogram. Admission also is considered for off-cycle or spring semester.

The PhD in biomedical science with an experimental pathology subprogram requires the following coursework.

Core Experimental Pathology Curriculum

Course #	Title	Hours
All of these:		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
BIOS:4120	Introduction to Biostatistics	3
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
PATH:6220	Seminar in Pathology	1
PATH:7211	Research in Pathology	arr.
PCOL:5204	Basic Biostatistics and Experimental Design	1

Typical Curriculum

First Year, Fall

Course #	Title	Hours
All of these:		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
PATH:7211	Research in Pathology	arr.
PCOL:5204	Basic Biostatistics and Experimental Design	1

First Year, Spring

Course #	Title	Hours
All of these:		
BIOS:4120	Introduction to Biostatistics	3
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
PATH:6220	Seminar in Pathology	1
PATH:7211	Research in Pathology	arr.

Second Year, Fall

Course #	Title	Hours
All of these:		
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
PATH:7211	Research in Pathology	arr.
Elective		3

Second Year, Spring

Course #	Title	Hours
All of these:		
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
PATH:6220	Seminar in Pathology	1
PATH:7211	Research in Pathology	arr.
Elective		3

Electives

The following are possible elective choices. Electives are determined by the area of thesis research.

Course #	Title	Hours
FRRB:7001/ PATH:7001	Molecular and Cellular Biology of Cancer	3
GENE:6150	Genetic Analysis of Biological Systems	3
GENE:7191	Human Molecular Genetics	3
IMMU:6201/ MICR:6201	Graduate Immunology	3
MICR:6247/ IMMU:6247	Graduate Immunology and Human Disease	4
MICR:6267	Graduate Viruses and Human Disease	4
MMED:6220/ ACB:6220/ MPB:6220	Mechanisms of Cellular Organization	3
MMED:6227/ ACB:6227/ MPB:6227	Cell Fate Decisions	1
MMED:8115	Molecular Physiology	4
NSCI:5653/ BIOL:5653/ PSY:5203	Fundamental Neurobiology I	3
NSCI:7235/ NEUR:7235	Neurobiology of Disease	3
PCOL:6225	Growth Factor Receptor Signaling	1

Additional Requirements

Laboratory Rotations

Rotations are not required as students entering the experimental pathology subprogram are directly admitted.

Teaching

The experimental pathology subprogram does not have a teaching requirement. However, there are opportunities to teach if students desire this experience.

Publication Requirements

Students must have one first-author, peer-reviewed paper published or in press, as well as a co-authored, peer-reviewed paper or review article published or in press prior to being allowed to schedule their dissertation defense.

Comprehensive Examination

The comprehensive examination is generally taken in the spring semester of the second year of study. Students with advanced standing (medical scientist training program students or those with an MS) may choose to take the examination in the fall semester of their second year.

The comprehensive examination is off-topic. The focus of the proposal is in the field of a student's research. To determine the topic, each of the five comprehensive exam committee members choose a recent high-profile paper in the area of the student's research interests, but not directly related to the dissertation project. After examining the papers, the student chooses one and makes it the subject of the comprehensive exam.

The student then prepares and submits a two-page, single-spaced abstract to the committee. The abstract should include the background/rationale, the significance of the question being asked, and an outline of the specific aims. Upon approval of the abstract, the student is given permission to prepare a full proposal based on the NIH R21 format. Specifically, the proposal should be seven single-spaced pages and must include significance, innovation, rationale, and experimental approach. The proposal is then defended orally in front of the entire committee.

Final Examination

The dissertation committee consists of the mentor and four additional faculty. Students are required to select and meet with their committee by the end of the first fall semester of their second year, and at least yearly thereafter.

Upon meeting all requirements, students may then defend their dissertation/final exam. Two weeks prior to the defense, students must provide the entire committee with a completed draft of their dissertation. On the day of the defense, students present a public seminar of their dissertation work. This is then followed by defense of the dissertation before the entire dissertation committee. A final version of the dissertation is prepared based on suggested edits provided by the committee. After final approval by the research advisor and committee, the dissertation is submitted to the Graduate College.

For more information, see the Experimental Pathology PhD Graduate Program on the Department of Pathology website.

Free Radical and Radiation Biology

The Doctor of Philosophy in biomedical science with a free radical and radiation biology subprogram is interdisciplinary and requires 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average of at least 3.00 to earn the degree. The possibility exists for a major emphasis in radiation biology or redox biology with a focus on cancer or degenerative diseases associated with aging. Although students with diverse academic backgrounds may enter the program, each student should have a science background which includes at least two years of chemistry, including organic chemistry; one year of physics; two years of biology; and mathematics, including at least one semester of calculus.

The PhD in biomedical science with a free radical and radiation biology subprogram requires the following coursework.

Typical Curriculum

First Year, Fall

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
FRRB:5000	Radiation Biology	4
PCOL:5204	Basic Biostatistics and Experimental Design	1

First Year, Spring

Course #	Title	Hours
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
FRRB:7000	Redox Biology and Medicine	4
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
PHAR:6504	Mastering Reproducible Science	1

Second Year, Fall

Course #	Title	Hours
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
FRRB:5000	Radiation Biology	4
FRRB:6000	Seminar: Free Radical and Radiation Biology	1
FRRB:6004	Research: Free Radical and Radiation Biology	arr.
FRRB:6006	Topics in Free Radical Biology and Medicine	1
FRRB:6008	Topics in Radiation and Cancer Biology	1
Electives (as appropriate)		

Second Year, Spring

Course #	Title	Hours
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
FRRB:6000	Seminar: Free Radical and Radiation Biology	1
FRRB:7000	Redox Biology and Medicine	4
FRRB:6006	Topics in Free Radical Biology and Medicine	1
FRRB:6008	Topics in Radiation and Cancer Biology	1
FRRB:6004	Research: Free Radical and Radiation Biology	arr.
MMED:6226/ ACB:6226/ MPB:6226	Cell Cycle Control	1
Electives (as appropriate)		

Elective Courses

Elective courses can be tailored to the student's area of interest.

Course #	Title	Hours
BMB:3140	Experimental Biochemistry (spring)	2
BMB:7251	Introduction to Protein Structures (fall)	1
BMB:7252	Enzymes, Carbohydrates, Nucleic Acids, Lipids, and Membranes (fall)	1
BMB:7253	Introduction to Metabolism (fall)	1
BMB:7254	Metabolism I (spring)	1
BMB:7255	Metabolism II (spring)	1
BMB:7256	Molecular Biology (spring)	1
ACB:5218/ BIOL:5218/ MICR:5218	Microscopy for Biomedical Research (spring)	arr.
BIOL:3713	Molecular Genetics (fall)	4
FRRB:7001/ PATH:7001	Molecular and Cellular Biology of Cancer (spring)	3
MMED:6220/ ACB:6220/ MPB:6220	Mechanisms of Cellular Organization (fall)	3
MMED:6227/ ACB:6227/ MPB:6227	Cell Fate Decisions (spring)	1
MICR:2157	General Microbiology (fall and spring)	3
MICR:3147	Immunology and Human Disease (fall)	3
MICR:6201/ IMMU:6201	Graduate Immunology (spring)	3
OEH:6710	Human Toxicology and Risk Assessment (spring)	3
PATH:8133	Introduction to Human Pathology for Graduate Students (fall)	3-4
PCOL:6225	Growth Factor Receptor Signaling	1
PSQF:6217/ GRAD:6217	Seminar in College Teaching (fall and spring)	1-3

Additional Requirements

Laboratory Rotations

Graduate students rotate through at least three different free radical and radiation biology laboratories during their first academic year with primary and secondary faculty.

Seminar and Journal Clubs

Students must enroll in one seminar for credit once a year for three years as well as a thesis defense seminar. Students should not register for the seminar during their first academic year.

Students enrolled for research credit are required to submit a research report to their advisor on the last day of class each semester. The report is evaluated and graded by the advisor. The report, written in a form that is appropriate for a peer-reviewed publication, should define the goals, aims, and objectives for the specific semester, and describe the progress made by the student toward completion of the research objectives.

Topics in Free Radical Biology and Medicine (FRRB:6006) and Topics in Radiation and Cancer Biology (FRRB:6008) must be taken at least two times.

Publication Requirements

Students must submit at least one first-author manuscript prior to the thesis defense. All PhD students are expected to have co-author publications prior to graduation and these publications should include first authorship.

Grant Writing Opportunities

National Institutes of Health (NIH) research grant proposals (i.e., F30, F31) and/or equivalent grant submissions are encouraged based on a student's work. The free radical and radiation biology program will provide resources and critiques of the application prior to submission. Students should review the instructions provided in the NIH publication, PHS-398, available from the National Institutes of Health website.

Comprehensive Examination

Students who have successfully completed four semesters since enrollment must take their comprehensive exam no later than February of their third year in the program. Students need to maintain full-time status (minimum of 9 s.h. per semester) prior to their comprehensive examination. The comprehensive examination includes both a written and an oral presentation on the topic of the student’s dissertation research. The written proposal needs to be organized following the National Institutes of Health guidelines for an R01 application. Students are encouraged to consult with their mentors and members of their PhD advisory/examination committee as they develop their research hypothesis and specific aims; this should be limited to one page. Once the hypothesis and aims page has been approved by the committee, the mentor and committee members will not have any input into the development and writing of the rest of the proposal. If appropriate, students are allowed a second attempt at the comprehensive examination. A second attempt needs to be completed no later than August of the same year as the first attempt of the comprehensive examination.

The written proposal is typically 14 pages, which includes an abstract (half-page summary, as a separate page); the hypothesis and aims (one page), body of proposal (12 pages), and references not included in the page count. A title page (not included in the page count) with only administrative information, such as the title of proposal, name of the student, date of examination, and other such information is encouraged. The proposal should be prepared as single-spaced text, in 11–point Arial font.

Final Examination

The final examination is a defense of the thesis and explanation of the scientific principles involved, given in a public seminar and closed door oral exam, with committee members. The student's research must be summarized in the format required by the Graduate College.

Combined Programs

PhD/MD

Students may work toward the Doctor of Medicine degree and a PhD in biomedical science (free radical and radiation biology subprogram) in a combined degree program offered by the Graduate College and the Carver College of Medicine. Applicants must be admitted to both programs before they may be admitted to the combined degree program. See the Medical Scientist Training Program (Carver College of Medicine) in the catalog.

Molecular Medicine

The Doctor of Philosophy in biomedical science with a molecular medicine subprogram provides interdisciplinary training in the concepts and methodologies fundamental to the investigation of biological processes and molecular mechanisms that relate to human disease. The PhD requires a minimum of 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average of at least 3.00 to earn the degree.

Students enter the molecular medicine subprogram through the Biomedical Science Program. The Biomedical Science Program is designed to provide students maximum flexibility during the first year of graduate studies to take a course of study compatible with several programs while completing research rotations. At the end of the first year, students choose a subprogram affiliation.

The curriculum is a sequence of required and elective courses, which provides students with broad exposure to areas including molecular biology, cell biology, biochemistry, and integrative sciences. It ensures a comprehensive exposure to conceptual and experimental aspects of molecular and cellular biology and of translational studies. Sufficient flexibility is provided so that students can adapt the program to permit specialization in their own area of interest. Faculty members are involved in a variety of research projects involving molecular and cellular biology and molecular medicine.

The PhD in biomedical science with a molecular medicine subprogram requires the following coursework.

Typical Curriculum

First Year

See the Core Curriculum [p. 1] at the beginning of the PhD in biomedical science section of the catalog for a typical first-year schedule.

Second Year

Students select coursework from the following three track areas: metabolic disorders, cardiovascular biology, and molecular and cellular medicine (general).

Course #	Title	Hours
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:7290	Seminars in Molecular Medicine	1
Electives		1-3

Students select coursework from the following three track areas: metabolic disorders, cardiovascular biology, and molecular and cellular medicine (general).

Metabolic Disorders

Course #	Title	Hours
BMB:7253	Introduction to Metabolism	1
BMB:7255	Metabolism II	1
MMED:6230	Pathogenesis of Metabolic and Cardiovascular Disorders	3
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:7310	Translational Medicine Education Rounds (taken fall and spring semesters)	1

Cardiovascular Biology

Course #	Title	Hours
MMED:6230	Pathogenesis of Metabolic and Cardiovascular Disorders	3
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:7310	Translational Medicine Education Rounds (taken fall and spring semesters)	1
Elective		3

Molecular and Cellular Medicine (General)

Course #	Title	Hours
MMED:6220/ ACB:6220/ MPB:6220	Mechanisms of Cellular Organization	3
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:7310	Translational Medicine Education Rounds (taken fall and spring semesters)	1
Related coursework from list in the molecular medicine Graduate Student Guidelines		2
3 s.h. from these:		
MMED:3310/ BMB:3310/ CBIO:3310	Practical Data Science and Bioinformatics	3
MMED:6226/ ACB:6226/ MPB:6226	Cell Cycle Control	1
MMED:6227/ ACB:6227/ MPB:6227	Cell Fate Decisions (elective, 1s.h. maximum)	1
PCOL:6225	Growth Factor Receptor Signaling	1
Elective		1

Additional Requirements

Laboratory Rotations

To ensure that students obtain early involvement in laboratory research, they are required to register for research credits and complete three laboratory rotations during their first year of graduate study. In general, these rotations are in laboratories of three different molecular medicine faculty members. In some cases, if approved by the molecular medicine program, students may be allowed to complete two of their rotations in the same laboratory.

Teaching

Students are required to complete a teaching requirement (3 s.h.). They may teach in a combination of 1 or 2 s.h. courses, or one 3 s.h. course. This teaching requirement must be met prior to the final dissertation defense and graduation. It is recommended that teaching occur in the third year following completion of the comprehensive examination.

Publication Requirements

Students are required to have a minimum of one first-author publication in a peer-reviewed journal. The article must be formally accepted and be in-press status or be published prior to graduation. A co-first-authored, peer-reviewed publication will count toward this requirement.

External Fellowship Application Requirement

Students are required to submit a fellowship to an external funding agency (i.e., National Institutes of Health, American Heart Association) within one year of completing their comprehensive examination or by a date that is mutually agreed upon by the student, the dissertation advisor, and the molecular medicine program.

Comprehensive Examination

Students are expected to complete the comprehensive examination, both written and oral components, before the beginning of their third year. The preliminary specific aims document can be submitted to the comprehensive examination committee any time after approval of the dissertation plan, but must be submitted before April 1. The committee evaluation of the specific aims will be returned to the student within one week. A rejected specific aims must be revised and resubmitted within three weeks. The committee then has one week to evaluate the resubmitted specific aims. The specific aims must be accepted by a majority vote of the committee before a student can proceed with development of a full proposal. Only two rounds of submission are allowed.

Following acceptance of the specific aims, a student must submit the written proposal within six weeks. The committee has two weeks to review the written document. The oral presentation to defend the written proposal should be scheduled as soon after the two weeks as possible or at the convenience of the committee. It is expected that all examinations will be completed by July 15, in advance of the end of the student's second year.

The detailed Molecular Medicine Graduate Student Guidelines is located under Program Information on the Molecular Medicine Program website.

Final Examination

The five-member thesis committee serves as an advisory body for preparation of the thesis. It is expected that a student meet with the committee annually, although the candidate, thesis advisor, or the committee can request a meeting at any time. The final examination takes the form of a seminar presented to the program followed by a final thesis defense with committee members. The student is required to present a complete copy of the thesis to the thesis committee members at least two weeks prior to the final defense date.

Combined Programs

PhD/MD

Students may work toward the Doctor of Medicine degree and a PhD in biomedical science (molecular medicine subprogram) in a combined degree program offered by the Graduate College and the Carver College of Medicine. Applicants must be admitted to both programs before they may be admitted to the combined degree program. See the Medical Scientist Training Program (Carver College of Medicine) in the catalog.

Molecular Physiology and Biophysics

The Doctor of Philosophy in biomedical science with a molecular physiology and biophysics subprogram offers opportunities for training and research. The degree requires

a minimum of 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average (GPA) of at least 3.00 to earn the degree.

Students enter the molecular physiology and biophysics subprogram through the Biomedical Science Program. The Biomedical Science Program is designed to provide students maximum flexibility during the first year of graduate studies to take a course of study compatible with several programs while completing research rotations. At the end of the first year, students choose a subprogram affiliation.

Students join an active group of faculty members and advanced students at a time of expanding interdisciplinary biomedical research at the University of Iowa. Faculty in the Department of Molecular Physiology and Biophysics have a strong research focus on the cellular, molecular, and physical mechanisms of physiological processes.

The PhD in biomedical science with a molecular physiology and biophysics subprogram requires the following coursework.

Typical Curriculum

First Year, Fall

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
PCOL:5204	Basic Biostatistics and Experimental Design	1
Elective course(s)		

First Year, Spring

Course #	Title	Hours
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
Elective course(s)		

Second Year, Fall

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
MPB:5153	Graduate Physiology	4
MPB:6302	Research Physiology and Biophysics	6

Second Year, Spring

Course #	Title	Hours
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
MMED:6226/ ACB:6226/ MPB:6226	Cell Cycle Control (elective)	1
MMED:6227/ ACB:6227/ MPB:6227	Cell Fate Decisions (elective)	1
MPB:6302	Research Physiology and Biophysics	2
PCOL:6225	Growth Factor Receptor Signaling	1

Elective Coursework Options

Any elective preapproved by the director of graduate studies can be used to meet the elective requirement. A total of 9 s.h. of elective coursework is required.

The most common elective options are the following.

Course #	Title	Hours
GENE:6150	Genetic Analysis of Biological Systems	3
IGPI:5270/ MMED:5270/ PATH:5270	Pathogenesis of Major Human Diseases	3
MPB:6220/ ACB:6220/ MMED:6220	Mechanisms of Cellular Organization	3
NSCI:5653/ BIOL:5653/ PSY:5203	Fundamental Neurobiology I	3

Additional Requirements

Plan of Study

In consultation with the director of graduate studies, each newly admitted student formulates a plan of study to be completed before the comprehensive examination. This plan should include projected dates for completion of the comprehensive examination as well as provision for removal of deficiencies. Before completing the comprehensive exams, the normal course load is 15 s.h. each semester.

Required Courses

It is the intention of the department to have a curriculum that allows coursework to be mostly completed within the first year, though in some instances additional coursework in subsequent years is required. The core curriculum represents a minimum of required classes; although with advice of the director of graduate studies and thesis advisor, some students may benefit from completing additional coursework.

Requests for waiver of required courses or change of course registration must be approved by the director of graduate studies after consultation with the faculty and the chair of the department.

Evaluation of Progress

Students must meet progress requirements of the Department of Molecular Physiology and Biophysics and the Graduate College. To meet departmental requirements, students must

earn a grade of B or higher in MPB:5153 Graduate Physiology and BMED:5207 Principles of Molecular and Cellular Biology (B-minus or lower constitutes a non-passing grade), a grade of satisfactory (S) for BMED:7270 Scholarly Integrity/Responsible Conduct of Research I, and a GPA of at least 3.00 in all elective coursework (a grade below B, but above D-minus, is permissible for individual electives, so long as the GPA of all combined electives taken during the graduate program remains higher than 3.00).

All core curriculum courses receiving a letter grade must be satisfactorily completed prior to taking the comprehensive exam. According to Graduate College regulations, students cannot take a comprehensive exam in a semester in which they are on academic probation.

Comprehensive Examination

Students admitted directly to the doctoral program are required to complete the comprehensive examination by June 30 of the second year in the program.

Workshop

All postcomprehensive students are required to present a workshop on the progress of their thesis research once per year. Students should consult with the workshop coordinator to arrange presentation dates. Precomprehensive students also are encouraged to present workshops, though it is not required. Students have an option to present a full or half workshop (typically 45 or 20 minutes, respectively).

Teaching

Experience in teaching is an important part of a student's academic training. To attain adequate teaching proficiency, students receive teaching assignments after successful completion of the comprehensive exam and in subsequent years as warranted. Individual assignments depend on the teaching needs of the department. Examples of teaching assignments include running review sessions in a graduate physiology course, formal lectures, participating in small group conferences, assisting in computer simulations, or bench mentoring of summer students. These teaching assignments are made by the director of graduate studies in consultation with appropriate course directors. Thesis advisors with specific suggestions concerning teaching assignments that would be particularly beneficial to the individual circumstances of a particular student are encouraged to share them with the director of graduate studies for consideration. However, final discretion for approval lies with the director of graduate studies who must preapprove all assignments.

Research Publication

It is expected that thesis research will result in findings that are of sufficient quality and completeness to warrant publication in good quality peer-reviewed journals. At least one first-author peer-reviewed research paper should be accepted for publication prior to the PhD thesis defense. The published paper or a letter from an editor indicating acceptance should be provided to the director of graduate studies before scheduling a final exam date. In certain cases, a first-author research manuscript might be written, but not yet accepted by a journal at the time a final PhD thesis exam is scheduled. In this case, the first-author requirement may be satisfied if trainees submit their manuscript to the preprint server for biology, bioRxiv.

Thesis Defense and Presentation

Students complete a thesis defense with their committee. Once this test is completed they must schedule a public thesis presentation.

Combined Programs

PhD/MD

Students may work toward the Doctor of Medicine degree and a PhD in biomedical science (molecular physiology and biophysics subprogram) in a combined degree program offered by the Graduate College and the Carver College of Medicine. Applicants must be admitted to both programs before they may be admitted to the combined degree program. See the Medical Scientist Training Program (Carver College of Medicine) in the catalog.

Pharmacology

The Doctor of Philosophy in biomedical science with a pharmacology subprogram requires a minimum of 72 s.h. of graduate credit. Students must maintain a cumulative grade-point average of at least 3.00 to earn the degree.

Qualified students who are interested in earning the Doctor of Medicine along with the PhD may apply to the Medical Scientist Training Program in a combined MD/PhD program. Students have the opportunity to tailor their curriculum with courses that enhance their educational goals. They take a combination of graduate courses that include seminar courses.

The PhD in biomedical science with a pharmacology subprogram requires the following coursework.

Core Pharmacology Curriculum

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
MPB:5153	Graduate Physiology	4
PCOL:5130	Fundamentals of Pharmacology	3
PCOL:5204	Basic Biostatistics and Experimental Design	1
PCOL:6203	Pharmacology for Graduate Students	5
PCOL:6210	Receptors and Cell Signaling	3
PCOL:6250	Advanced Problem Solving in Pharmacological Sciences	1

Typical Curriculum

First Year, Fall

Course #	Title	Hours
BMED:5207	Principles of Molecular and Cellular Biology	3

BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
MPB:5153	Graduate Physiology	4
PCOL:5204	Basic Biostatistics and Experimental Design	1

First Year, Spring

Course #	Title	Hours
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	arr.
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270/ IGPI:5270/ MMED:5270	Pathogenesis of Major Human Diseases	3
PCOL:5130	Fundamentals of Pharmacology	3
PCOL:6250	Advanced Problem Solving in Pharmacological Sciences	1
PHAR:6504	Mastering Reproducible Science	1

Second Year, Fall

Course #	Title	Hours
BMED:7270	Scholarly Integrity/ Responsible Conduct of Research I	0
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
PCOL:6090	Graduate Research in Pharmacology	arr.
PCOL:6203	Pharmacology for Graduate Students	5

Second Year, Spring

Course #	Title	Hours
BMED:7271	Scholarly Integrity/ Responsible Conduct of Research II	0
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
PCOL:6090	Graduate Research in Pharmacology	arr.
PCOL:6210	Receptors and Cell Signaling	3

Additional Requirements

Laboratory Rotations

Newly admitted students complete three 12-week laboratory rotations by the end of the second semester.

Seminar and Journal Clubs

In subsequent semesters, students enroll in PCOL:6015 Topics in Pharmacology and Neuroscience and PCOL:6080 Pharmacology Seminar.

Comprehensive Examination

The comprehensive examination process normally begins during the fourth semester and is completed during the fifth semester in the program. The exam consists of writing and defending a research proposal in an area not directly related to work being conducted by the student or in the laboratory of the student's mentor(s). During the oral defense, the Comprehensive Exam Committee may pose questions related to the written proposal and also may ask questions to determine whether the student has broad knowledge in the pharmacological sciences.

Publication

A first-authored manuscript derived from a student’s thesis research must be accepted for publication before the PhD is granted.

Final Examination

The final oral examination is a defense of the thesis and is conducted by the Thesis Committee, typically immediately after a thesis seminar.

Combined Programs

PhD/MD

Students may work toward the Doctor of Medicine degree and a PhD in biomedical science (pharmacology subprogram) in a combined degree program offered by the Graduate College and the Carver College of Medicine. Applicants must be admitted to both programs before they may be admitted to the combined degree program. See the Medical Scientist Training Program (Carver College of Medicine) in the catalog.

Academic Plans

Sample Plans of Study

Sample plans represent one way to complete a program of study. Actual course selection and sequence will vary and should be discussed with an academic advisor. For additional sample plans, see MyUI.

Biomedical Science, PhD

- Cancer Biology Subprogram [p. 14]
- Cell and Developmental Biology Subprogram [p. 14]
- Experimental Pathology Subprogram [p. 15]
- Free Radical and Radiation Biology Subprogram [p. 16]
- Molecular Medicine Subprogram [p. 17]
- Molecular Physiology and Biophysics Subprogram [p. 18]
- Pharmacology Subprogram [p. 19]

Cancer Biology Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a]		
Graduate College program GPA of at least 3.00 is required. [b]		
	Hours	**0**
First Year		
Any Semester		
Select PhD Mentor		
	Hours	**0**
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	6
PCOL:5204	Basic Biostatistics and Experimental Design	1
Elective course [c]		3
	Hours	**15**
Spring		
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	6
FRRB:7001	Molecular and Cellular Biology of Cancer	3
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270	Pathogenesis of Major Human Diseases	3
PHAR:6504	Mastering Reproducible Science	1
	Hours	**15**
Second Year		
Fall		
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	6
CBIO:7000	Clinical Connections	1
CBIO:7500	Crafting a Scientific Proposal	1
Elective course [c]		3
	Hours	**13**
Spring		
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	6
Elective course [c]		1
	Hours	**9**
Summer		
Comprehensive Exam		
CBIO:6500	Research in Cancer Biology	1
	Hours	**1**
Third Year		
Fall		
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	5
	Hours	**7**
Spring		
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	4
	Hours	**6**
Fourth Year		
Fall		
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	1
	Hours	**3**
Spring		
CBIO:5500	Topics in Cancer Biology	1
CBIO:6000	Seminar: Cancer Research	1
CBIO:6500	Research in Cancer Biology	1
Final Exam [d]		
	Hours	**3**
	Total Hours	**72**

a Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.

b Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.

c Work with faculty advisor to determine appropriate graduate elective coursework and sequence.

d Dissertation defense.

Cell and Developmental Biology Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a]		
Graduate College program GPA of at least 3.00 is required. [b]		
	Hours	**0**
First Year		
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1

BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	1
PCOL:5204	Basic Biostatistics and Experimental Design	1
Elective course [c]		3
	Hours	**10**
Spring		
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	1
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270	Pathogenesis of Major Human Diseases	3
Elective course [c]		3
	Hours	**9**
Second Year		
Any Semester		
Comprehensive Exam		
	Hours	**0**
Fall		
ACB:5206	Graduate Research in Cell and Developmental Biology [d]	8
ACB:5224	Graduate Seminar in Cell and Developmental Biology	1
ACB:6220	Mechanisms of Cellular Organization	3
ACB:6237	Critical Thinking in Biochemistry and Molecular Biology	1
ACB:6239	Critical Thinking in Cell Biology	1
ACB:6248	Critical Thinking in Development	1
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
	Hours	**15**
Spring		
ACB:5206	Graduate Research in Cell and Developmental Biology [d]	11
ACB:5224	Graduate Seminar in Cell and Developmental Biology	1
ACB:6238	Critical Thinking in Genetics	1
ACB:6249	Critical Thinking in Cellular Physiology	1
ACB:6250	Critical Thinking in Scientific Writing and Presentations	1
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0
	Hours	**15**
Summer		
ACB:5206	Graduate Research in Cell and Developmental Biology [e]	arr.
	Hours	**0**
Third Year		
Fall		
Complete Teaching Requirement [f]		
ACB:5206	Graduate Research in Cell and Developmental Biology [g]	8
ACB:5224	Graduate Seminar in Cell and Developmental Biology	1
	Hours	**9**
Spring		
ACB:5206	Graduate Research in Cell and Developmental Biology [g]	8
ACB:5224	Graduate Seminar in Cell and Developmental Biology	1
	Hours	**9**
Fourth Year		
Fall		
ACB:5206	Graduate Research in Cell and Developmental Biology	1
ACB:5224	Graduate Seminar in Cell and Developmental Biology	1
	Hours	**2**
Spring		
ACB:5206	Graduate Research in Cell and Developmental Biology	1
ACB:5224	Graduate Seminar in Cell and Developmental Biology	1
GRAD:6003	Doctoral Final Registration	1
Final Exam [h]		
	Hours	**3**
	Total Hours	**72**

a Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.
b Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.
c Work with faculty advisor to determine appropriate graduate elective coursework and sequence.
d Take enough credit hours of ACB:5206 to bring semester total up to 15 s.h.
e Register for 1 s.h. of ACB:5206 if Comprehensive Exam is scheduled over the summer.
f Can be done during any one semester before thesis defense and graduation.
g Take enough credit hours of ACB:5206 to satisfy degree requirements.
h Dissertation defense.

Experimental Pathology Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a]		
Graduate College program GPA of at least 3.00 is required. [b]		
	Hours	**0**
First Year		
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3

BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
PATH:7211	Research in Pathology	10
PCOL:5204	Basic Biostatistics and Experimental Design	1
	Hours	**15**
Spring		
BIOS:4120	Introduction to Biostatistics	3
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270	Pathogenesis of Major Human Diseases	3
PATH:6220	Seminar in Pathology	1
PATH:7211	Research in Pathology	7
	Hours	**15**
Second Year		
Fall		
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
PATH:7211	Research in Pathology [c]	12
Elective relevant to Experimental Pathology [d]		3 - 4
	Hours	**15-16**
Spring		
Exam: Doctoral Comprehensive Exam [e]		
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0
PATH:6220	Seminar in Pathology	1
PATH:7211	Research in Pathology [c]	11
Elective relevant to Experimental Pathology [d]		3 - 4
	Hours	**15-16**
Third Year		
Fall		
PATH:7211	Research in Pathology	3
	Hours	**3**
Spring		
PATH:7211	Research in Pathology	3
	Hours	**3**
Fourth Year		
Fall		
PATH:7211	Research in Pathology	3
	Hours	**3**
Spring		
PATH:7211	Research in Pathology	3
Exam: Doctoral Final Exam [f]		
	Hours	**3**
	Total Hours	**72-74**

a Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.

b Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.

c Adjust research credit hours depending on whether the elective course is 3 or 4 s.h.

d Only one elective is required, and it can be taken either in the fall or spring semester of second year. Adjust research hours during non-elective semester so that total hours equals 15 s.h.

e Completed during second year spring semester; exam includes oral defense of comp exam proposal.

f Dissertation defense.

Free Radical and Radiation Biology Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a]		
Graduate College program GPA of at least 3.00 is required. [b]		
	Hours	**0**
First Year		
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research [c]	5
FRRB:5000	Radiation Biology [d]	4
PCOL:5204	Basic Biostatistics and Experimental Design	1
	Hours	**15**
Spring		
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research [c]	5
FRRB:7000	Redox Biology and Medicine [d]	4
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270	Pathogenesis of Major Human Diseases	3
PHAR:6504	Mastering Reproducible Science	1
	Hours	**15**
Second Year		
Fall		
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
FRRB:5000	Radiation Biology [d]	4
FRRB:6000	Seminar: Free Radical and Radiation Biology [e]	1
FRRB:6004	Research: Free Radical and Radiation Biology [f]	5
FRRB:6006	Topics in Free Radical Biology and Medicine [g]	1
FRRB:6008	Topics in Radiation and Cancer Biology [g]	1
Elective course		3
	Hours	**15**

Spring		
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0
FRRB:6000	Seminar: Free Radical and Radiation Biology [e]	1
FRRB:6004	Research: Free Radical and Radiation Biology [f]	4
FRRB:6006	Topics in Free Radical Biology and Medicine [g]	1
FRRB:6008	Topics in Radiation and Cancer Biology [g]	1
FRRB:7000	Redox Biology and Medicine [d]	4
MMED:6226	Cell Cycle Control	1
Elective course		3
	Hours	**15**
Third Year		
Fall		
FRRB:6000	Seminar: Free Radical and Radiation Biology [e]	1
FRRB:6004	Research: Free Radical and Radiation Biology [f]	5
	Hours	**6**
Spring		
Exam: Doctoral Comprehensive Exam [h]		
FRRB:6004	Research: Free Radical and Radiation Biology [f]	4
	Hours	**4**
Fourth Year		
Fall		
FRRB:6004	Research: Free Radical and Radiation Biology [f]	1
	Hours	**1**
Spring		
FRRB:6004	Research: Free Radical and Radiation Biology [f]	1
Exam: Doctoral Final Exam [i]		
	Hours	**1**
	Total Hours	**72**

a Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.
b Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.
c If only taking the courses described here, register for the indicated credit hours of BMED:7888; if taking additional courses, register for enough credit hours to bring total up to 15 s.h.
d Students must take this course just once, either during their first or second year.
e Take three times.
f On average, FRRB students complete a total of 30 s.h. of research credit for their PhD degree; no more than 6 s.h. of research credit per semester allowed without prior approval of FRRB faculty.
g Note: Students who are on the T32 Training Grant are required to give a seminar once a year.
h Take by third year spring semester.
i Dissertation defense.

Molecular Medicine Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a]		
Graduate College program GPA of at least 3.00 is required. [b]		
	Hours	**0**
First Year		
Fall		
BIOS:4120 or PCOL:5204	Introduction to Biostatistics or Basic Biostatistics and Experimental Design	1, 3
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	1
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:8115	Molecular Physiology	4
	Hours	**12-14**
Spring		
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	3
MMED:5270	Pathogenesis of Major Human Diseases	3
MMED:6260	Methods for Molecular and Translational Medicine	1
MMED:6280	Critical Thinking in Molecular Medicine	1
PHAR:6504	Mastering Reproducible Science	1
Relevant elective course [c]		3
	Hours	**13**
Second Year		
Fall		
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
BMED:7888	Biomedical Science Research	5
MMED:6230	Pathogenesis of Metabolic and Cardiovascular Disorders	3
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:7290	Seminars in Molecular Medicine	1
MMED:7310	Translational Medicine Education Rounds	1
Relevant elective course [c]		3
	Hours	**14**
Spring		
Exam: Doctoral Comprehensive Exam [d]		
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0

BMED:7888	Biomedical Science Research	11
MMED:6280	Critical Thinking in Molecular Medicine	1
MMED:7290	Seminars in Molecular Medicine	1
MMED:7310	Translational Medicine Education Rounds	1
	Hours	**14**
Summer		
MMED:7305	Molecular Medicine Research	1
	Hours	**1**
Third Year		
Fall		
MMED:7290	Seminars in Molecular Medicine	1
MMED:7305	Molecular Medicine Research	6
	Hours	**7**
Spring		
MMED:7290	Seminars in Molecular Medicine	1
MMED:7305	Molecular Medicine Research	6
	Hours	**7**
Fourth Year		
Fall		
MMED:7290	Seminars in Molecular Medicine	1
MMED:7305	Molecular Medicine Research	1
	Hours	**2**
Spring		
MMED:7290	Seminars in Molecular Medicine	1
MMED:7305	Molecular Medicine Research	1
Exam: Doctoral Final Exam [e]		
	Hours	**2**
	Total Hours	**72-74**

a Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.
b Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.
c Work with faculty advisor to choose appropriate graduate coursework from an approved list.
d Typically taken no later than the end of summer before third year.
e Dissertation defense.

Molecular Physiology and Biophysics Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a]		
Graduate College program GPA of at least 3.00 is required. [b]		
	Hours	**0**
First Year		
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	6
PCOL:5204	Basic Biostatistics and Experimental Design	1
Elective course [c]		3
	Hours	**15**
Spring		
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research	4
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270	Pathogenesis of Major Human Diseases	3
Elective course [c]		3
Elective course [c]		3
	Hours	**15**
Second Year		
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
MPB:5153	Graduate Physiology	4
MPB:6302	Research Physiology and Biophysics	8
	Hours	**15**
Spring		
Exam: Doctoral Comprehensive Exam		
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0
MMED:6226	Cell Cycle Control	1
MMED:6227	Cell Fate Decisions	1
MPB:6302	Research Physiology and Biophysics	12
PCOL:6225	Growth Factor Receptor Signaling	1
	Hours	**15**
Third Year		
Fall		
MPB:6302	Research Physiology and Biophysics	9
	Hours	**9**
Spring		
MPB:6302	Research Physiology and Biophysics	1
	Hours	**1**
Fourth Year		
Fall		
GRAD:6002	Doctoral Continuous Registration	1
	Hours	**1**
Spring		
GRAD:6002	Doctoral Continuous Registration	1

Exam: Doctoral Final Exam [d]		
	Hours	**1**
	Total Hours	**72**

a Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.
b Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.
c Work with faculty advisor to choose from an approved list of electives.
d Dissertation defense.

Pharmacology Subprogram

Course	Title	Hours
Academic Career		
Any Semester		
72 s.h. must be graduate level coursework; graduate transfer credits allowed upon approval. More information is included in the General Catalog and on department website. [a, b, c]		
Graduate College program GPA of at least 3.00 is required. [d]		
	Hours	**0**
First Year		
Fall		
BMED:5207	Principles of Molecular and Cellular Biology	3
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research [e]	5
MPB:5153	Graduate Physiology [f]	4
PCOL:5204	Basic Biostatistics and Experimental Design	1
	Hours	**15**
Spring		
BMED:5208	Topics in Principles of Molecular and Cellular Biology	1
BMED:7777	Biomedical Science Seminar	1
BMED:7888	Biomedical Science Research [e]	4
MMED:6260	Methods for Molecular and Translational Medicine	1
PATH:5270	Pathogenesis of Major Human Diseases	3
PCOL:5130	Fundamentals of Pharmacology [f]	3
PCOL:6250	Advanced Problem Solving in Pharmacological Sciences [f]	1
PHAR:6504	Mastering Reproducible Science	1
	Hours	**15**
Second Year		
Fall		
BMED:7270	Scholarly Integrity/Responsible Conduct of Research I	0
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
PCOL:6090	Graduate Research in Pharmacology [g]	8
PCOL:6203	Pharmacology for Graduate Students	5
	Hours	**15**
Spring		
Exam: Doctoral Comprehensive Exam [h]		
BMED:7271	Scholarly Integrity/Responsible Conduct of Research II	0
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
PCOL:6090	Graduate Research in Pharmacology [g]	10
PCOL:6210	Receptors and Cell Signaling	3
	Hours	**15**
Third Year		
Fall		
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
	Hours	**2**
Spring		
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
	Hours	**2**
Fourth Year		
Fall		
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
	Hours	**2**
Spring		
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
	Hours	**2**
Fifth Year		
Fall		
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
	Hours	**2**
Spring		
PCOL:6015	Topics in Pharmacology and Neuroscience	1
PCOL:6080	Pharmacology Seminar	1
Exam: Doctoral Final Exam [i]		
	Hours	**2**
	Total Hours	**72**

a Students complete three 12-week laboratory rotations by the end of the second semester.

b During the first two semesters, all registered students enroll in BMED:5208 and BMED:7777. In subsequent semesters, students enroll in PCOL:6015 and PCOL:6080.
c Students must complete specific requirements in the University of Iowa Graduate College after program admission. Refer to the Graduate College website and the Manual of Rules and Regulations for more information.
d Graduate College program GPA is comprised of all courses that are approved degree requirements. If a student takes more than the minimum required number of semester hours to complete the degree, but all courses taken are eligible to count toward the degree, those courses will be included in the Graduate College program GPA.
e Register for the indicated credit hours of BMED:7888 if taking the courses exactly as listed on the plan for this semester. If enrolling for additional courses, adjust BMED:7888 credit hours to bring total up to 15 s.h.
f Taking this course now allows for coursework completion in an optimal timeframe.
g Register for the indicated credit hours of PCOL:6090 if taking the courses exactly as listed on the plan for this semester. If enrolling for additional courses, adjust PCOL:6090 credit hours to bring total up to 15 s.h.
h The comprehensive examination process normally begins during the fourth semester and is completed during the fifth semester in the program.
i Dissertation defense.