CANCER, DEVELOPMENTAL AND REGENERATIVE BIOLOGY — M.S., PH.D.

Co-program directors
Mary Kearns-Jonker
Julia Unternaehrer-Hamm

The basic sciences of the School of Medicine offers curricula leading to the Master of Science and Doctor of Philosophy degrees. The core curriculum provides a broad background in molecular biology, cell biology, and biochemistry. Advanced courses allow each student to fully develop an area of interest. Research strengths of the program include: cancer biology (prostate, breast, thyroid, ovarian, cervical, pancreatic, leukemia), molecular mechanisms controlling normal development and regeneration, stem cell-based cardiovascular repair, oxidative stress in mechanism of anticancer agents, stem cell delivery of gene therapy for regenerative medicine, neuronal injury and axonal regeneration, transcriptional regulation, normal and malignant immune cell development and function, nanoparticles for therapeutic applications, cellular and molecular mechanisms of cardiovascular diseases and aging, plasticity and interconnection between normal and cancer stem cells, miRNA regulation in ovarian cancer and early development, epigenomic/transcriptomic reprogramming and longevity, calcium signaling during lung development, developmental programming of health and disease, stem cell reprogramming, and genome editing.

The thesis or research Master of Science degree provides training for individuals who will become technicians involved in biomedical research in universities or in the biotechnology industry. The nonthesis Master of Science degree provides content appropriate for secondary teachers in universities or in the biotechnology industry. The nonthesis Master of Science degree provides content appropriate for secondary teachers seeking admission to a professional school, such as medicine or dentistry.

The Doctor of Philosophy degree is designed to prepare students for a career in independent research and teaching in a university, clinical, or biotechnology environment. Doctoral degree students are expected to develop creativity and independence in addition to technical skills.

Program student learning outcomes
Students will demonstrate a broad knowledge of the biomedical sciences.

- Students will demonstrate subject mastery in cancer, developmental or regenerative biology.
- Students will interpret the current literature in the field.
- Students will demonstrate ability to design hypothesis-driven studies to address key questions in the field.
- Students will make original contributions to the body of biomedical knowledge.
- Students will demonstrate an understanding of the principles of scientific and professional ethics.
- Students will write effective scientific publications and grant proposals. *

*This objective is not applicable to M.S. degree students.

M.S. requirements
A minimum of 45 units is required for the M.S. degree, as detailed in the table below. Two options, a research track and a course work track, are available. Students must maintain a G.P.A. of at least 3.0. Students must adhere to all University and program policies as published in the Student Handbook, University CATALOG, or "Student Guide." Policies and requirements are subject to change.

<table>
<thead>
<tr>
<th>Basic science core</th>
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<tbody>
<tr>
<td>IBGS 501</td>
<td>Biomedical Communication and Integrity</td>
<td>2</td>
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<tr>
<td>IBGS 502</td>
<td>Biomedical Information and Statistics</td>
<td>2</td>
</tr>
<tr>
<td>IBGS 511</td>
<td>Cellular Mechanisms and Integrated Systems I</td>
<td>6</td>
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<tr>
<td>IBGS 512</td>
<td>Cellular Mechanisms and Integrated Systems II</td>
<td>6</td>
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<tr>
<td>IBGS 522</td>
<td>Cellular Mechanisms and Integrated Systems II Journal Club</td>
<td>2</td>
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<tr>
<td>IBGS 523</td>
<td>Cellular Mechanisms and Integrated Systems III Journal Club</td>
<td>2</td>
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<tr>
<th>Seminars (all required)</th>
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<tbody>
<tr>
<td>IBGS 604</td>
<td>Introduction to Integrative Biology Presentation Seminar</td>
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<td>IBGS 605</td>
<td>Integrative Biology Presentation Seminar</td>
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<tr>
<th>Religion</th>
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<tbody>
<tr>
<td>REL_ ____</td>
<td>Graduate-level religion course (RELE, RELR, or RELT)</td>
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<th>Program specific courses</th>
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<tr>
<td>IBGS 698</td>
<td>Thesis (1-3 units)</td>
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Choose from the following:

- ANAT 507 Stem Cell Biology and Medicine
- ANAT 544 Human Embryology Lecture
- BCHM 44 Advanced Topics in Biochemistry
- BCHM 605 Seminar in Stem Cells and Cancer or BCHM 61 Cancer Journal Club
- PHSL 555 Biology of Cancer

<table>
<thead>
<tr>
<th>Degree completion options</th>
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<tbody>
<tr>
<td>Electives (8 units)</td>
<td>8</td>
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<tr>
<td>Research track:</td>
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<tr>
<td>BCHM 697 Research</td>
<td>1</td>
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<tr>
<td>IBGS 698 Thesis (1-3 units)</td>
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<th>Elective (0-2 units)</th>
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<tr>
<td>Total Units</td>
<td>45</td>
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Available Electives

| ANAT 488 Introductory Flow Cytometry | 1 |
| BCHM 530 Biochemical Basis of Human Disease SM | 2 |
| IBGS 525 Translational Research Training | 2 |
| MDCJ 520 Basis of Medical Genetics | 2 |
| MDCJ 560 Basis of Medical Genetics | 2 |
| MICR 515 Introduction to Bioinformatics and Genomics | 2 |
| MICR 530 Immunology | 4 |
| MICR 537 Selected Topics in Molecular Biology | 3 |
| PHSL 541 Cell and Molecular Biology | 4 |
| PHSL 587 Physiology of Reproduction | 2 |
Registration and attendance required every quarter in residence, but units do not count toward total required for graduation.

May substitute with another religion course at the 500-level or greater.

Noncourse requirements
Course work track: a comprehensive written examination over the graduate course work in lieu of preparing a thesis.

Research track: pass an oral examination given by his/her graduate guidance committee after the thesis has been completed.

Normal time to complete the program
2 years — based on full-time enrollment; part time permitted

Comparison
See the comparison (http://llucatalog.llu.edu/medicine/cancer-dev-and-regen-biology/comparison) of the M.S. Course work, M.S. Research and Ph.D. tracks of this program.

Ph.D. requirements
For the Ph.D. degree, students must complete a minimum of 61 units—as detailed in the table below—and must maintain a G.P.A. of at least 3.0. Students must adhere to all University and program policies as published in the Student Handbook, University CATALOG, or "Student Guide." Policies and requirements are subject to change.

Basic science core
IBGS 501 Biomedical Communication and Integrity 2
IBGS 502 Biomedical Information and Statistics 2
IBGS 503 Biomedical Grant Writing 2
IBGS 511 Cellular Mechanisms and Integrated Systems I 6
IBGS 512 Cellular Mechanisms and Integrated Systems II 6
IBGS 522 Cellular Mechanisms and Integrated Systems II Journal Club 2
IBGS 523 Cellular Mechanisms and Integrated Systems III Journal Club 2
IBGS 524 Seminar in Religion and the Sciences 3

Seminars (all required)
IBGS 604 Introduction to Integrative Biology Presentation Seminar 1
IBGS 605 Integrative Biology Presentation Seminar 2 2
IBGS 607 Integrated Biomedical Graduate Studies Seminar 1 0

Religion
RELE 525 Ethics for Scientists 3 3
RELR 588 Personal and Family Wholeness 3 3
RELT 617 Seminar in Religion and the Sciences 3 3

Program specific courses
Emphasis: Developmental/regenerative biology
ANAT 507 Stem Cell Biology and Medicine
ANAT 544 Human Embryology Lecture

Emphasis: Cancer biology
BCHM 544 Advanced Topics in Biochemistry
BCHM 605 Seminar in Stem Cells and Cancer
or BCHM 610 Cancer Journal Club
PHSL 555 Biology of Cancer

Electives: 6-12

Choose from the following and other courses as approved by advisor:
BCHM 550 Clinical Exposure in Oncology
BCHM 530 Biochemical Basis of Human Disease SM
IBGS 525 Translational Research Training
IBGS 537A Special Topics in Biomedical Sciences
MDJ 560 Basis of Medical Genetics
MICR 515 Introduction to Bioinformatics and Genomics
MICR 530 Immunology
NSBB 506 Fundamentals of Electrophysiology
PHSL 541 Cell and Molecular Biology
PHSL 587 Physiology of Reproduction

Research and dissertation
BCHM 697 Research 2 12
IBGS 696 Research Rotations 2 2
IBGS 699 Dissertation 1-5

Total Units 61

1 Registration and attendance required every quarter in residence, but units do not count toward total required for graduation.
2 Multiple registrations required to fulfill total units required.
3 May substitute with another graduate religion course with the same prefix and numbered 500 or above.

Noncourse requirements
- pass both written and oral comprehensive examinations in order to advance to candidacy.
- successfully defend the dissertation before their guidance committee prior to being awarded the Ph.D. degree.

Normal time to complete the program
4 years — full-time enrollment, part-time permitted

Comparison
See the comparison (http://llucatalog.llu.edu/medicine/cancer-dev-and-regen-biology/comparison) of the M.S. Course work, M.S. Research and Ph.D. tracks of this program.