NEUROSCIENCE, SYSTEMS BIOLOGY AND BIOENGINEERING — M.S., PH.D.

Program director
Michael Pecaut

Associate program director
Christopher Wilson

The core curriculum provides a broad background in molecular biology, immunology, and medical microbiology and infectious diseases. Advanced courses allow each student to fully develop an area of interest. Research strengths of the program include: cellular and systems neurosciences, bioinformatics, molecular biology, computational modeling, biostatistics and data analytics, radiation physics, functional/structural imaging, in vivo and in vitro physiology, as well as biomedical engineering.

The thesis or research option for the Master of Science degree provides training for individuals who will become technicians involved in biomedical research in universities or in the biotechnology industry, and for medical technologists seeking specialized research training. The nonthesis Master of Science degree option provides content appropriate for secondary school teachers seeking advanced training in areas such as neuroscience, systems biology, bioinformatics, medical imaging; and for students 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 learning outcomes
By the end of this program, the graduate should be able to:

1. Articulate fundamental concepts in the biomedical sciences.
2. Integrate aspects of neuroscience, systems biology, or bioengineering.
3. Interpret the literature within neuroscience, systems biology, or bioengineering.
4. Demonstrate the principles of scientific and professional ethics
5. Make original contributions to the body of biomedical knowledge.
6. Explain the process of applying for external funding.

*This learning outcome does not apply 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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</thead>
<tbody>
<tr>
<td>IBGS 501 Biomedical Communication and Integrity 2</td>
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<tr>
<td>IBGS 502 Biomedical Information and Statistics 2</td>
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<tr>
<td>IBGS 511 Cellular Mechanisms and Integrated Systems I 6</td>
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<tr>
<td>IBGS 512 Cellular Mechanisms and Integrated Systems II 6</td>
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<table>
<thead>
<tr>
<th>Seminars (all required)</th>
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<tbody>
<tr>
<td>IBGS 604 Introduction to Integrative Biology Presentation Seminar 1</td>
</tr>
<tr>
<td>IBGS 605 Integrative Biology Presentation Seminar 1</td>
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<tr>
<td>IBGS 607 Integrated Biomedical Graduate Studies Seminar 0</td>
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<thead>
<tr>
<th>Religion</th>
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<tbody>
<tr>
<td>REL_ ____ Graduate-level religion course (RELE, RELR, or RELT) 3</td>
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<thead>
<tr>
<th>Program specific courses</th>
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<tbody>
<tr>
<td>Choose from the following three (3) areas:</td>
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#### Neuroscience
- Required core: (10-15 units)
  - ANAT 516 Neuroscience GS
  - NSBB 500 Foundations in Neuroscience
  - NSBB 504 Neuroscience Methods
  - NSBB 506 Fundamentals of Electrophysiology
  - NSBB 507 History of Neuroscience
  - NSBB 520 Neuroinflammation: Neuron-Glia Interactions
  - PHRM 554 Neuropharmacology
  - PSYC 551 Psychobiological Foundations
- Electives: (5-6 units)
  - NSBB 510 Cortical Circuits
  - NSBB 515 Contemporary Neuroimaging
  - NSBB 526 Neurosciences Journal Club

#### Systems biology
- Required core: (10-15 units)
  - HLIF 520 Data Management: Modeling and Development
  - MICR 515 Introduction to Bioinformatics and Genomics or BCHM 515 Introduction to Bioinformatics
  - MICR 540 Physiology and Molecular Genetics of Microbes
  - NSBB 551 Systems Biology — A Practical Approach
  - NSBB 553 Advanced Bioinformatics — Sequence and Genome Analysis
  - NSBB 555 Genomics and Bioinformatics: Tools
  - NSBB 557 Integration of Computational and Experimental Biology
- Electives: (7-12) 2
  - HLIF 530 Data Analytics and Decision Support
  - IBGS 525 Translational Research Training
  - MDCJ 560 Basis of Medical Genetics
  - NSBB 524 Systems Biology Journal Club

#### Bioengineering
- Required core: (10 units)
  - NSBB 571 Engineering Analysis of Physiological Systems
  - NSBB 572 Cellular and Molecular Engineering
  - NSBB 575 Orthopaedic Regenerative Engineering and Mechanobiology
- Electives: (10-18 units) 2
Neuroscience, Systems Biology and Bioengineering — M.S., Ph.D.

<table>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>NSBB 525</td>
<td>Bioengineering Journal Club</td>
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<tr>
<td>NSBB 579</td>
<td>Bioengineering Fabrication</td>
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<tr>
<td>NSBB 580</td>
<td>Medical Imaging Physics</td>
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<tr>
<td>NSBB 584</td>
<td>Medical Image Analysis</td>
</tr>
<tr>
<td>NSBB 585</td>
<td>Radiation Detectors for Medical Applications</td>
</tr>
<tr>
<td>NSBB 587</td>
<td>Radiation Therapy Physics</td>
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**Degree completion options**  
11

**Coursework track:**
- Electives (Choose 11 units from available electives listed in above areas of specialization)

**Research track:**
- Elective (0-2 units)
- NSBB 697 Research (8 units)
- IBGS 698 Thesis (1-3 units)

**Total Units**  
45

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1. Registration and attendance required every quarter in residence, but units do not count toward total required for graduation.
2. With instructor, mentor and program director approval, students may opt to take classes from another track or program to focus on a specific type of research topic (e.g., neuroscience, immunology, cancer).

**Noncourse requirements**

- Coursework 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**

Two (2) years — based on full-time enrollment; part time permitted

**Comparison**

See the comparison (http://llucatalog.llu.edu/medicine/neurosci-syst-biol-bioeng/comparison) of the M.S. and Ph.D. degree programs.

**Ph.D. requirements**

For the Ph.D. degree, students must complete a minimum of 70 units— as detailed in the table below—and must maintain a G.P.A. of at least 3.0. Based on research dissertation focus, other courses may be required as recommended by the dissertation committee and approved by School of Medicine graduate academic affairs committee. 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**

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<td>Biomedical Grant Writing</td>
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<td>IBGS 511</td>
<td>Cellular Mechanisms and Integrated Systems I</td>
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<td>IBGS 512</td>
<td>Cellular Mechanisms and Integrated Systems II</td>
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<tr>
<td>IBGS 522</td>
<td>Cellular Mechanisms and Integrated Systems II Journal Club</td>
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<tr>
<td>IBGS 523</td>
<td>Cellular Mechanisms and Integrated Systems III Journal Club</td>
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**Seminars (all required)**

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<td>IBGS 604</td>
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<td>IBGS 607</td>
<td>Integrated Biomedical Graduate Studies Seminar</td>
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</table>

**Religion**

RELE 5_  
- Must be numbered 500 or above

RELR 5_  
- Must be numbered 500 or above

RELT 5_  
- Must be numbered 500 or above

**Program specific courses**

Choose from the following three (3) areas: 20

**Neuroscience**

- Required: (11-18 units)
  - ANAT 516 Neuroscience GS
  - NSBB 500 Foundations in Neuroscience
  - NSBB 504 Neuroscience Methods
- Electives: (2-6 units)
  - NSBB 506 Fundamentals of Electrophysiology
  - NSBB 507 History of Neuroscience
  - NSBB 510 Cortical Circuits
  - NSBB 515 Contemporary Neuroimaging
  - NSBB 520 Neuroinflammation: Neuron-Glia Interactions
  - NSBB 526 Neurosciences Journal Club
  - PHRM 554 Neuropharmacology

**Systems biology**

- Required: (10-15 units)
  - HLIF 520 Data Management: Modeling and Development
  - MICR 515 Introduction to Bioinformatics and Genomics
  - NSBB 551 Systems Biology — A Practical Approach
  - NSBB 552 Data Analytics
- Electives: (2-10 units)
  - MICR 521 Medical Microbiology
  - NSBB 524 Systems Biology Journal Club
  - NSBB 553 Advanced Bioinformatics — Sequence and Genome Analysis
  - NSBB 555 Genomics and Bioinformatics: Tools
  - NSBB 557 Integration of Computational and Experimental Biology

**Bioengineering**

- Required: (10 units)
  - NSBB 552 Data Analytics
  - NSBB 557 Integration of Computational and Experimental Biology
  - NSBB 572 Cellular and Molecular Engineering
  - NSBB 579 Bioengineering Fabrication
- Electives: (2-10 units)
  - NSBB 525 Bioengineering Journal Club
  - NSBB 575 Orthopaedic Regenerative Engineering and Mechanobiology
  - NSBB 580 Medical Imaging Physics
  - NSBB 584 Medical Image Analysis
  - NSBB 585 Radiation Detectors for Medical Applications
  - NSBB 587 Radiation Therapy Physics
Research

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<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
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<tbody>
<tr>
<td>IBGS 696</td>
<td>Research Rotations (1) ²</td>
<td>2</td>
</tr>
<tr>
<td>NSBB 697</td>
<td>Research (1-8) ²</td>
<td>12</td>
</tr>
<tr>
<td>IBGS 699</td>
<td>Dissertation (1-5)</td>
<td>2.5</td>
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Total Units 70

¹ Registration and attendance required every quarter in residence, but units do not count toward total required for graduation.
² Must take at least 3 units of course work with a clear microbiology focus.
³ Must take at least 3 units with a clear immunology focus.

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

Five (5) years – based on full-time enrollment; part time permitted

Comparison

See the comparison (http://llucatalog.llu.edu/medicine/neurosci-syst-biol-bioeng/comparison) of the M.S. and Ph.D. degree programs.