

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, and 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 as well as for medical technologists seeking specialized research training. The non-thesis Master of Science degree option provides content appropriate for secondary school teachers seeking advanced training in areas such as neuroscience, systems biology, bioinformatics, and medical imaging, as well as 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 coursework 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.

Basic science core

IBGS 501	Biomedical Communication and Integrity	2
IBGS 502	Biomedical Information and Statistics	2
IBGS 511	Cellular Mechanisms and Integrated Systems I	6
IBGS 512	Cellular Mechanisms and Integrated Systems II	6

Seminars (all required)

IBGS 604	Introduction to Integrative Biology Presentation Seminar	1
IBGS 605	Integrative Biology Presentation Seminar	1
IBGS 607	Integrated Biomedical Graduate Studies Seminar ¹	1

Religion

REL_ ____	Graduate-level religion course (RELE, RELR, or RELT)	3
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Program specific courses

NSBB 552	Data Analytics	3
NSBB 526	Journal Club (1) ²	2
Choose from the following three (3) areas:		11

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

Systems biology

Required core: (10-15 units)

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

STAT 521 Biostatistics I

STAT 522 Biostatistics II

Electives: (7-12)³

HLIF 520	Data Management: Modeling and Development
HLIF 530	Data Analytics and Decision Support
IBGS 525	Translational Research Training
MDCJ 560	Basis of Medical Genetics
STAT 523	Biostatistics III

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	
NSBB 579	Bioengineering Fabrication
NSBB 580	Medical Imaging Physics
NSBB 584	Medical Image Analysis
NSBB 585	Radiation Detectors for Medical Applications
NSBB 587	Radiation Therapy Physics
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) ³
IBGS 698	Thesis (1-3 units)
Total Units	48

¹ Registration and attendance required every quarter in residence, but units do not count toward total required for graduation.

² Credit toward degree for the first two registrations only.

³ 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).

Service learning requirement

This requirement may be met by taking a religion course designated as a service learning course. For more information about this requirement and a list of religion courses that fulfill it, see section on academic service learning (<http://llucatalog.llu.edu/about-university/academic-policies-information/degree-completion-requirements/>) in this CATALOG.

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 their 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

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

Seminars (all required)

IBGS 604	Introduction to Integrative Biology Presentation Seminar	1
IBGS 605	Integrative Biology Presentation Seminar ¹	2
IBGS 607	Integrated Biomedical Graduate Studies Seminar ¹	1

Religion

RELE 5__	Must be numbered 500 or above	3
RELR 5__	Must be numbered 500 or above	3
RELT 5__	Must be numbered 500 or above	3

Program specific courses

NSBB 526	Journal Club (1) ²	2
NSBB 552	Data Analytics	3
Choose from the following three (3) areas:		18

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
PHRM 554	Neuropharmacology

Systems biology

Required: (10-15 units)	
NSBB 551	Systems Biology – A Practical Approach
STAT 521	Biostatistics I
STAT 522	Biostatistics II
Electives: (2-10 units)	
HLIF 520	Data Management: Modeling and Development
NSBB 553	Advanced Bioinformatics – Sequence and Genome Analysis
NSBB 555	Genomics and Bioinformatics: Tools
NSBB 557	Integration of Computational and Experimental Biology
STAT 523	Biostatistics III

Bioengineering

Required: (10 units)	
NSBB 557	Integration of Computational and Experimental Biology
NSBB 572	Cellular and Molecular Engineering
NSBB 579	Bioengineering Fabrication
Electives: (2-10 units)	

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		
IBGS 696	Research Rotations (1) ²	2
NSBB 697	Research (1-8) ²	12
IBGS 699	Dissertation (1-5)	2-5
Total Units		73

¹ Registration and attendance required every quarter in residence, but units do not count toward total required for graduation.

² Credit toward degree for the first two registrations only.

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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.