Neuroscience, PHD

Program Director: SuJean Choi, Ph.D.
Neuroscience Graduate Program website (http://www.marquette.edu/grad/programs-neuroscience.php)

Degree Offered
Doctor of Philosophy

Educational Goals and Student Learning Outcomes
Upon completion of the neuroscience doctorate program, a student is able to:

1. Demonstrate an in-depth mastery of advanced interdisciplinary concepts in the neurosciences.
2. Demonstrate independent scientific reasoning.
3. Design and execute original research in an area of neuroscience specialization.
4. Demonstrate effective oral communication of interdisciplinary neuroscience concepts.

Program Description
Neuroscience is the study of the structure and function of the brain and nervous system and is currently one of the fastest growing areas in science education and research. The graduate program in neuroscience involves, at a minimum, faculty from the Departments of Biological Sciences; Biomedical Engineering; Biomedical Sciences; Mathematics, Statistics and Computer Science; Philosophy; Physical Therapy-Exercise Science; and Psychology. It is designed to provide students with research training and didactic course work that includes a broad foundation of neuroscience that can then be complemented with specialized courses within subfields.

Neuroscience Doctorate
Specializations: Behavioral and Cognitive Neuroscience; Cellular and Molecular Neuroscience; Computational, Neurorehabilitation and Neuroimaging Neuroscience

Neuroscience is the interdisciplinary study of the function of the nervous system, encompassing a broad spectrum of approaches from cellular and molecular function to anatomical circuitry to behavior, disorders and treatments. The neuroscience doctoral program is designed with interdisciplinary research training and curriculum, research writing and analysis skills toward preparing students for doctoral-level interdisciplinary career opportunities in the growing arena of neuroscience research and industry. The program involves faculty from the Departments of Biological Sciences; Biomedical Engineering; Biomedical Sciences; Physical Therapy-Exercise Science; Mathematics, Statistics and Computer Science; Philosophy; and Psychology. The program is designed to provide students with research training and didactic course work that includes a broad foundation in neuroscience that can then be complemented with specialized courses within subfields.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required courses:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BISC 5140</td>
<td>Functional Neuroanatomy</td>
<td>3</td>
</tr>
<tr>
<td>NRSC/BISC 8001</td>
<td>Neuroscience Foundations 1</td>
<td>4</td>
</tr>
<tr>
<td>NRSC/BISC 8002</td>
<td>Neuroscience Foundations 2</td>
<td>4</td>
</tr>
<tr>
<td>NRSC/BISC 8003</td>
<td>Individual Development Plan</td>
<td>1</td>
</tr>
<tr>
<td>NRSC/BISC 8004</td>
<td>Science Writing and Ethics 1 (or equivalent)</td>
<td>1</td>
</tr>
<tr>
<td>NRSC/BISC 8005</td>
<td>Science Writing and Ethics 2 (or equivalent)</td>
<td>1</td>
</tr>
<tr>
<td>NRSC/BISC 8096</td>
<td>First Year Lab Rotations (taken three times at 1 cr. each)</td>
<td>3</td>
</tr>
<tr>
<td>Graduate statistics course from BIOL, BISC, MSCS, PSYC or another course as approved by the director of graduate studies.</td>
<td>3-4</td>
<td></td>
</tr>
<tr>
<td>A minimum of 12 credit hours from within the declared specialization.</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>NRSC 8999 Doctoral Dissertation</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Total Credit Hours: 44-45

1 Taking an equivalent course, such as PSYC 8125 Advanced Research Methods or MSSC 6090 Research Methods/Professional Development (repeated twice) may increase the overall credit total.
2 Depending on the specialization, 2-3 credits are taken at the 6000 or 8000 level, and a maximum of 3 credits may be taken at the 5000 level. One final course (at least 2-3 credits) may be chosen from the courses and seminars offered in any of the specializations or other doctoral level courses offered by participating departments (e.g., Biological Sciences; Biomedical Engineering; Biomedical Sciences; Physical Therapy-Exercise Science; Mathematics, Statistics and Computer Science; Philosophy; and Psychology), as appropriate to individual training plans.
Specializations

BEHAVIORAL AND COGNITIVE NEUROSCIENCE

Students in this specialization acquire a foundational background in behavioral and cognitive processes and their neuroanatomical and neurophysiological foundations. Areas of focus include: perception, attention, learning, memory, executive functioning, social and affective functioning, reward, stress, mental health and disorders, development, aging and dementia.

Behavioral and cognitive neuroscience students must complete a minimum of 12 credit hours from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required course:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSYC 8740</td>
<td>Foundations and Processes of Human Cognition</td>
<td>3</td>
</tr>
<tr>
<td>or PSYC 8780</td>
<td>Biological Bases of Behavior</td>
<td></td>
</tr>
<tr>
<td>Choose three of the following (may not repeat). At least two courses must be from the PHIL or PSYC courses below:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSYC 8102</td>
<td>Advanced Statistics and Design 2 (or other approved advanced/applied statistics course)</td>
<td>9</td>
</tr>
<tr>
<td>PSYC 8740</td>
<td>Foundations and Processes of Human Cognition</td>
<td></td>
</tr>
<tr>
<td>PSYC 8780</td>
<td>Biological Bases of Behavior</td>
<td></td>
</tr>
<tr>
<td>PHIL 6440</td>
<td>Philosophy of Science</td>
<td></td>
</tr>
<tr>
<td>PHIL 6450</td>
<td>Philosophy of Mind</td>
<td></td>
</tr>
<tr>
<td>PHIL 6470</td>
<td>Problems in Metaphysics</td>
<td></td>
</tr>
<tr>
<td>PHIL 6959</td>
<td>Seminar in Philosophy (when topic approved by director)</td>
<td></td>
</tr>
</tbody>
</table>

Alternative course/seminar with director approval.

Cellular and Molecular Neuroscience

Students in this specialization acquire a foundational background in core neuroscience concepts including a strong understanding of both neuronal and non-neuronal cells of the nervous system, electrical/chemical mechanisms of synaptic signaling, structure/function of the nervous system, and behavioral, physiological, and cognitive outputs of the healthy and dysfunctional nervous system. Areas of focus include: fundamental processes underlying drug and alcohol addiction, stress, depression, schizophrenia, learning and memory, obesity and eating disorders, neurodegeneration, circadian biology, ion channel function and spinal cord injury.

Cellular and molecular neuroscience students must complete a minimum of 12 credit hours from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 8101</td>
<td>Protein Structure and Function</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 8102</td>
<td>Biochemistry and Function of Nucleic Acids</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 8202</td>
<td>Principles of Eukaryotic Genetics</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 8302</td>
<td>Protein Trafficking and Organelle Identity in Eukaryotic Cells</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 8603</td>
<td>Cell and Molecular Biology of Early Development</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 8704</td>
<td>Cellular Homeostasis</td>
<td>2</td>
</tr>
<tr>
<td>BISC 5155</td>
<td>Diseases of the Brain</td>
<td>3</td>
</tr>
<tr>
<td>BISC 6097</td>
<td>Laboratory Research in Neuroscience (Laboratory Research in Neuroscience)</td>
<td>1</td>
</tr>
<tr>
<td>BISC 8953</td>
<td>Seminar in Neuroscience</td>
<td>1</td>
</tr>
</tbody>
</table>

Alternative course/seminar with director approval.

Computational, Neurorehabilitation and Neuroimaging Neuroscience

Students in this specialization acquire a foundational background in computational modeling, neurorehabilitation and/or neuroimaging. Computational modeling explores processes from single neurons to neuronal networks including neural interconnections, neural signal processing, and synaptic plasticity. Neurorehabilitation explores the mechanisms and clinical and laboratory methods for studying neural disorders and the treatment strategies to address them. Neuroimaging neuroscience explores imaging physics, mathematics, and methods toward problems in basic and applied neuroscience. Areas of focus include: statistical models for magnetic resonance imaging, computational models of gene regulatory networks, predictive models of neurophysiological processes and clinical outcomes, human visuomotor processing, functional neuroimaging, brain structural and functional connectivity, spinal cord imaging and human motor control, neural and neurodevelopmental disorders, neurodegenerative diseases, and rehabilitative strategies.

Computational, neurorehabilitation and neuroimaging neuroscience students must complete a minimum of 12 credit hours from within focus area 1, 2 or 3. See course lists for each focus, below:
## Computational

**Code** | **Title** | **Hours**
---|---|---
MSSC 5760 | Time Series Analysis | 3
MSSC 5780 | Regression Analysis | 3
MSSC 6010 | Computational Probability | 3
MSSC 6020 | Statistical Simulation | 3
MSSC 6230 | Multivariate Statistical Analysis | 3
MSSC 6240 | Design and Analysis of Scientific Experiments | 3

Complete at least 12 credit hours for the Computational focus area:

### Statistical Analysis/Data Science courses
- MSSC 5760: Time Series Analysis
- MSSC 5780: Regression Analysis
- MSSC 6010: Computational Probability
- MSSC 6020: Statistical Simulation
- MSSC 6230: Multivariate Statistical Analysis
- MSSC 6240: Design and Analysis of Scientific Experiments

### Computer Science courses
- COSC 5600: Fundamentals of Artificial Intelligence
- COSC 5610: Data Mining
- COSC 5800: Principles of Database Systems
- COSC 6050: Elements of Software Development
- COSC 6060: Parallel and Distributed Systems

### Mathematical courses
- MSSC 6030: Applied Mathematical Analysis
- MSSC 6040: Applied Linear Algebra
- MSSC 6110: Applied Discrete Mathematics
- MSSC 6120: Optimization
- MSSC 6130: Dynamical Systems

Alternative course/seminar with director approval.

## Neurorehabilitation

**Code** | **Title** | **Hours**
---|---|---
EXRS 6001 | Applied and Rehabilitative Systems Physiology | 3
EXRS 6030 | Advanced Principles and Instrumentation in Biomechanics | 3
EXRS 6201 | Neurophysiological Principles in Disease and Rehabilitation | 3

Complete the following 12 credit hours for the Neurorehabilitation focus area:

Additional course/seminar with director approval.

## Neuroimaging

**Code** | **Title** | **Hours**
---|---|---
BIEN 5600 | Neural Engineering | 3
BIEN 6600 | Neuromotor Control | 3

Choose at least 12 credit hours for the Neuroimaging/Neuroengineering focus area:

### Neural Systems courses
- BIEN 5600: Neural Engineering
- BIEN 6600: Neuromotor Control

### Signal Processing courses
- BIEN 6200: Biomedical Signal Processing
- BIEN 6210: Advanced Biomedical Signal Processing
- BIEN 6220: Multidimensional Biomedical Time Series Analysis

### Modeling courses
- BIEN 5230: Intelligent Biosystems
- BIEN 5710: Analysis of Physiological Models

### Imaging courses
- BIEN 5500: Medical Imaging Physics
- BIEN 5510: Image Processing for the Biomedical Sciences
- BIEN 6500: Mathematics of Medical Imaging

Alternative course/seminar with director approval.
ACCELERATED BACHELOR'S-Doctoral DEGREE PROGRAM

The Graduate School offers a combined bachelor's-doctoral program available to outstanding Marquette University biomedical sciences undergraduate students. This program enables students to complete their undergraduate degree within the first year of the neuroscience graduate program, allowing them to complete their doctorate in less than traditional graduate students. Biomedical sciences undergraduate students can apply for early admission to the neuroscience doctoral program in the first term of their junior year. The cellular and molecular neuroscience specialization must be chosen. Students may request permission to move to another specialization, though requests are not guaranteed.

Students accepted into this program are eligible to enroll in up to 14 credits (7-8 credits/semester) of graduate neuroscience courses in their senior year that can be used to fulfill both undergraduate and graduate degree requirements. Interested students should contact their adviser early in their undergraduate career to plan the curriculum for the biomedical sciences major accordingly. Students must submit an application to the Graduate School, indicate their interest in the accelerated degree program and meet all other admission criteria as stated in the Application Requirements section. If accepted to the ADP, students must notify the Graduate School upon successful completion of bachelor’s degree, and their admission as a full-time graduate student is then activated.

University Policies

- Academic Censure - Graduate School
- Academic Integrity
- Academic Misconduct
- Academic Program Definitions
- Accelerated Degree Programs
- Attendance - Graduate School
- Awarding Diplomas and Certificates
- Background Checks, Drug Testing
- Class Rank
- Commencement
- Conferral of Degrees and Certificates
- Course Levels
- Credit Hour
- Credit Load - Graduate School
- Faculty Grading
- Family Education Rights and Privacy Act-FERPA
- Grade Appeals
- Grading System - Graduate School and Graduate School of Management
- Graduation - Graduate School
- Immunization and Tuberculosis Screening Requirements
- Last Date of Attendance/Activity
- Military Call to Active Duty or Training
- Registration - Graduate School
- Repeated Courses - Graduate School
- Student Data Use and Privacy
- Transcripts-Official
- Transfer Course Credit - Graduate School
- Withdrawal - Graduate School

Graduate School Policies

- Academic Performance
- Academic Programs Overview
- Advising
- Assistantships and Fellowships
- Certificate Concurrent Enrollment
- Conduct
- Confidentiality of Proprietary Information
NRSC 8001  Neuroscience Foundations 1 (4 credits)
Comprehensive survey of nervous system function at the cellular level including biochemical synthesis and degradation, receptors and intracellular signaling pathways. Same as BISC 8001; credit is not awarded for both.
Prerequisite: Admitted to NRSC program or cons. of instr.
Level of Study: Graduate
Last four terms offered: 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208001)

NRSC 8002  Neuroscience Foundations 2 (4 credits)
Comprehensive survey of nervous system function at the systems and behavioral level and includes motor, sensory and regulatory systems, imaging, cognitive and computational modeling. Same as BISC 8002; credit is not awarded for both.
Prerequisite: Admitted to NRSC program or cons. of instr.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208002)

NRSC 8003  Individual Development Plan (1 credits)
Guidance of students toward identifying their current interests to facilitate future career paths as well as develop a graduate career plan based on necessary skills and expertise. Same as BISC 8003; credit is not awarded for both.
Prerequisite: Admitted to NRSC program or cons. of instr.
Level of Study: Graduate
Last four terms offered: 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208003)

NRSC 8004  Science Writing and Ethics 1 (1 credits)
An introduction of scientific writing skills necessary for a successful career in science. Same as BISC 8004; credit is not awarded for both.
Prerequisite: BISC 8003 or NRSC 8003.
Level of Study: Graduate
Last four terms offered: 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208004)

NRSC 8005  Science Writing and Ethics 2 (1 credits)
Advanced writing skills necessary for grant writing. Same as BISC 8005; credit is not awarded for both.
Prerequisite: BISC 8004 or NRSC 8004.
Level of Study: Graduate
Last four terms offered: 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208005)

NRSC 8096  First Year Lab Rotations (1 credits)
Introductory lab rotations for first year graduate students based on mutual preferences of the student and faculty member. May include lab group meetings, literature search, bench work, presentation of findings and/or research plans to lab members. Same as BISC 8096; credit is not awarded for both.
Prerequisite: Admitted to NRSC program or cons. of instr.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208096)
NRSC 8931 Topics in Neuroscience (1-3 credits)
Subject matter varies as determined by needs of neuroscience graduate students. May be repeated, as subject matter changes. Same as BISC 8931; credit is not awarded for both.
Prerequisite: Admitted to NRSC program or cons. of instr.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208931)

NRSC 8999 Doctoral Dissertation (1-12 credits)
S/U grade assessment.
Prerequisite: Cons. of dept. ch.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%208999)

NRSC 9970 Graduate Standing Continuation: Less than Half-Time (0 credits)
Fee. SNC/UNC grade assessment. Designated as less than half-time status only, cannot be used in conjunction with other courses, and does not qualify students for financial aid or loan deferment.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209970)

NRSC 9974 Graduate Fellowship: Full-Time (0 credits)
Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209974)

NRSC 9975 Graduate Assistant Teaching: Full-Time (0 credits)
Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2022 Spring Term, 2021 Fall Term, 2021 Spring Term, 2020 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209975)

NRSC 9976 Graduate Assistant Research: Full-Time (0 credits)
Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2022 Spring Term, 2021 Fall Term, 2021 Spring Term, 2020 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209976)

NRSC 9987 Doctoral Qualifying Examination Preparation: Less than Half-Time (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week toward their doctoral qualifying exam.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2021 Spring Term, 2020 Fall Term, 2020 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209987)

NRSC 9988 Doctoral Qualifying Examination Preparation: Half-Time (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week toward their doctoral qualifying exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209988)
NRSC 9989  Doctoral Qualifying Examination Preparation: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week toward their doctoral qualifying exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Fall Term, 2021 Spring Term, 2020 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209989)

NRSC 9997  Doctoral Dissertation Continuation: Less than Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209997)

NRSC 9998  Doctoral Dissertation Continuation: Half-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209998)

NRSC 9999  Doctoral Dissertation Continuation: Full-Time  (0 credits)
Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.
Prerequisite: Cons. of program dir.
Level of Study: Graduate
Last four terms offered: 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=NRSC%209999)