# **Bioinformatics, MS**

Biological Sciences Chairperson: Michelle Mynlieff, Ph.D. Mathematical and Statistical Sciences Chairperson: Anne Clough, Ph.D. Program Director: Lisa Petrella, Ph.D. Bioinformatics website (https://www.marquette.edu/grad/programs-bioinformatics.php)

# **Degree Offered**

Master of Science, students are admitted under Plan B (non-thesis option) but Plan A (thesis option) is also offered

# **Program Description**

This interdisciplinary program is jointly offered by Marquette University and Medical College of Wisconsin. The program prepares students for a multidisciplinary career in the biomedical sciences using mathematics, statistics and computer science. It is designed to provide students quantitative tools for analyzing data and problems associated with molecular, cellular, physiological and particularly, genetic systems. Students may select courses from a list of approved courses offered by the following departments at Marquette: Computer Science; Mathematical and Statistical Sciences; Biology; Biomedical Engineering; and Electrical and Computer Engineering. In addition, courses are offered by the Department of Physiology and the Division of Biostatistics at Medical College of Wisconsin. The program meets the needs of recent undergraduates seeking an advanced degree as well as employed professionals interested in opportunities for career advancement.

Students may pursue the degree on a full-time or part-time basis. Many courses are offered evenings.

## **General Information**

Students interested in applying to the program should consult the program website (https://www.marquette.edu/grad/programs-bioinformatics.php) for a list of currently approved courses and scheduled course offerings for the next term.

Special registration for this program is required, as courses are taken at both institutions. Students must register for BIIN 6947 Medical College of Wisconsin/BIIN-Joint Degree through Marquette University and for the matching MCW course through Medical College of Wisconsin.

Students are admitted to the program under Plan B (non-thesis option), although with the co-directors' approval, students may elect to transfer to Plan A (thesis option). In both options below, courses taken for credit in this program must be from the list of courses approved by the steering committee. Exceptions must be approved by the steering committee.

All students are required to take a minimum of 18 credits at Marquette University. If taking the Medical College of Wisconsin alternative to BIIN 6000, students must register for both BIIN 6947 through Marquette and MCW 17150 Systems Biology through MCW. Any other courses taken at MCW, must receive permission from the program director and then register for both BIIN 6947 through MArquette and MCW 17150 Systems Biology through MCW.

### PLAN B Course OPTION (33 CREDITS)

Students must complete 33 credit hours of course work, of which at least 15 hours must be earned in 6000-level courses and above. Plan B Option students must take at least 18 credits at Marquette University.

Code	Title	Hours
BIOL 5201	Genomics and Bioinformatics	3
COSC 6050	Elements of Software Development	3
BIIN 6980	Practicum in Bioinformatics	3
BIIN 6947	Medical College of Wisconsin/BIIN-Joint Degree (and MCW 17150 Systems Biology)	3
or BIIN 6000	Introduction to Bioinformatics	
3 credits of approved computer science courses (6000-level or above) <sup>1</sup>		
COSC 6260	Advanced Algorithms	
COSC 6380	Big Data Systems	
COSC 6510	Data Intelligence	
COSC 6520	Data Analytics	
COSC 6570	Data at Scale	
Additional courses as approved	by director of graduate studies.	
3 credits of approved biological science courses <sup>1</sup>		
BIOL 5102	Experimental Molecular Biology	
BIOL 5401	Advanced Ecology	
BIOL 5404	Molecular Evolution	

BIOL 5532	Biochemistry 2: Bioenergetics and Metabolism	
BISC 5340	Human and Applied Medical Genetics	
CHEM 5530	Biochemistry 1: Macromolecular Structure and Function	
Additional courses as approved by	director of graduate studies.	
3 credits of approved statistical science	ce courses <sup>1</sup>	3
MSSC 5710	Mathematical Statistics	
MSSC 5720	Statistical Methods	
MSSC 5730	Introduction to R for Statistics and Data Science (1 credit) <sup>2</sup>	
MSSC 5740	Biostatistical Methods and Models	
MSSC 5750	Computational Statistics	
MSSC 5760	Time Series Analysis	
MSSC 5780	Regression Analysis	
MSSC 5790	Bayesian Statistics	
MSSC 6010	Computational Probability	
MSSC 6020	Statistical Simulation	
MSSC 6240	Design and Analysis of Scientific Experiments	
MSSC 6250	Statistical Machine Learning	
Additional courses as approved by	director of graduate studies.	
12 credits of approved electives <sup>1</sup>		12
BIIN 6947	Medical College of Wisconsin/BIIN-Joint Degree <sup>3</sup>	
BIIN 6995	Independent Study in Bioinformatics	
BIOL 5501	Cellular Neurobiology	
BIOL 5806	Immunobiology	
BISC 5145	Human Physiology	
BISC 5155	Diseases of the Brain	
BISC 5160	Human Molecular Pathology and Clinical Therapeutics	
BISC 5325	Endocrinology	
BISC 5342	Epigenetics and Human Disease	
BISC 5850	Systems Neuroscience	
BISC 7514	Human Microanatomy	
COSC 5500	Visual Analytics	
COSC 5610	Data Mining and Machine Learning	
COSC 5800	Principles of Database Systems	
COSC 6330	Advanced Machine Learning	
COSC 6820	Data Ethics	
MSSC 5540	Numerical Analysis	
MSSC 5630	Mathematical Modeling and Analysis	
MSSC 5700	Theory of Probability	
MSSC 6000	Scientific Computing	
MSSC 6030	Applied Mathematical Analysis	
MSSC 6040	Applied Linear Algebra	
Additional courses as approved by	director of graduate studies.	

### **Total Credit Hours:**

<sup>1</sup> Courses not taken to fulfill specified requirements may be used toward elective credits.

<sup>2</sup> MSSC 5730 Introduction to R for Statistics and Data Science must be taken concurrently with MSSC 5720 Statistical Methods or MSSC 5740 Biostatistical Methods and Models.

<sup>3</sup> Program director must approve the specific course being taken at the Medical College of Wisconsin.

33

### PLAN A Thesis OPTION (33 CREDITS)

Students must complete 27 credit hours of course work, of which at least 18 credit hours must be earned in 6000-level courses and above. Plan A Option students must take at least 15 credits at Marquette University. Students must also complete a master's thesis for 6 credit hours and pass an oral examination concentrated on the thesis.

Code	Title	Hours		
BIOL 5201	Genomics and Bioinformatics	3		
COSC 6050	Elements of Software Development	3		
BIIN 6980	Practicum in Bioinformatics	3		
BIIN 6947	Medical College of Wisconsin/BIIN-Joint Degree (and MCW 17150 Systems Biology)	3		
or BIIN 6000	Introduction to Bioinformatics			
3 credits of approved computer science courses (6000-level or above) <sup>1</sup>				
COSC 6260	Advanced Algorithms			
COSC 6380	Big Data Systems			
COSC 6510	Data Intelligence			
COSC 6520	Data Analytics			
COSC 6570	Data at Scale			
Additional courses as approved by	/ director of graduate studies.			
3 credits of approved biological scien	ice courses <sup>1</sup>	3		
BIOL 5102	Experimental Molecular Biology			
BIOL 5401	Advanced Ecology			
BIOL 5404	Molecular Evolution			
BIOL 5532	Biochemistry 2: Bioenergetics and Metabolism			
BISC 5340	Human and Applied Medical Genetics			
CHEM 5530	Biochemistry 1: Macromolecular Structure and Function			
Additional courses as approved by	/ director of graduate studies.			
3 credits of approved statistical scien	ce courses <sup>1</sup>	3		
MSSC 5710	Mathematical Statistics			
MSSC 5720	Statistical Methods			
MSSC 5730	Introduction to R for Statistics and Data Science (1 credit) <sup>2</sup>			
MSSC 5740	Biostatistical Methods and Models			
MSSC 5750	Computational Statistics			
MSSC 5760	Time Series Analysis			
MSSC 5780	Regression Analysis			
MSSC 5790	Bayesian Statistics			
MSSC 6010	Computational Probability			
MSSC 6020	Statistical Simulation			
MSSC 6240	Design and Analysis of Scientific Experiments			
MSSC 6250	Statistical Machine Learning			
Additional courses as approved by	/ director of graduate studies.			
6 credits of approved electives <sup>1</sup>		6		
BIIN 6947	Medical College of Wisconsin/BIIN-Joint Degree <sup>3</sup>			
BIIN 6995	Independent Study in Bioinformatics			
BIOL 5501	Cellular Neurobiology			
BIOL 5806	Immunobiology			
BISC 5145	Human Physiology			
BISC 5155	Diseases of the Brain			
BISC 5160	Human Molecular Pathology and Clinical Therapeutics			
BISC 5325	Endocrinology			
BISC 5342	Epigenetics and Human Disease			
BISC 5850	Systems Neuroscience			
BISC 7514	Human Microanatomy			
COSC 5500	Visual Analytics			

Г	otal Credit Hours		33
31	IN 6999	Master's Thesis	6
	Additional courses as approved by	director of graduate studies.	
	MSSC 6040	Applied Linear Algebra	
	MSSC 6030	Applied Mathematical Analysis	
	MSSC 6000	Scientific Computing	
	MSSC 5700	Theory of Probability	
	MSSC 5630	Mathematical Modeling and Analysis	
	MSSC 5540	Numerical Analysis	
	COSC 6820	Data Ethics	
	COSC 6330	Advanced Machine Learning	
	COSC 5800	Principles of Database Systems	
	COSC 5610	Data Mining and Machine Learning	

#### **Total Credit Hours:**

1 Courses not taken to fulfill specified requirements may be used toward elective credits.

- 2 MSSC 5730 Introduction to R for Statistics and Data Science must be taken concurrently with MSSC 5720 Statistical Methods or MSSC 5740 Biostatistical Methods and Models.
- 3 Program director must approve the specific course being taken at the Medical College of Wisconsin.

### ACCELERATED BACHELOR'S-MASTER'S DEGREE PROGRAM

The accelerated degree program in bioinformatics allows Marguette University students to earn both a bachelor's degree and a master's degree in bioinformatics in five years. This option is especially well-suited for students interested in pursuing careers in data science with applications in biology or biomedical science. Interested students with at least junior standing must meet the following criteria in order to apply for the ADP:

- Students must have a minimum cumulative undergraduate GPA of 3.000.
- Students must be enrolled in the undergraduate bioinformatics minor/major or have completed BIOL 1001 General Biology 1, BIOL 3201 Genetics or BISC 4340 Human and Applied Medical Genetics, COSC 1020 Object-Oriented Software Design and COSC 2100 Data Structures by the end of the junior year.

Students participating in this program are granted early admission to the Graduate School and should complete 12 hours of approved graduate courses toward the bioinformatics master's during the senior undergraduate year that also count as part of the undergraduate credit hour requirement. The Graduate School administratively transfers credits for ADP students during the summer term each year.

For additional information, interested students should contact the program co-directors for the master's program in bioinformatics.

### **University Policies**

- Academic Censure Graduate School (https://bulletin.marquette.edu/policies/academic-censure/graduate/)
- Academic Integrity (https://bulletin.marguette.edu/policies/academic-integrity/)
- Academic Misconduct (https://bulletin.marguette.edu/policies/academic-misconduct-policy/)
- Academic Program Definitions (https://bulletin.marguette.edu/policies/academic-programs-defined/)
- Accelerated Degree Programs (https://bulletin.marquette.edu/policies/accelerated-degree-programs/)
- Attendance Graduate School (https://bulletin.marquette.edu/policies/attendance/graduate/)
- Awarding Diplomas and Certificates (https://bulletin.marquette.edu/policies/awarding-diplomas-certificates/)
- Background Checks, Drug Testing (https://bulletin.marquette.edu/policies/background-checks-drug-testing/)
- Class Rank (https://bulletin.marquette.edu/policies/class-rank/)
- · Commencement (https://bulletin.marquette.edu/policies/commencement/)
- · Course Levels (https://bulletin.marquette.edu/policies/course-levels/)
- Credit Hour (https://bulletin.marguette.edu/policies/credit/)
- Credit Load Graduate School (https://bulletin.marquette.edu/policies/credit-load/graduate/)
- · Faculty Grading (https://bulletin.marquette.edu/policies/faculty-grading/)
- Family Education Rights and Privacy Act-FERPA (https://bulletin.marquette.edu/policies/ferpa/)
- Grade Appeals (https://bulletin.marguette.edu/policies/grade-appeals/)
- · Grading System Graduate School and Graduate School of Management (https://bulletin.marquette.edu/policies/grading-system/graduatemanagement/)
- Graduation Graduate School (https://bulletin.marguette.edu/policies/graduation/graduate/)

- Immunization and Tuberculosis Screening Requirements (https://bulletin.marquette.edu/policies/immunization-and-tuberculosis-screening/)
- Last Date of Attendance/Activity (https://bulletin.marquette.edu/policies/last-dateof-attendance-activity/)
- Military Call to Active Duty or Training (https://bulletin.marquette.edu/policies/militarycall-active-duty-training/)
- · Registration Graduate School (https://bulletin.marquette.edu/policies/registration/graduate/)
- Repeated Courses Graduate School (https://bulletin.marquette.edu/policies/repeated-courses/graduate/)
- · Student Consumer Complaints (https://bulletin.marquette.edu/policies/student-complaints/)
- Student Data Use and Privacy (https://bulletin.marquette.edu/policies/student-data-use-privacy/)
- Transcripts-Official (https://bulletin.marquette.edu/policies/transcripts-official/)
- Transfer Course Credit Graduate School (https://bulletin.marquette.edu/policies/transfer-course-credit-policy/graduate/)
- Withdrawal Graduate School (https://bulletin.marquette.edu/policies/withdrawals/graduate/)

### Graduate School Policies

- Academic Performance (https://bulletin.marquette.edu/graduate/policies/academic-performance/)
- Advising (https://bulletin.marquette.edu/graduate/policies/advising/)
- Certificate Concurrent Enrollment (https://bulletin.marquette.edu/graduate/policies/certificate-concurrent-enrollment/)
- · Conduct (https://bulletin.marquette.edu/graduate/policies/conduct/)
- Confidentiality of Proprietary Information (https://bulletin.marquette.edu/graduate/policies/confidentiality-proprietary-information/)
- · Continuous Enrollment (https://bulletin.marquette.edu/graduate/policies/continuous-enrollment/)
- Courses and Prerequisites (https://bulletin.marquette.edu/graduate/policies/courses-prerequisites/)
- · Cross-listed Courses (https://bulletin.marquette.edu/graduate/policies/cross-listed-courses/)
- · Deadlines (https://bulletin.marquette.edu/graduate/policies/deadlines/)
- Doctoral Degree Academic Program Overview (https://bulletin.marquette.edu/graduate/policies/doctoral-program-overview/)
- Dual/Joint Programs of Study (https://bulletin.marquette.edu/graduate/policies/dual-joint-programs/)
- Graduate Credit (https://bulletin.marquette.edu/graduate/policies/graduate-credit/)
- Graduate School Policies (https://bulletin.marquette.edu/graduate/policies/)
- Independent Study (https://bulletin.marquette.edu/graduate/policies/independent-study/)
- Intellectual Property (https://bulletin.marquette.edu/graduate/policies/intellectual-property/)
- Master's Degree Academic Program Overview (https://bulletin.marquette.edu/graduate/policies/masters-program-overview/)
- Merit-Based Aid Registration Requirements (https://bulletin.marquette.edu/graduate/policies/merit-based-aid-registration-requirements/)
- Research Involving Humans, Animals, Radioisotopes or Recombinant DNA/Transgenic Organisms (https://bulletin.marquette.edu/graduate/policies/ research-involving-humans-animals-radioisotopes-recombinant-dnatransgenic-organisms/)
- Temporary Withdrawal from Graduate Program (https://bulletin.marquette.edu/graduate/policies/temporary-withdrawal-graduate-program/)
- Time Limitations (https://bulletin.marquette.edu/graduate/policies/time-limitations/)
- · Working with Minors (https://bulletin.marquette.edu/graduate/policies/working-minors/)

### **Bioinformatics Related Programs**

- Applied Statistics, MS (https://bulletin.marquette.edu/graduate/applied-statistics-ms/)
- Data Science, MS (https://bulletin.marquette.edu/graduate/data-science-ms/)

#### BIIN 6000 Introduction to Bioinformatics (3 credits)

The application of knowledge gained through previous course work in informatics, information systems, mathematics, medical and/or biological research to the design, development, implementation and evaluation of information systems and analysis methods applied to biomedical data. *Prerequisite:* BIOL 1004 and CHEM 2112 which may be taken concurrently; and COSC 2100; and cons. of dept. ch. Consent required. *Level of Study:* Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206000)

#### BIIN 6931 Topics in Bioinformatics (3 credits)

Topics vary. Students may enroll more than once as the subject matter changes.

Prerequisite: Cons. of dept. ch. Consent required.

Level of Study: Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206931)

### BIIN 6947 Medical College of Wisconsin/BIIN-Joint Degree (1-8 credits)

Graduate-level course in selected areas of the life sciences offered at Medical College of Wisconsin.

Prerequisite: Cons. of dept. ch. Consent required.

Level of Study: Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206947)

#### BIIN 6960 Seminar in Bioinformatics (1-3 credits)

Seminars in research and development tools and applications designed for M.S. in bioinformatics program. *Level of Study:* Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206960)

#### BIIN 6980 Practicum in Bioinformatics (3 credits)

An opportunity to participate in the practice of research and/or development in the area of bioinformatics.

Prerequisite: Admitted to BIIN program; BIIN 6000; and cons. of dept. ch. Consent required.

Level of Study: Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206980)

#### BIIN 6995 Independent Study in Bioinformatics (1-3 credits)

An in-depth study on a topic or subject matter usually not offered in the established curriculum with faculty and independent of the classroom setting. *Prerequisite:* Admitted to BIIN program; cons. of dept. ch. Consent required.

Level of Study: Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206995)

### BIIN 6999 Master's Thesis (1-6 credits)

S/U grade assessment.

Prerequisite: Cons. of dept. ch. Consent required.

Level of Study: Graduate

Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIIN%206999)