

SYSTEMS BIOLOGY AND BIOINFORMATICS, MS

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Degree: Master of Science (MS)

Field of Study: Systems Biology and Bioinformatics

Program Overview

Do you want to convert big data into understandable models that just might change the world? With a graduate degree in systems biology and bioinformatics, you can combine your love of math, statistics, computers and biology to develop computational models with which to provide new insight and understanding of big data, leading to big discoveries in both laboratory and clinical settings.

Data science is the convergence of data engineering, math, statistics, advanced computing, the scientific method and subject-matter expertise. It involves the collection, management and transformation of "big data" into actionable information that can answer some of the world's most pressing problems. Yet there is a distinct need for data science experts who can efficiently interpret data into information that is useful for strategic decision-making. It is the goal of the Systems Biology and Bioinformatics program to produce the scientists that are needed to assist in extracting meaning from the burgeoning biological 'omics field.

The SYBB program offers a multidisciplinary training program personally customized to the student leading to an MS or PhD. The program draws training faculty (currently 38 trainers) from more than 12 departments and 6 schools across the CWRU campus, ensuring students in the program acquire the core competencies needed to succeed in the bioinformatics analysis of biological big data.

The SYBB participating departments and centers include:

- Biology
- Biomedical Engineering
- Case Comprehensive Cancer Center
- Cleveland Clinic Lerner College of Medicine
- Center for Proteomics and Bioinformatics
- Center for Systems Immunology
- Electrical Engineering and Computer Science
- Epidemiology and Biostatistics
- Genetics and Genome Sciences
- Mathematics
- Nutrition
- Physiology and Biophysics
- Pharmacology

Program Competencies

The specific academic requirements of the SYBB Program are intended to provide students with a required core curriculum in Systems Biology and a set of electives designed both to assure minimum competencies in **Fundamental Core Competencies** and equip them for their particular thesis research discipline. Each trainee will be guided in their customized course of study by a mentoring committee to ensure the completion of training in the program competencies as well as maintenance of a focus on molecular systems theory. These competencies include:

- Evaluation of the scientific discovery process and of the role of bioinformatics in it in detail, including data generation steps and understanding biology
- Application of computational and statistical methods appropriate to solve a given scientific problem
- Construction of software systems of varying complexity based on design and development principles
- Effective teamwork to accomplish a common scientific goal
- Building knowledge in local and global impact of bioinformatics and systems biology on individuals, organizations, and society
- Effective communication of bioinformatics and systems biology problems to a range of audiences, including, but not limited to, other bioinformatics professionals.

Graduate Policies

For graduate policies and procedures, please review the School of Graduate Studies section of the General Bulletin.

Program Requirements

Masters Degree Plan A Summary

The minimum requirements for the master's degree under Plan A are 21 semester hours of course work plus a thesis equivalent to at least 9 semester hours of registration for 30 hours total. These must include **SYBB 501** Biomedical Informatics and Systems Biology Journal Club, and a minimum of 9 hours of **SYBB 651** Thesis MS. Additional required courses for the Translational Bioinformatics and Molecular and Computational Biology tracks are **SYBB 459** Bioinformatics for Systems Biology and **SYBB 555** Current Proteomics. The curriculum plan must be approved by the program steering committee and include appropriate coverage of the core competencies in genes and proteins, bioinformatics, and quantitative modeling and analysis. At least 18 semester hours of course work, in addition to thesis hours, must be at the 400-level or higher.

Each student must prepare an individual thesis that must conform to regulations concerning format, quality, and time of submission as established by the dean of graduate studies as well as conforming to the SYBB program guidelines. For completion of master's degrees under Plan A, an oral examination (defense) of the master's thesis is required, where the examination is conducted by a committee of at least three members of the university faculty.

Masters Degree Plan B Summary

The minimum requirements for the master's degree under Plan B are 30 semester hours of course work (with at least 18 semester hours of course work at the 400 level or higher) and a written comprehensive examination or major project with report to be administered and evaluated by the program steering committee. The coursework must include **SYBB 501** Biomedical Informatics and Systems Biology

Journal Club. Additional required courses for the Translational Bioinformatics and Molecular and Computational Biology tracks are **SYBB 459** Bioinformatics for Systems Biology and **SYBB 555** Current Proteomics. The curriculum plan must be approved by the program steering committee and include appropriate coverage of the core competencies in genes and proteins, bioinformatics, and quantitative modeling and analysis.

Required Core Courses

Code	Title	Hours
SYBB 459	Bioinformatics for Systems Biology	3
SYBB 555	Current Proteomics and Bioinformatics	3
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
SYBB 601	Systems Biology and Bioinformatics Research	up to 9
SYBB 651	Thesis M.S. (For MS Students only) * ⁹ credits for Plan A, 0 credits for Plan B	*
SYBB 701	Dissertation Ph.D. (For PhD students only)	18

Elective Courses

Genes and Proteins Courses

Code	Title	Hours
PHOL/CHEM/ PHRM/BIOC/ NEUR 475	Protein Biophysics	3
PHOL 456		
PHOL 480	Physiology of Organ Systems	4
IBMS 453	Cell Biology I	3
IBMS 455	Molecular Biology I	3
BIOC 452	Nutritional Biochemistry and Metabolism	3
BIOC 412	Proteins and Enzymes	3
BIOC 420	Current Topics in Cancer	3
BIOC 454	Biochemistry and Biology of RNA	3
SYBB 528	Contemporary Approaches to Drug Discovery	3
BETH 412	Ethical Issues in Genetics/Genomics	3

Bioinformatics and Computational Biology Courses

Code	Title	Hours
BIOL/ECSE 419	Applied Probability and Stochastic Processes for Biology	3
PQHS 451	A Data-Driven Introduction to Genomics and Human Health	3
CSDS 458	Introduction to Bioinformatics	3
NEUR 478/ BIOL 378/COGS/ MATH 378/ BIOL 478/EBME 478	Computational Neuroscience	3
SYBB 411A	Survey of Bioinformatics: Technologies in Bioinformatics	1
SYBB 411B	Survey of Bioinformatics: Data Integration in Bioinformatics	1
SYBB 411C	Survey of Bioinformatics: Translational Bioinformatics	1

SYBB 412	Survey of Bioinformatics: Programming for Bioinformatics	3
SYBB 459	Bioinformatics for Systems Biology	3
SYBB 472	BioDesign	3

Quantitative Analysis and Modeling

Code	Title	Hours
MPHP 405	Statistical Methods in Public Health	3
PQHS 431	Statistical Methods I	3
PQHS 432	Statistical Methods II	3
CSDS 435	Data Mining	3
PQHS 515	Secondary Analysis of Large Health Care Databases	3
PQHS 480	Introduction to Mathematical Statistics	3
CSDS 440	Machine Learning	3
MATH 441	Mathematical Modeling	3
EBME 300/ MATH 449	Dynamics of Biological Systems: A Quantitative Introduction to Biology	3
MIDS 301	Introduction to Information: A Systems and Design Approach	3
PQHS 457	Current Issues in Genetic Epidemiology: Design and Analysis of Sequencing Studies	3
PQHS 451	A Data-Driven Introduction to Genomics and Human Health	3
PQHS 452	Statistical Methods for Genetic Epidemiology	3
PQHS 453	Categorical Data Analysis	3
PQHS 459	Longitudinal Data Analysis	3

Part-time SYBB MS program

The program in systems biology and bioinformatics offers a flexible curriculum with a minimal number of required classes (SYBB 501 Biomedical Informatics and Systems Biology Journal Club), SYBB 459 Bioinformatics for Systems Biology, SYBB 555 Current Proteomics and Bioinformatics are the only required classes); the majority of classes taken toward the MS are tailored to the student's research interests and thesis project. This flexibility enables students that are interested in pursuing the MS on a part-time basis to maximize employee tuition benefits. A CWRU employee (or spouse) has a total of 15 credit hours/year (6 per semester and 3 per summer session) with which to pursue a degree. Taking only this number will net a part-time student an MS in 5 semesters and 2 summer sessions; not taking a class during the summer sessions will result in taking 6 semesters to get the MS; and if a student were to take a single class a semester, it would take 11 semesters to reach the requisite number of classes needed for the MS.

Concentration Requirements

The Case Western Reserve University (CWRU) graduate program in Systems Biology and Bioinformatics (SYBB) has two tracks:

Translational Bioinformatics

The SYBB track in Translational Bioinformatics poises students to work at the interface of applied 'omics research and clinical medicine. From integrating genomic and functional genomic data into electronic medical records, to developing meta-analysis tools for communicating genomic risk to patients to utilizing this data in personalized medicine. Students trained in the Translational Bioinformatics track work to integrate bioinformatics tools and technologies into clinical workflows. Graduates

of this training track will find ample opportunities within industry and, as genomics enters the clinical arena, within hospitals, as well.

Molecular and Computational Biology

The SYBB track in Molecular and Computational Biology embraces the pursuit of basic science research, employing the application and development of computational approaches to address difficult questions derived from today's "Big data" derived from 'omics approaches. This track equips students in the acquisition of experimental data utilizing approaches including proteomics, metabolomics, genomics and structural biology and extends this work with interpretation provided by computational analysis. Graduates of this training track will find ample opportunities within the pharmaceutical industry, contract research organizations as well as more traditional academic career paths.

Sample Plan of Study

Molecular and Computational Biology Track

First Year

Fall		Hours
SYBB 411A	Survey of Bioinformatics: Technologies in Bioinformatics	1
SYBB 411B	Survey of Bioinformatics: Data Integration in Bioinformatics	1
SYBB 411C	Survey of Bioinformatics: Translational Bioinformatics	1
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
PQHS 431	Statistical Methods I	3
Topical Elective from Elective Course List		3
Hours		9

Spring

SYBB 412	Survey of Bioinformatics: Programming for Bioinformatics	3
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
SYBB 555	Current Proteomics and Bioinformatics	3
Additional 3 Credit Course TBD		3
Hours		9

Second Year

Fall		
CSDS 440	Machine Learning	3
BIOC 475	Protein Biophysics	3
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
SYBB 651	Thesis M.S.	3
Hours		9
Spring		
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
SYBB 651	Thesis M.S.	3-6
Hours		3-6
Total Hours		30-33