

SYSTEMS BIOLOGY AND BIOINFORMATICS, PHD

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More Information: <https://case.edu/medicine/nutrition/sybb>

Degree: Doctor of Philosophy (PhD)

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.

Admissions

Students are admitted to this PhD program through the Biomedical Sciences Training Program (BSTP) or the Medical Scientist Training Program (MSTP).

Biomedical Sciences Training Program (BSTP)

The BSTP offers a common entry point to most of the School of Medicine's biomedical PhD programs. BSTP students can choose among research mentors in many different PhD programs in the School of Medicine.

Medical Scientist Training Program (MSTP)

Students in the MSTP earn the dual MD/PhD degree. MSTP students also have the choice of mentors in many different PhD programs. The admission requirements of those programs can be viewed on their pages in the Bulletin. Program requirements for the dual can be found on the Medical Scientist Training Program, PhD/Medicine, MD program page.

PhD Policies

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

Program Requirements

The Systems Biology and Bioinformatics program differs from current CWRU programs in the comprehensive requirement for an understanding of biological systems, bioinformatics, and quantitative analysis & modeling. The program includes a minimal set of required courses including (SYBB 501) and a course in the Responsible Conduct of research (IBMS 500). Additional required courses for the Translational Bioinformatics and Molecular and Computational Biology tracks are SYBB 459 and SYBB 555. At least six additional courses will be required based upon individualized student interests. Other requirements include a qualifier exam, a PhD Dissertation, and oral defense. The total credits required for the PhD is at least 54 credit hours: 24 graded credit hours, 12 pre-dissertation research credit hours, and at least 18 dissertation research credit hours. Admissions to this program may be obtained through the integrated **Biomedical Sciences Training Program**, by direct

admission to the department in rare cases or via the **Medical Scientist Training Program**.

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	0-9
SYBB 651	Thesis M.S. ^a	0-9
SYBB 701	Dissertation Ph.D.	18

a 9 credit hours for Plan A students, 0 credit hours for Plan B students.

Elective Courses

Genes and Proteins Courses

Code	Title	Hours
PHOL/CHEM/ PHRM/BIOC/ NEUR 475	Protein Biophysics	3
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
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

Biomedical Sciences Training Program (BSTP) Requirements

Coursework

Students take integrated courses in Cell and Molecular Biology (IBMS 453, IBMS 455). They also complete a course in biostatistics (IBMS 450) and a literature based reading course (IBMS 456A). These four courses, offered in the fall semester, emphasize the molecular approaches that form the basis of modern biology. We also seek students with strong quantitative training who may have majored in physics or math, and offer alternative courses for these students to acquire foundations in biology. Qualified students also may take more specialized elective courses. All students take IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research.

Research Rotations

The research rotations allow students to explore research areas and become familiar with faculty members and their laboratories. The main purpose of these rotations is to aid students in selecting a laboratory for their thesis work. Students are encouraged to begin their rotations in July. Doing so gives them the opportunity to complete rotations during the summer before classes begin at the end of August. Students must complete at least three rotations.

Choosing a Thesis Advisor

During the first year, students select an advisor for their dissertation research. Each student also joins the PhD program with which their advisor is affiliated. Once students choose a PhD program, the requirements of that program are followed to obtain the PhD. The emphasis of the PhD work is on research, culminating in the completion of an original, independent research thesis and publishing the results in the scientific literature. PhD programs also focus on educating students to work as professional scientists.

Sample Plan of Study

Plan of study includes required courses as well as electives. Please review the Nutrition Department's website for additional information.

Translational Bioinformatics Track

First Year

Fall		Hours
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
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
IBMS 453	Cell Biology I	3
IBMS 455	Molecular Biology I	3
SYBB 601	Systems Biology and Bioinformatics Research	1-9
Hours		10-18
Spring		
SYBB 412	Survey of Bioinformatics: Programming for Bioinformatics	3
SYBB 555	Current Proteomics and Bioinformatics	3
SYBB 459	Bioinformatics for Systems Biology	3
SYBB 601 & SYBB 651	Systems Biology and Bioinformatics Research and Thesis M.S.	1-9
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
IBMS 500	On Being a Professional Scientist: The Responsible Conduct of Research	1
Hours		11-19

Second Year

Fall		
SYBB 528	Contemporary Approaches to Drug Discovery	3
SYBB 421	Fundamentals of Clinical Information Systems	3
PQHS 431	Statistical Methods I	3
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
Hours		9
Spring		
SYBB 472	BioDesign	3
SYBB 501	Biomedical Informatics and Systems Biology Journal Club	0
SYBB 601	Systems Biology and Bioinformatics Research	3
PQHS 432	Statistical Methods II	3
Hours		9

Third Year

Fall		
SYBB 701	Dissertation Ph.D.	1 - 9
Hours		1-9

Spring

SYBB 701	Dissertation Ph.D.	1 - 9
Hours		1-9

Fourth Year

Fall		
SYBB 701	Dissertation Ph.D.	1 - 9
Hours		1-9

Spring

SYBB 701	Dissertation Ph.D.	1 - 9
Hours		1-9

Fifth Year

Fall		
SYBB 701	Dissertation Ph.D.	1 - 9
Hours		1-9

Spring

SYBB 701	Dissertation Ph.D.	1 - 9
IBMS 501	Responsible Conduct of Research for Advanced Trainees	0
Hours		1-9
Total Hours		45-109