Computational & Systems Biology, PhD

Degree Requirements

Computational & Systems Biology

The Computational and Systems Biology Program is a graduate training program at WashU, housed under the Roy and Diana Vagelos Division of Biology and Biomedical Sciences (DBBS).

The goal of the Computational and Systems Biology Program is to train the next generation of scientists in technology intensive, quantitative, systems level approaches to molecular biology. We aim to graduate students who are as comfortable operating the latest high-end instrumentation as they are manipulating the mathematical formalisms that are required to make sense of their data. It is our hope that the students who join the Computational and Systems Biology Program will apply these approaches to unravel the complex genetic circuits that control the cell and to understand the genetics of human disease.

Technological advances are having a major impact on molecular biology. Advances in experimental techniques mean that large amounts of sequence, expression, and localization data are now routinely gathered by individual investigators. In addition, terabytes of these kinds of data are stored in various public and private databases. Concurrently, access to large scale computing resources has become more and more common in molecular biology laboratories. Students in the Computational and Systems Biology Program will learn to leverage these advances in both experimental and computational resources.

Some of the general areas in which faculty work include the following:

- Large-scale genetic network analysis and reconstruction
- Technology development for high-throughput collection of genetic and biochemical data
- Molecular modeling of genetic regulatory circuits
- Real time, single cell analyses of genetic regulatory circuits
- Specificity and evolution of DNA-protein interactions
- Algorithm development for comparison of DNA, RNA, and protein sequences
- Synthetic biology
- Human microbiome and other health-relevant microbial communities
- Complex trait analysis
- Population genetic analysis of genetic variation
- Functional genomic approaches to disease gene identification

To earn a PhD at within the Roy and Diana Vagelos Division of Biology and Biomedical Sciences at Washington University, a student must complete all courses required by their department; maintain satisfactory academic progress; pass the qualifying examination; complete all requirements for doctoral candidacy; create a Research Advisory Committee (RAC); submit a Title, Scope, and Procedure Form; fulfill residence and Mentored Experience Requirements; write, defend, and submit a dissertation; and apply for program completion (graduation) via Workday Student.

Program Requirements

- **Total Units Required:** 36 units
- **Degree Length:** Seven years
  - Students are expected to maintain satisfactory academic progress in accordance with academic milestones. Students entering their seventh year in the program will receive a warning letter in regards to reaching their stated degree length. Students entering their eighth year in the program will be required to obtain permission from the Associate Dean of Graduate Education. Across DBBS programs, the average time to degree is 5.6 years.
  - **Note:** Students must be enrolled in 9 graduate credits each semester to retain full-time status. As students complete their coursework, if enrolled in fewer than 9 graduate credits, they must enroll in a specific Biology & Biomedical Sciences research graduate course to maintain full-time status. Prior to completing 36 credit units, student will enroll in BBS 5900 Research for research credit; after completing 36 credit units, students will enroll in BBS 9000 Full-Time Graduate Research/ Study, which will show 0 credit units but fulfills full-time status. Students should follow advising instructions to ensure proper enrollment prior to Add/Drop.
  - Continued support is guaranteed for the duration of the student's graduate studies, provided that the student maintains satisfactory progress toward completion of the degree.
- **Grade Requirement:** Required courses generally consist of four to nine courses in areas fundamental to the student's program. Students are expected to maintain a B average in graduate courses.

Required Courses

DBBS Required Courses

- BBS 5098 Graduate Research Fundamentals
- BBS 5011 Ethics & Research Science

Program Required Courses

- CSE 5807 Algorithms for Computational Biology
- BBS 5488 Genomics

Three Advanced Electives

In consultation with their advisor, students choose a minimum of three advanced electives or special topics of at least 3 credit units each. Students may substitute one of these three elective requirements by combining multiple 1- and 2-credit courses totaling at least 3 credits. To pursue this substitution option, students must submit a petition in advance to the Program Directors for each 1- or 2-credit course that they wish to substitute with a brief rationale. Because students will be expected to demonstrate substantive command of molecular biology, applied mathematics, and computer science in their qualifying exam, the advanced electives will typically be chosen in areas in which the student does not feel adequately prepared or will emphasize areas of primary interest for the student. The interdisciplinary nature of the program allows considerable flexibility in choosing these courses, depending upon the student's needs. Common choices for these electives include the following:

- BBS 5014 Biotech Industry Innovators
- BBS 5312 Macromolecular Interactions
- BBS 5357 Chemistry and Physics of Biomolecules
- BBS 5483 Human Genetic Analysis
- BBS 5491 Advanced Genetics
- SDS 5210 Statistical Computation
- SDS 5010 Probability
- SDS 5020 Mathematical Statistics
- CSE 5104 Data Mining
- SDS 5480 Topics in Statistics : Machine Learning Methods in Biological Sciences
- INFO 5558 Applications of Deep Neural Networks
- MSB 5555 Computational Statistical Genetics
- BBS 5910 Nano Topics in Biology and Biomedical Sciences

Three Semesters of Journal Clubs

Students are required to register for three semesters of journal clubs. First-year students must enroll in BBS 5496 Seminar in Computational Molecular Biology for two semesters and then may choose another journal club or seminar to fulfill their third semester, as long as it has a presentation requirement. Students may take BBS 5496 Seminar in Computational Molecular Biology for a third time to fulfill the final requirement, if interested.

Laboratory Rotations

Selecting a thesis advisor is the most important decision a student makes in graduate school. To help each student make an informed, thoughtful choice, the Division builds in flexibility to explore options. Students usually participate in three lab rotations during their first year. Additional rotations can be arranged, and rotation lengths are flexible. Students usually begin their thesis research by the end of their first year.

Scientific Scholarship

Keeping abreast of scientific developments is critical for faculty and students alike. The Division offers many ways to stay current. More than 15 weekly biology seminars provide excellent opportunities to meet outstanding scientists from outside Washington University. Several annual symposia bring internationally recognized speakers to campus. Journal clubs meet weekly for students, postdoctoral fellows and faculty to present and discuss current scientific literature. A number of Interdisciplinary Research Pathways allow students to enhance their PhD program. Program retreats allow for informal interaction among students and faculty. The Division also provides funds for each student for professional development.

Mentored Experience Implementation Plan

As part of their degree requirements, PhD students must complete a program-defined Mentored Experience Requirement (MER) as per these guidelines. The Mentored Experience Implementation Plan (MEIP) is the written articulation of a program-defined degree requirement for PhD students to engage in mentored teaching activities and/or mentored professional activities, collectively referred to as *MERs.*

Mentored Experience Requirements (MERs)

Philosophy of Teaching

Effective communication of information and concepts is a critical skill for biomedical research scientists. Although much of the teaching that scientists engage in is through one-on-one interactions with individuals in the laboratory, all scientists must have fundamental instruction in and experience with pedagogy principles, be able to deliver effective lectures to a wide audience, and be prepared to teach courses to undergraduate and graduate students. These represent the goals of the required Mentored Teaching Experience (MTE).

Preparatory Engagement

Preparatory Engagement activities are those that represent an introduction to the foundational skills associated with teaching or communication. Pedagogical preparation engagement activities are normally completed before students are permitted to engage in assisting or teaching in a classroom.

Prior to beginning their MTE and typically during their first graduate year, Division of Biology & Biomedical Sciences (DBBS) students will be required to complete the Graduate Student Teaching Orientation, including three Foundations in Teaching (FiT) workshops offered by the Center for Teaching and Learning. Students will meet with assigned course director(s) prior to the start of the semester and complete a teaching expectations form.

Mentored Teaching Experiences (MTEs)

Assistant in Instruction (AI)

An Assistant in Instruction (AI) is a PhD student who is directly engaged in the organization, instruction, and/or support of a semester-long course *primarily taught by a faculty member.* An AI receives mentorship from a faculty member related to best practices in classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. Students and mentors complete a mentorship plan prior to the start of each AI experience. To complete each AI assignment and to ensure that it applies toward their degree requirements, students must register for the appropriate course number for each semester of engagement. Refer to the "Required Pathways for Completion" section below for course numbers and details.

DBBS students will serve as mentored AIs in courses approved by the Associate Dean. Units for a given course will be determined ahead of the assignment. A unit is equivalent to approximately one hour per week, so 5 units would involve five hours of support (on average per week) for a course. The PhD student is formally listed as instructional support in the course listings and receives mentorship from the faculty member in best practices for classroom engagement, instruction in the field, interpersonal engagement, and other relevant skills. The mentored teaching training must incorporate at least one of the following activities: delivering lectures, leading lab activities or discussion groups, or conducting review sessions for groups of students. Grading exams or papers, holding office hours, administrative tasks, one-on-one tutoring, and so on may also be components of the assistantship and should be counted in the 5 units; however, these activities are not sufficient to meet the DBBS teaching training requirement. In general, AI assignments connect to undergraduate or lower-level graduate courses that the AI has taken previously. Students must enroll in MGS 8005 MTE - Assistant in Instruction experience during the semester(s) of their assigned MTEs.

The PhD student should receive regular feedback or evaluation from the mentor throughout the semester, a formal evaluation of teaching skills by the faculty at the end of the semester, and evaluation by the students at the end of the term as part of the course evaluation. If the course director determines that the PhD student's facility with essential teaching skills is unsatisfactory, the student will be counseled by the course director and the Associate Dean of Graduate Education and then will complete another MTE to attain mastery of these skills. Mentored teaching opportunities will be reviewed annually to ensure that the experiences meets the requirements established in this policy.

Required Pathways for Completion

Students work with their faculty mentor and their Director of Graduate Studies to plan how and when they will complete their MERs. Students register during the normal registration period for courses in accordance with one of these approved pathways.

- Preparatory Engagement completed during the first year

Pathway #1

MGS 8005	Take one time

Optional Activity: Professional Intensive Pathway (PIP)

The PIP is an optional pathway for those students whose career interests lie outside of academia or who want to benefit from mentored professional experiences (MPEs). An MPE is an unpaid professional experience for PhD students that allows students to develop skills and experiences relevant to their intended career outcomes. Students and mentors complete a mentorship plan prior to the start of each MPE. Students who are interested in participating in this elective experience must formally request to participate, which is subject to program approval. Due to this experience being an elective, unpaid experience, students who participate in the PIP will not receive compensation.

Students and mentors complete a mentorship plan prior to the start of each MPE. To complete each MPE assignment and ensure that it applies toward their degree requirements, students must submit the Mentorship Registration Request form for approval and register for the appropriate course number (MGS 8120 MTE - Mentored Professional Experience) for each semester of engagement.

The DBBS MPE via the PIP is an optional activity. Students should engage in activities that enhance their professional development and record these activities at their thesis update meetings. For some students, an optional MPE is encouraged. The DBBS MPE can be fulfilled by a wide range of activities that advance the careers and professional development of DBBS PhD students. These could include, for example, opportunities in biotech or pharmaceuticals (including at a startup or established company); science communication; science outreach; diversity, equity, and inclusion work; government or policy opportunities; consulting; or higher education administration. Academic-track students may use the MPE to learn a new technique at a core facility or other lab. The duties and responsibilities of the MPE should be intellectually substantive and offer opportunities for the student to develop new skills and experiences. MPEs are distinct from internships in that they are considered part of the PhD training and are recorded on students' transcripts as courses. The scope of the MPE will be determined in conversation among the student, the site mentor, and DBBS staff, and the final plan must be approved by the principal investigator and the program director. An average of 10 hours per week of MPE for a total of 150 to 180 hours is expected for each student. The nature of some MPEs may take students away from their academic pursuits for full-time participation. In these cases, coverage of a percentage of the student's stipend may be pursued by consulting DBBS leadership.

Prior to the start of an MPE, the student and the site mentor will submit a plan to DBBS detailing the scope of the project(s) to be undertaken and including a schedule and list of anticipated outcomes, and the mentor will provide an explicit commitment to the mentorship. This plan should be directly related to the goals developed

via the student's recent completion of an Individual Development Plan, and students should enroll in MGS 8120 MTE - Mentored Professional Experience. During the semester, the mentor and the mentee should meet frequently (i.e., weekly or biweekly) to track the progress of the student's work. At the end of the MPE, the mentor should provide a written assessment (approximately 500 words) of the overall learning experience for the student and the quality of the work completed, and the student will submit a self-reflection statement detailing the skills and experiences gained and how their career goals may (or may not) have changed. The mentor will register the completion of MGS 8120 MTE - Mentored Professional Experience as Pass/No Pass.

Optional Pathway

MGS 8120	Take one time