COMPUTATIONAL MEDICINE, MINOR

https://icm.jhu.edu/

The Institute for Computational Medicine (ICM) offers an undergraduate minor in Computational Medicine, the *first* educational program in CM, reflecting Johns Hopkins University's leadership in this field. Like the ICM, the undergraduate minor in Computational Medicine is integrative and multidisciplinary. The ICM Core Faculty who serve as advisors to the undergraduate minor hold primary and joint appointments in multiple Johns Hopkins University departments and schools including Biomedical Engineering, Computer Science, Electrical and Computer Engineering, Mechanical Engineering, Applied Mathematics and Statistics (WSE); Neurosurgery, Emergency Medicine, Medicine, and the Divisions of Cardiology and Health Sciences Informatics (SOM); and Health Policy and Management (BSPH).

With a minor in CM, undergraduates gain a solid grounding in the development and application of computational methods in key areas of medicine. Specifically, undergraduates will understand how mathematical models can be constructed from biophysical laws or experimental data, and how predictions from these models facilitate diagnosis and treatment of a disease. Undergraduates will become conversant with a wide variety of statistical, deterministic and stochastic modeling methods, skills that are essential to the advancement of modern medicine, and are prized both in academic research and industrial research.

Declaring the Minor

Students interested in the minor should contact Sabrina Sengupta, Sr. Academic Coordinator, at ssengu19@jhu.edu to receive guidance about the program and be assigned a minor advisor.

Program Requirements

Minor Prerequisites

Before attempting the minor, undergraduates will have taken the following courses. For a course to count towards the minor, a minimum grade of C- is required:

1. Calculus I
2. Calculus II
3. Probability and Statistics: either a single course covering both (e.g. Intermediate Probability and Statistics (EN.553.311)) or a course devoted to each (e.g., Probability (EN.553.420) **and** Mathematical Statistics (EN.553.430)) – this may be taken concurrent with core courses Introduction to Computational Medicine: Imaging (EN.580.431) and Introduction to Computational Medicine: The Physiome (EN.580.433).
4. At least one (1) additional course in mathematics or applied mathematics (at least 3 credits)
5. At least one (1) computer programming course (at least 3 credits)
6. At least one (1) biological sciences course at the 200 level or higher (at least 3 credits). AP Biology credits do not satisfy this requirement.

A list of approved courses for each prerequisite can be found here (https://icm.jhu.edu/academics/undergraduate-programs/undergraduate-minor/).

Core Courses

Code	Title	Credits
EN.580.431	Introduction to Computational Medicine: Imaging [1]	2
EN.580.433	Introduction to Computational Medicine: The Physiome [1]	2
Select one of the following:		3-4
AS.110.445	Mathematical and Computational Foundations of Data Science	3
EN.553.450	Computational Molecular Medicine	4
EN.580.430	Systems Pharmacology and Personalized Medicine	4
EN.580.447	Computational Stem Cell Biology	3
EN.580.458	Computing the Transcriptome	3
EN.580.488	Foundations of Computational Biology and Bioinformatics	3
EN.601.649	Computational Genomics: Applied Comparative Genomics	3
PH.140.628	Data Science for Public Health I	4
or PH.140.629	Data Science for Public Health II	

Distinguished Seminar Series

Students enrolled in the Computational Medicine Minor are required to attend 6 ICM Distinguished Seminars via Zoom prior to graduation. Documentation of seminar attendance is two-fold. For each seminar attended students must:

1. Attend the Zoom seminar synchronously with the student's JHU email
2. Complete a Seminar Attendance Form

Elective Courses

Following satisfaction of the prerequisites, to complete the minor undergraduates must take at least 18 credits of CM courses. This includes the core courses plus approved elective courses selected from those listed below. The following restrictions are noted:

1. No more than 3 of the 18 elective credits may consist of independent research in computational medicine or approved CM-related research. Eligibility of independent research as "M", "C", "MC", or neither is at the advisor's discretion.
2. The 18 credits will be at 300-level or above, and courses must be passed at a C- level or above;
3. At least 1 non-core/elective course must be outside the student's home department;
4. At least 2 non-core/elective courses must have a substantial biology or medicine component, as identified in the list below with an (M) designation;
5. At least 1 non-core course must have a significant component of "applied programming" (distinct from a course on computer language or on programming such as Intermediate Computer Programming in Computer Science) to satisfy the computational component, as identified in the list of electives with a (C) designation;
6. All courses must be passed at a C- level or above;
7. A class may not be counted as both a prerequisite and an elective.

Students may suggest elective courses to be added to the list by making requests to Sabrina Sengupta (ssengu19@jhu. (aflynn12@jhu.edu)d

(aflynn12@jhu.edu)eu (aflynn12@jhu.edu)). All suggestions will be reviewed by the CM Minor Curriculum Committee for potential approval.

Code	Title	Credits
Significant Biology/Medicine Component (M)		
EN.530.676	Locomotion Dynamics & Control	3
EN.540.421	Project in Design: Pharmacodynamics	3
EN.580.430	Systems Pharmacology and Personalized Medicine	4
EN.580.435	Applied Bioelectrical Engineering	3
EN.580.447	Computational Stem Cell Biology	3
EN.580.460	Epigenetics at the Crossroads of Genes and the Environment	1.5
EN.580.462	Representations of Choice	3
EN.580.464	Advanced Data Science for Biomedical Engineering	4
EN.580.480	Precision Care Medicine I	4
EN.580.481	Precision Care Medicine II	4
EN.580.488	Foundations of Computational Biology and Bioinformatics	3
EN.580.689	Modern Optical Microscopy: Theory and Practice	3
EN.601.350	Genomic Data Science	3
EN.601.447	Computational Genomics: Sequences	3
EN.601.649	Computational Genomics: Applied Comparative Genomics	3
Significant Computational Component (C)		
AS.050.375	Probabilistic Models of the Visual Cortex	3
AS.250.302	Modeling the Living Cell	4
EN.520.353	Control Systems	4
EN.520.432	Medical Imaging Systems	3
EN.520.433	Medical Image Analysis	3
EN.540.409	Dynamic Modeling and Control	4
EN.540.414	Computational Protein Structure Prediction and Design	3
EN.540.421	Project in Design: Pharmacodynamics	3
EN.553.361	Introduction to Optimization	4
EN.553.386	Scientific Computing: Differential Equations	4
EN.553.436	Introduction to Data Science	4
EN.553.492	Mathematical Biology	3
EN.580.430	Systems Pharmacology and Personalized Medicine	4
EN.580.437	Biomedical Data Design	4
EN.580.438	Biomedical Data Design II	4
EN.580.447	Computational Stem Cell Biology	3
EN.580.460	Epigenetics at the Crossroads of Genes and the Environment	1.5
EN.580.462	Representations of Choice	3
EN.580.464	Advanced Data Science for Biomedical Engineering	4
EN.580.480	Precision Care Medicine I	4
EN.580.481	Precision Care Medicine II	4
EN.580.488	Foundations of Computational Biology and Bioinformatics	3
EN.580.491	Learning, Estimation and Control	3
EN.580.689	Modern Optical Microscopy: Theory and Practice	3
EN.601.350	Genomic Data Science	3
EN.601.447	Computational Genomics: Sequences	3
EN.601.455	Computer Integrated Surgery I	4
EN.601.461	Computer Vision	3
EN.601.475	Machine Learning	3
EN.601.476	Machine Learning: Data to Models	3
EN.601.482	Machine Learning: Deep Learning	4
EN.601.649	Computational Genomics: Applied Comparative Genomics	3
PH.340.677	Infectious Disease Dynamics: Theoretical and Computational Approaches	4
Other Electives		
The following courses may be used to satisfy (M) or (C) requirements, but not both.		
EN.520.315	Intro. to Bio-Inspired Processing of Audio-Visual Signals	3
EN.520.621	Introduction To Nonlinear Systems	3
EN.530.343	Design and Analysis of Dynamical Systems	3
EN.530.410	Biomechanics of the Cell	3
EN.530.616	Introduction to Linear Systems Theory	3
EN.553.391	Dynamical Systems	4
EN.553.420	Probability	4
EN.553.426	Introduction to Stochastic Processes	4
EN.553.430	Mathematical Statistics	4