SYSTEMS BIOLOGY

Our Website (https://www.ais.science.vt.edu/academics/sysbio.html)

Overview

The Systems Biology program is a joint effort of the departments of Biological Sciences, Physics, Chemistry, Mathematics and Computer Science. The program resides in, and is organized as a division of, the College of Science's Academy of Integrated Science.

A "systems approach" to biology involves the study of the biological, chemical, and physical processes within living organisms as they interact in complex ways to produce life-supporting behaviors. The Virginia Tech program in Systems Biology focuses on the powerful, emerging paradigm of molecular systems biology, i.e., on computational, systems-level approaches that connect the biochemical and genetic properties of individual macromolecules (DNA, RNA, protein, lipids, polysaccharides) with the physiological behavior of living cells and tissues. These levels of biological organization, which comprise the gap between interacting macromolecules and cell physiology, embody an active area of research producing technological and biomedical innovations. The Systems Biology program bridges the molecular/cell divide, training students for employment or graduate education in this burgeoning field.

Satisfactory Progress

University policy requires that students who are making satisfactory progress toward a degree meet minimum criteria toward the General Education (Curriculum for Liberal Education or Pathways to General Education) (see "Academic Policies (https://catalog.vt.edu/undergraduate/academic-policies/)") and toward the degree.

Satisfactory progress requirements toward the B.S. in Systems Biology can be found on the major checksheet by visiting the University Registrar website at https://www.registrar.vt.edu/graduation-multi-brief/checksheets.html.

Minor in Systems Biology

Please visit the University Registrar's website at https://www.registrar.vt.edu/graduation-multi-brief/checksheets.html for requirements toward a minor in Systems Biology.

Division Leader: I. Lazar
Program Manager: C. Conley
Principle Faculty: F. Aylward, A. Banerjee, W. Baumann, A. M. Brown, Y. Cao, J. Chen, L. Childs, M. Chung, D. Cimini, S. Ciupe, S. Hauf, R. Jensen, P. Kraikivski, L. Li, and T.M. Murali

Undergraduate Course Descriptions (SYSB)

SYSB 2024 - Fundamentals of Systems Biology (3 credits)
Introduction to fundamental concepts of systems biology: biological systems, molecular regulatory networks, modeling approaches in systems biology with case studies, high-throughput data generation and bioinformatics data processing.
Prerequisite(s): MATH 1225 and (BIOL 1105 or ISC 1106H) and (CHEM 1036 or CHEM 1056 or CHEM 1056H or ISC 1106H)
Instructional Contact Hours: (3 Lec, 3 Crd)

SYSB 2034 - Mathematical Methods in Systems Biology (3 credits)
Fundamental mathematical methods in systems biology, including differential equations, graph theory, Boolean mathematics, and concepts of probability. Applications of these methods to developing models of biological regulatory networks and dynamical systems. Software tools for Systems Biology.
Prerequisite(s): SYSB 2024 and MATH 1226 and (CS 1064 or CS 1114)
Corequisite(s): MATH 2114, MATH 2114H
Instructional Contact Hours: (3 Lec, 3 Crd)

SYSB 2984 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course

SYSB 2994 - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course

SYSB 3035 - Genomics and Bioinformatics (4 credits)
Bioinformatic approaches in omics, namely genomics and transcriptomics. 3035: Genomic architecture and evolution. Gene expression and post-translational regulation. Structure and function of genes and other genetic elements. Experimental techniques for generating genomic and transcriptomic data. 3036: Statistical, evolutionary, and computational models and methods to analyze omics data. Techniques for visualization and biological interpretation of omics data derived from experiments. Application of Python and R to bioinformatics. Case studies and specific applications in molecular biology, including comparative genomics, cancer, and infectious diseases.
Prerequisite(s): BIOL 2004
Instructional Contact Hours: (3 Lec, 3 Lab, 4 Crd)

SYSB 3036 - Genomics and Bioinformatics (4 credits)
Bioinformatic approaches in omics, namely genomics and transcriptomics. 3035: Genomic architecture and evolution. Gene expression and post-translational regulation. Structure and function of genes and other genetic elements. Experimental techniques for generating genomic and transcriptomic data. 3036: Statistical, evolutionary, and computational models and methods to analyze omics data. Techniques for visualization and biological interpretation of omics data derived from experiments. Application of Python and R to bioinformatics. Case studies and specific applications in molecular biology, including comparative genomics, cancer, and infectious diseases.
Prerequisite(s): SYSB 3035
Instructional Contact Hours: (3 Lec, 3 Lab, 4 Crd)

SYSB 3115 - Network Dynamics and Cell Physiology (4 credits)
In-depth study of how molecular regulatory networks determine the physiological properties of prokaryotic and eukaryotic cells. 3115: Biochemical reaction networks, nonlinear dynamical systems, parameter estimation, bifurcation theory, switches and oscillators, gene regulatory networks, signaling pathways, metabolic networks, neural networks, applications. 3116: Stochastic effects, cell cycle and cancer, spatial effects, motility, development, tissue dynamics, applications.
Prerequisite(s): SYSB 2034
Instructional Contact Hours: (3 Lec, 3 Lab, 4 Crd)

SYSB 3116 - Network Dynamics and Cell Physiology (4 credits)
In-depth study of how molecular regulatory networks determine the physiological properties of prokaryotic and eukaryotic cells. 3115: Biochemical reaction networks, nonlinear dynamical systems, parameter estimation, bifurcation theory, switches and oscillators, gene regulatory networks, signaling pathways, metabolic networks, neural networks, applications. 3116: Stochastic effects, cell cycle and cancer, spatial effects, motility, development, tissue dynamics, applications.
Prerequisite(s): SYSB 3115
Instructional Contact Hours: (3 Lec, 3 Lab, 4 Crd)

SYSB 4024 - Careers and Professionalism in Systems Biology (2 credits)
Career planning, interviewing skills, and training in written and oral communication in systems biology. Critical evaluation of research, effective communication of scientific results, ethical standards in science, societal trends.
Prerequisite(s): SYSB 3036 and SYSB 3116
Corequisite(s): SYSB 4065
Instructional Contact Hours: (2 Lec, 2 Crd)

SYSB 4065 - Research Experience in Systems Biology (2 credits)
Training and practical experience in the conduct of systems biology research. 4065: Plan a research project, develop a research hypothesis, and perform preliminary testing and analysis. 4066: Execute, refine, complete, and document the projects results.
Prerequisite(s): SYSB 3036 and SYSB 3116
Corequisite(s): SYSB 4135
Instructional Contact Hours: (2 Lec, 2 Crd)

SYSB 4066 - Research Experience in Systems Biology (2 credits)
Training and practical experience in the conduct of systems biology research. 4065: Plan a research project, develop a research hypothesis, and perform preliminary testing and analysis. 4066: Execute, refine, complete, and document the projects results.
Prerequisite(s): SYSB 4065
Corequisite(s): SYSB 4136
Instructional Contact Hours: (2 Lec, 2 Crd)

SYSB 4114 - Applied Models of Gene Regulatory Networks (3 credits)
Dynamic modeling of gene regulatory networks. Gene regulatory networks with oscillatory and switch-like dynamic behavior. Design of synthetic genetic switches and oscillators. Modeling gene regulation controlling cell fate, cell differentiation, cell-to-cell communication, synchronization and developmental processes. Real-world research problems and applications.
Prerequisite(s): SYSB 2034 or CMDA 2006
Instructional Contact Hours: (3 Lec, 3 Crd)

SYSB 4224 - Big Data Analysis Methods in Systems Biology (3 credits)
Big data analysis in systems biology. Emphasis on data storage/retrieval and curation, statistical modeling of gene expression, enrichment analysis, clustering, parameter optimization and estimation in systems biology models, linear and nonlinear classification methods.
Prerequisite(s): (SYSB 2034 or MATH 1226) and (STAT 3005 or STAT 3615)
Instructional Contact Hours: (3 Lec, 3 Crd)

SYSB 4974 - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

SYSB 4994 - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course