Systems Biology and Biotechnology Specialization

Expertise for Professionals and Students in Biotechnology and Biomedical Data Sciences

Learn Methodologies in Systems Biology Including: Bioinformatics, Dynamical Modeling, Genomics, Network and Statistical Modeling, Proteomics, Omics Technologies Single Cell Research Technologies

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Courses

Intermediate Specialization.
Some related experience required.

1. **COURSE 1**

Introduction to Systems Biology

Current session: Jun 26 — Sep 11.

Commitment
6-8 hours/week

Subtitles
English, Chinese (Simplified)

About the Course

This course will introduce the student to contemporary Systems Biology focused on mammalian cells, their constituents and their functions. Biology is moving from molecular to modular. As our knowledge of our genome and gene expression deepens and we develop lists of molecules (proteins, lipids, ions) involved in cellular processes, we need to understand how these molecules interact with each other to form modules that act as discrete functional systems. These systems underlie core subcellular processes such as signal transduction, transcription, motility and electrical excitability. In turn these processes come together to exhibit cellular behaviors such as secretion, proliferation and action potentials. What are the properties of such subcellular and cellular systems? What are the mechanisms by which emergent behaviors of systems arise? What types of experiments inform systems-level thinking? Why do we need computation and simulations to understand these systems? The course will develop multiple lines of reasoning to answer the questions listed above. Two major reasoning threads are: the design, execution and interpretation of multivariable experiments that produce large data sets; quantitative reasoning, models and simulations. Examples will be discussed to demonstrate “how” cell- level functions arise and “why” mechanistic knowledge allows us to predict cellular behaviors leading to disease states and drug responses.

2. **COURSE 2**

Experimental Methods in Systems Biology

Upcoming session: Jul 10 — Sep 11.

Commitment
: 6-8 hours/week

Subtitles
: English

About the Course

Learn about the technologies underlying experimentation used in systems biology, with particular focus on RNA sequencing, mass spec-based proteomics, flow/mass cytometry and live-cell imaging. A key driver of the systems biology field is the technology allowing us to delve deeper and wider into how cells respond to experimental perturbations. This in turns allows us to build more detailed quantitative models of cellular function, which can give important insight into applications ranging from biotechnology to human disease. This course gives a broad overview of a variety of current experimental techniques used in modern systems biology, with focus on obtaining the quantitative data needed for computational modeling purposes in downstream analyses. We dive deeply into four technologies in particular, mRNA sequencing, mass spectrometry-based proteomics, flow/mass cytometry, and live-cell imaging. These techniques are often used in systems biology and range from genome-wide coverage to single molecule coverage, millions of cells to single cells, and single time points to frequently sampled time courses. We present not only the theoretical background upon which these technologies work, but also enter real wet lab environments to provide instruction on how these techniques are performed in practice, and how resultant data are analyzed for quality and content.

3. **COURSE 3**

Network Analysis in Systems Biology

Upcoming session: Jul 17 — Oct 2.

Commitment
: 6-8 hours/week

Subtitles
: English

About the Course

An introduction to data integration and statistical methods used in contemporary Systems Biology, Bioinformatics and Systems Pharmacology research. The course covers methods to process raw data from genome-wide mRNA expression studies (microarrays and RNA-seq) including data normalization, differential expression, clustering, enrichment analysis and network construction. The course contains practical tutorials for using tools and setting up pipelines, but it also covers the mathematics behind the methods applied within the tools. The course is mostly appropriate for beginning graduate students and advanced undergraduates majoring in fields such as biology, math, physics, chemistry, computer science, biomedical and electrical engineering. The course should be useful for researchers who encounter large datasets in their own research. The course presents software tools developed by the Ma’ayan Laboratory (http://icahn.mssm.edu/research/labs/maayan-laboratory) from the Icahn School of Medicine at Mount Sinai, but also other freely available data analysis and visualization tools. The ultimate aim of the course is to enable participants to utilize the methods presented in this course for analyzing their own data for their own projects. For those participants that do not work in the field, the course introduces the current research challenges faced in the field of computational systems biology.

4. **COURSE 4**

Dynamical Modeling Methods for Systems Biology

Current session: Jun 26 — Aug 21.

Commitment
: 8-10 hours/week

Subtitles
: English

About the Course

An introduction to dynamical modeling techniques used in contemporary Systems Biology research. We take a case-based approach to teach contemporary mathematical modeling techniques. The course is appropriate for advanced undergraduates and beginning graduate students. Lectures provide biological background and describe the development of both classical mathematical models and more recent representations of biological processes. The course will be useful for students who plan to use experimental techniques as their approach in the laboratory and employ computational modeling as a tool to draw deeper understanding of experiments. The course should also be valuable as an introductory overview for students planning to conduct original research in modeling biological systems. This course focuses on dynamical modeling techniques used in Systems Biology research. These techniques are based on biological mechanisms, and simulations with these models generate predictions that can subsequently be tested experimentally. These testable predictions frequently provide novel insight into biological processes. The approaches taught here can be grouped into the following categories: 1) ordinary differential equation-based models, 2) partial differential equation-based models, and 3) stochastic models.

5. **COURSE 5**

Integrated Analysis in Systems Biology

Current session: Jun 26 — Jul 31.

Commitment
: 6-8 hours/week

Subtitles
: English

About the Course

This course will focus on developing integrative skills through directed reading and analysis of the current primary literature to enable the student to develop the capstone project as the overall final exam for the specialization in systems biology.

6. **COURSE 6**

Systems Biology and Biotechnology Capstone

Upcoming session: Sep 4 — Oct 2.

Subtitles
: English

About the Capstone Project

NOTE: In order to take this course you should have taken and complete the following courses in the Signature Track: Introduction to Systems Biology, Network Analysis in Systems Biology, Dynamical Modeling Methods for Systems Biology, Experimental Methods in SB and Integrated Analysis In Systems Biology

Creators

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  Icahn School of Medicine at Mount Sinai, in New York City, is a leader in medical and scientific training and education, biomedical research and patient care. The Institute for Systems Biomedicine is an interdisciplinary entity that brings together faculty who are world leaders in systems biology, medicine and systems pharmacology research at Mount Sinai.

  The Icahn School of Medicine at Mount Sinai, in New York City is a leader in medical and scientific training and education, biomedical research and patient care.

- **Avi Ma'ayan, PhD**

  

  Director, Mount Sinai Center for Bioinformatics

- **Ravi Iyengar, PhD**

  Dorothy H. and Lewis Rosenstiel Professor

- **Eric Sobie, PhD**

Associate Professor

- **Susana Neves, PhD**

Assistant Professor

- **Marc Birtwistle, PhD**

Assistant Professor