School of Molecular & Cellular Biology

MCB 493 sxn FMO, Spring 2025

Functional Multiomics

3 credit hours

Instructor
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Class Meeting Schedule
Tuesday, Thursday 12 – 13:20
Location: TBD
Office Hours: By appointment

Course Overview and Description

This course introduces the principles and applications of functional multiomics, an emerging field that integrates genomics, transcriptomics, proteomics, and metabolomics data to elucidate the complex relationships within biological systems. Students will learn cutting-edge techniques for data integration, analysis, and interpretation, enabling them to uncover functional insights and gain a holistic understanding of biological networks. Through hands-on practical sessions, students will work with real multiomics datasets, collaborate on research projects, and develop skills in bioinformatics tools and data visualization techniques.

Course Prerequisites

MCB 250 Molecular Genetics, MCB 317 Genetics and Genomics. Students are strongly encouraged to familiarize themselves with RStudio and the basics of programming in R prior to taking this class.

Student Learning Outcomes

By the end of the course, students will be able to:

- Understand the fundamental concepts and significance of functional multiomics in systems biology and precision medicine.

- Describe the various high-throughput technologies and analytical approaches used in genomics, transcriptomics, proteomics, and metabolomics.
- Integrate and interpret multiomics data to uncover functional relationships within biological networks.
- Apply bioinformatics tools and statistical methods for multiomics data analysis and visualization.
- Design and execute a mini multiomics research project to address specific biological questions.
- Critically evaluate and discuss the challenges, ethical considerations, and future perspectives of functional multiomics research.

Course Text/Materials Information

Recommended textbook: Narad, Priyanka, and S. V. Kirthanashri. Omics approaches, technologies and applications: integrative approaches for understanding OMICS data (2018) https://link.springer.com/book/10.1007/978-981-13-2925-8

Student assignments will also include reading primary literature and reviews related to topics over the course of the semester.

Course Tools

MCB493 will have a Canvas site for accessing the syllabus and grades. The course will also utilize a Slack workspace as a resource for course communication between students, instructor, and between team members for group projects (https://slack.com).

Grading Information and Breakdown

30% Class participation: includes attendance and participation (30 points total)
- Regular class attendance (sign-in sheet)
- Active participation in discussions
- Engagement in lab sessions and group activities

20% Journal club presentation (20 points)
- Teams of 3-5 students
- Present and critically analyze a recent omics paper
- Lead class discussion

20% Final team presentation (20 points)
- Present multiomics approach for biological question of interest
- Demonstrate integration of course concepts

- Q&A session

30% Exams (30 points total)

- Midterm 1: 10 points
- Midterm 2: 10 points
- Final Exam: 10 points

Total: 100 points

Grade format

97–100% (A+) 93–96% (A) 90–92% (A-)
87–89% (B+) 83–86% (B) 80–82% (B-)
77–79% (C+) 73–76% (C) 70–72% (C-)
67–69% (D+) 63–66% (D) 60–62% (D-)
0–59% (F)

COURSE CALENDAR (2025)

Module 1: Introduction to Functional Multiomics

January 21, 2025	Lecture 1: Course Overview and Introduction to Omics Research
January 23, 2025	Lecture 2: Omics Technologies: High-throughput sequencing, mass spectrometry, and other platforms
January 28, 2025	Lecture 3: Data Analysis in Omics Research
January 30, 2025	Lecture 4: Experimental Design in Omics Research

Module 2: Genomics and Transcriptomics Integration

February 4, 2025	Lecture 5: Introduction to Genomics. Genome Assembly and Annotation
February 6, 2025	Lecture 6: Genome-Wide Association Studies (GWAS). Rare Genetic Variation and Structural Variation
February 11, 2025	Midterm 1 Review and Journal Club (Teams 1 & 2)
February 13, 2025	MIDTERM EXAM 1
February 18, 2025	Lecture 7: Introduction to Epigenomics and Epigenomic Profiling
February 20, 2025	Lecture 8: Introduction to Transcriptomics. RNA-seq Data Analysis
February 25, 2025	Lecture 9: Epitranscriptomics and m6A Regulation
February 27, 2025	Lecture 10: Introduction to Single-Cell Genomics
March 4, 2025	Lab 1: Single-Cell Data Analysis - Part 1 (Data Processing and QC)

March 6, 2025	Lab 2: Single-Cell Data Analysis - Part 2 (Clustering and Trajectory Analysis)

Module 3: Proteomics and Metabolomics Integration

March 11, 2025	Midterm 2 Review and Journal Club (Teams 3 & 4)
March 13, 2025	**MIDTERM EXAM 2**
March 25, 2025	Lecture 11: Introduction to Proteomics. Mass Spectrometry-based Proteomics
March 27, 2025	Lecture 12: Protein-Protein Interactions and Structural Proteomics
April 1, 2025	Lecture 13: Targeted Proteomics and Biomarker Discovery
April 3, 2025	Lecture 14: Introduction to Metabolomics
April 8, 2025	Lab 3: Proteomics and Metabolomics Data Analysis

Module 4: Emerging Technologies in Multiomics

April 10, 2025	Lecture 15: Spatial Omics Technologies and Applications
April 15, 2025	Lecture 16: Connectomics: Principles and Technologies
April 17, 2025	Final Exam Review and Journal Club (Teams 5 & 6)
April 22, 2025	**FINAL EXAM**
April 24, 2025	Final Presentations (Teams 1, 2, 3)
April 29, 2025	Final Presentations (Teams 4, 5, 6)
May 1, 2025	Guest Lecture - Omics Resources on Campus
May 6, 2025	Course Wrap-up and Future Perspectives in Multiomics

Classes end May 6

Assignments, due dates, and course expectations

This is an upper-level undergraduate, graduate-level course that integrates theory and hands-on application of functional multiomics approaches. Active participation in lectures and lab sessions (maximum 30 points, 30% of total grade) is crucial for mastering this multidisciplinary field. Students are expected to notify the instructor in advance if they need to miss a class, so an appropriate plan can be made. Throughout the semester, students will actively participate in team-based journal clubs and present their analysis of current research in functional multiomics (20 points, 20% of total grade). Collaborative learning is encouraged, with regular team communication and group work facilitated through a dedicated workspace. Teams will also develop and present a final presentation demonstrating their understanding of multiomics integration in a biological research project of their choice (20 points, 20% of total grade). Three exams (30 points total, 10 points each) will assess individual understanding of course concepts. The course aims to provide a comprehensive understanding of functional multiomics through a blend of

lectures, hands-on activities, teamwork, and critical analysis, enabling students to become proficient in this rapidly evolving field.

Academic integrity

Students are expected to be familiar with the code of policies and regulations applied in all instances of academic misconduct. Please refer to http://studentcode.illinois.edu, and, in particular, Article 1 part 4: http://studentcode.illinois.edu/article1/part4/1-401/

Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail a message to disability@uiuc.edu. http://www.disability.illinois.edu/.

Inclusive classroom statement

The effectiveness of this course is dependent upon the creation of an encouraging and safe classroom environment. Exclusionary, offensive or harmful speech, such as racism, sexism, homophobia, and transphobia, will not be tolerated and in some cases will be subject to University harassment procedures. We are all responsible for creating a positive and safe environment that allows all students equal respect and comfort. We expect each of you to help establish and maintain an environment where you and your peers can contribute without fear of ridicule or intolerant or offensive language.

Sexual misconduct policy and reporting

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential. Other information about resources and reporting is available here: wecare.illinois.edu.