# Biology (BIOL)

**BIOL 6010. Genomic Pipeline Optimization. 3 Hours.**
This course provides training in the design, implementation, and optimization of computational pipelines for genomic data analysis. Students will evaluate tools and strategies for scalability, reproducibility, and computational efficiency. Case studies will focus on variant calling, transcriptomics, and genome assembly pipelines. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Design and implement computational pipelines for genomic analyses. 2. Evaluate tools and platforms for pipeline scalability and efficiency. 3. Optimize workflows for accuracy, reproducibility, and performance. 4. Integrate version control and containerization into genomic pipelines. 5. Troubleshoot and validate results from complex computational workflows. Prerequisites: Acceptance in the MS Genomics degree. FA.

**BIOL 6040. Multi-omics Data Analysis. 3 Hours.**
This course explores computational approaches to analyze and integrate multiple omics datasets, including genomics, transcriptomics, proteomics, and metabolomics. Students will learn statistical and machine learning techniques for discovering patterns, biomarkers, and biological insights across data modalities. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Apply computational tools to analyze genomic, transcriptomic, proteomic, and metabolomic data. 2. Integrate multiple omics datasets to identify cross-platform patterns. 3. Employ statistical and machine learning techniques in multi-omics analysis. 4. Interpret biological significance from integrated datasets. 5. Communicate findings through visualizations and scientific reporting. Corequisite: BIOL 6045. Prerequisites: Acceptance into the MS Genomics degree. SP.

**BIOL 6045. Multi-omics Data Analysis Lab. 1 Hour.**
This laboratory course provides hands-on experience with software, databases, and computational tools for multi-omics integration. Students will work directly with real-world datasets to practice data preprocessing, statistical analysis, and visualization. The lab emphasizes practical skill development and application of concepts introduced in the lecture course. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Preprocess and manage large-scale multi-omics datasets. 2. Perform computational integration of diverse omics data types. 3. Apply statistical and machine learning methods to multi-omics case studies. 4. Generate visualizations to effectively communicate multi-omics results. 5. Develop reproducible workflows for applied multi-omics projects. Corequisite: BIOL 6040. Prerequisites: Acceptance in the MS Genomics degree. SP.

**BIOL 6050. Histology. 2 Hours.**
This course provides methodological training in animal histology, emphasizing experimental techniques, specimen preparation, and microscopic analysis used in modern biological and biomedical research. Students learn the principles and practice of tissue fixation, embedding, sectioning, and staining (including histochemical and immunohistochemical approaches). The course integrates lectures with extensive laboratory experience using animal models to examine tissue structure, function, and pathology. Data interpretation, digital imaging, and quantitative morphometric analysis are included to prepare students for applying histological methods in research. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Apply core histological methods including fixation, embedding, sectioning, and staining of animal tissues. 2. Operate light and digital microscopy systems for image acquisition and analysis. 3. Interpret histological features in the context of tissue function, experimental design, or pathology. 4. Evaluate histological data using quantitative and digital analysis tools. 5. Integrate histological methods into research workflows involving animal models. Prerequisites: Acceptance in the MS Genomics degree. SP.

**BIOL 6070. AI & Machine Learning in Biology. 3 Hours.**
This course focuses on the application of machine learning theories and methods to bioinformatics. This advanced course covers a range of topics, including computational resources required for ML in bioinformatics, biological sequence analysis, gene expression data analysis, genomics/proteomics data interpretation, and structural inference from sequence data. Students will explore AI/ML applications in various bioinformatics problems, gaining hands-on experience with Python to implement algorithms. The course integrates traditional machine learning and advanced deep learning methods, providing students with a comprehensive skill set to analyze and model complex biological data. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Describe a data analysis process as it applies to machine learning. 2. Describe computational resources and infrastructure required for machine learning algorithms. 3. Create machine learning algorithms that facilitate biological data analysis. Prerequisites: Acceptance into the MS Genomics degree. FA.

**BIOL 6100. Biomedical Research Ethics. 1 Hour.**
This course examines the ethical principles and regulatory frameworks governing biomedical, genomic, and bioinformatics research. Through case studies and discussion, students will address issues such as human subjects research, data integrity, authorship, conflicts of interest, personal data privacy, and the responsible conduct of research. Special attention is given to the ethical challenges associated with large-scale genomic datasets and bioinformatics applications. Emphasis is placed on applying ethical reasoning to complex scenarios in genomics and developing skills to identify and resolve ethical dilemmas in professional practice. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Identify major ethical principles and regulations governing biomedical and genomic research. 2. Apply ethical frameworks to case studies involving human subjects, data privacy, authorship, and research integrity. 3. Evaluate ethical dilemmas in professional settings, such as genomics research, and justify decisions using established ethical standards. 4. Demonstrate an understanding of responsible conduct of research, including data management, collaboration, and mentorship. 5. Communicate ethical considerations clearly in both written and oral formats. Prerequisites: Acceptance into the MS Genomics degree. FA.

**BIOL 6105R. Genomics Lab Rotation. 1-3 Hours.**
This course provides graduate students the opportunity to rotate through multiple research laboratories in genomics, functional genomics, and bioinformatics. Students will engage directly with faculty principal investigators (PIs), gain exposure to diverse research approaches, and develop familiarity with experimental techniques, computational methods, and laboratory culture. The rotation experience allows students to evaluate potential research mentors and areas of specialization in preparation for their Capstone project. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Demonstrate familiarity with the research focus, methodologies, and ongoing projects of multiple genomics-related and bioinformatics laboratories. 2. Compare and contrast different research approaches and problem-solving strategies in genomics, functional genomics, and bioinformatics. 3. Communicate laboratory experiences and insights through written summaries and oral discussions. 4. Evaluate alignment between personal research interests and available faculty expertise to inform Capstone project selection. Prerequisites: Acceptance in the MS Genomics Degree. FA, SP, SU.

**BIOL 6130. Statistical Genomics. 3 Hours.**
This course introduces statistical frameworks and quantitative approaches for analyzing genomic data. Topics include population genetics, quantitative trait mapping, gene expression analysis, and statistical modeling of high-dimensional datasets. Emphasis is placed on applying rigorous statistical methods to ensure valid interpretation of genomic research findings. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Apply statistical models to genomic and population-scale data. 2. Perform quantitative trait and association analyses. 3. Evaluate sources of bias, error, and variability in genomic datasets. 4. Implement statistical techniques for high-dimensional data analysis. 5. Critically assess statistical approaches in genomic literature and research. Prerequisites: Acceptance in the MS Genomics degree. SP.

**BIOL 6310. Bioinformatic Algorithms. 3 Hours.**
This course introduces fundamental programming skills tailored for bioinformatics applications. Students will learn to write, debug, and optimize code for tasks such as sequence alignment, data parsing, and large-scale genomic analysis. Emphasis is placed on developing computational literacy, applying algorithms to biological datasets, and building reproducible and efficient workflows. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Write and debug code to perform common bioinformatics tasks. 2. Apply programming principles to parse and analyze genomic datasets. 3 Employ algorithms for sequence and structural analysis. 4. Construct reproducible scripts and workflows for bioinformatics research. 5 Optimize code performance for large-scale biological data. Prerequisites: Acceptance in the MS Genomics Degree. FA.

**BIOL 6320. Scripting for Biologist. 3 Hours.**
In this course, students learn techniques in computational biology to apply their computer science skillset to biological data. Specifically, it is focused on learning best-practices to design scripts for computational biology through hands-on coding exercises. These exercises will allow students to refine their ability to analyze data using essential concepts in computer science such as conditionals, loops, functions, classes, regular expressions, and recursion. Topics of version control, code readability, and documentation design are used to highlight the importance of reproducibility in science. While the course is taught using Python, students are allowed to explore and use other scripting languages. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Implement best practices in script development for computational biology. 2. design computer programs to analyze their own (and other) biological data. 3. critically review coding scripts used in the primary literature. 4. Create reader-friendly documentation to help others implement their code for similar datasets (or to simply reproduce their results). Prerequisites: Acceptance into the MS Genomics degree. FA.

**BIOL 6330. Genomics & Precision Medicine. 3 Hours.**
This course surveys how modern genomics informs precision health. Through guided lectures and case-based discussions, students will learn the concepts behind NGS pipelines, apply ACMG/AMP frameworks to interpret variants, and evaluate pharmacogenomic guidance for genotype-informed care. Emphasis is on critical appraisal of primary literature, integration of genomic and clinical evidence for risk assessment and therapy selection, and clear, ethical communication of results, including consent, privacy, uncertainty, and equity considerations Assessment centers on weekly reading quizzes, brief case write-ups, a variant-interpretation memo (ACMG/AMP), a pharmacogenomics guideline brief (CPIC), an in-class midterm, and participation in discussions, prioritizing analysis and communication. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Explain how next-generation sequencing (NGS) and variant interpretation pipelines contribute to precision health applications. 2. Apply ACMG/AMP and CPIC frameworks to interpret genomic variants and guide genotype-informed care. 3. Critically evaluate and synthesize genomic and clinical evidence from primary literature for risk assessment and therapy selection. 4. Communicate genomic findings clearly and ethically, addressing issues of consent, privacy, uncertainty, and health equity. 5. Integrate genomic and pharmacogenomic data to develop evidence-based recommendations for personalized medicine. Prerequisites: Acceptance into the MS Genomics Program. SP.

**BIOL 6430. Genetic Engineering. 3 Hours.**
This course provides an advanced study of the principles and applications of genetic engineering. Topics include recombinant DNA technology, CRISPR/Cas and other genome editing systems, gene cloning, transgenic and knockout models, gene expression regulation, and biotechnological applications in medicine, agriculture, and industry. Students will explore both the molecular basis of genome manipulation and its ethical, regulatory, and societal implications. The course integrates lectures, discussions, and critical evaluation of current research literature to develop a deep understanding of modern genetic engineering strategies. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Explain the molecular mechanisms underlying recombinant DNA and genome editing technologies. 2. Design experimental approaches for gene modification and vector construction. 3. Evaluate current research literature in genetic engineering and synthetic biology. 3. Apply genetic engineering principles to real-world biomedical, agricultural, and biotechnological problems. 4. Discuss ethical, legal, and safety considerations in genetic engineering research and applications. Prerequisites: Acceptance into the MS Genomics degree. FA.

**BIOL 6500. Stem Cell Biology. 2 Hours.**
This course explores the fundamental principles of stem cell biology, including stem cell types, self-renewal, differentiation, and signaling pathways governing cell fate. Emphasis is placed on experimental approaches, current research advances, and biomedical applications. Designed for graduate students, the course integrates lectures and literature discussions to develop a conceptual and practical understanding of stem cell systems. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Explain the key properties and types of stem cells, including embryonic, adult, and induced pluripotent stem cells. 2. Describe the molecular and cellular mechanisms underlying stem cell self-renewal, differentiation, and lineage commitment. 3. Critically evaluate current research literature in stem cell biology and regenerative medicine. 4. Apply experimental and analytical approaches used to study stem cells in basic and translational contexts. 5. Discuss ethical and regulatory considerations related to stem cell research and its clinical applications. Prerequisite: Acceptance into MS Genomics Degree. SP.

**BIOL 6550. Advance Cell Biology. 2 Hours.**
This upper-level course offers a deep dive into the molecular and structural principles that govern cellular function. Designed for upper-level undergraduate and graduate students, it builds on foundational cell biology to expand students understanding of the dynamic processes that sustain life at the cellular level. Through a combination of lectures and guided discussions, students will investigate the complex mechanisms underlying cellular behavior, organization, and communication. A central component of the course is the critical analysis of current scientific literature, with assigned readings drawn from recent peer-reviewed publications to deepen engagement with emerging discoveries and experimental approaches. By the end of the course, students will be equipped to analyze cellular systems as integrated networks and understand how cellular dysfunction contributes to disease. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Explain the molecular and structural mechanisms underlying cellular organization, communication, and regulation using appropriate scientific terminology. 2. Evaluate current peer-reviewed literature to identify key findings, assess experimental design, and critique scientific interpretations in the field of cell biology. 3. Apply modern cell biology techniques, such as fluorescence microscopy and gene editing, to propose experimental approaches for investigating cellular processes. 4. Integrate knowledge of cellular systems to analyze how dysfunction at the molecular level contributes to human disease. Corequisite: BIOL 6555. Prerequisite: Acceptance into the MS Genomics degree. FA.

**BIOL 6555. Advance Cell Culture. 2 Hours.**
This course provides first-year graduate students with practical and conceptual training in mammalian cell culture using established cell lines. Emphasis is placed on developing strong technical skills, understanding cellular behavior and communication, and designing reproducible experiments. Students will learn aseptic technique, subculturing, cryopreservation, contamination control, and safe handling of cell cultures. Laboratory activities focus on analyzing cell growth, morphology, and interactions using methods such as basic imaging, viability assays, and migration studies. Through hands-on practice and guided data analysis, students will gain the competence to plan, perform, and interpret cell-based experiments for research or biotechnology applications. **COURSE LEARNING OUTCOMES (CLOS)** At the successful conclusion of this course students will: 1. Demonstrate mastery of aseptic technique and proper handling of established cell lines. 2. Analyze cellular behavior, morphology, and communication under varying culture conditions. 3. Interpret experimental data related to cell growth, signaling, and organization. 4. Identify and troubleshoot issues related to contamination, variability, or data quality. 5. Design simple, reproducible cell culture experiments addressing biological questions. Corequisites: BIOL 6550. Prerequisites: Acceptance in the MS Genomics Degree. FA.

**BIOL 6630. 3D Cell Culture. 2 Hours.**
This graduate (or upper-division) course introduces three-dimensional (3D) cell culture systems and organoid models derived from different tissues. The emphasis is on practical methods for creating and maintaining organoids (e.g., intestinal, liver, brain, kidney) and understanding how they mirror tissue structure and basic function. Students will learn scaffold-free and scaffold-based culture techniques, analyze development and differentiation of organoids, and explore common applications (disease modeling, drug screening). The course limits extremely advanced engineering/bioprinting so that the focus remains on usability and breadth rather than full technical depth. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course: 1. Create and sustain organoids from at least two distinct tissues (for example intestinal and hepatic). 2. Characterize basic morphological and functional features of the organoids (e.g., marker expression, simple viability/assay readouts). 3. Compare 2D vs 3D culture performance in terms of differentiation and function. 4. Interpret published studies using organoids across different tissues and propose simple use-cases (toxicology screen, disease model, drug test). 5. Discuss limitations of organoid methods (lack of full vascularization, scale, cost, reproducibility) and plan modest validation/quality checks. Prerequisites: BIOL 6555 (Grade C or higher) and admission to the MS in Genomics program. SP.

**BIOL 6900R. Genomics Capstone. 1-3 Hours.**
The Genomics Capstone is the culminating experience of the masters program, allowing students to integrate and apply knowledge from coursework and research training. Students will design and execute an independent genomics project, analyze and interpret results, and prepare a comprehensive written report. The capstone experience concludes with an oral or poster presentation to faculty and peers, demonstrating mastery of genomics concepts, methods, and professional communication skills. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Design and implement independent research or applied genomics project that integrates advanced methods in functional genomics and/or bioinformatics. 2. Collect, analyze, and interpret experimental or computational data to address a defined research question. 3. Synthesize findings into a comprehensive written capstone report or thesis that demonstrates mastery of genomics concepts and techniques. 4. Deliver a professional oral or poster presentation that effectively communicates project outcomes to both specialized and interdisciplinary audiences. 5. Critically evaluate their own research in relation to existing scientific literature, identifying limitations and proposing future directions. Prerequisites: Acceptance into MS Genomics degree. FA, SP, SU.

**BIOL 6910. Genomics Seminar I. 1 Hour.**
This course introduces students to current research topics in genomics, with an emphasis on functional genomics and bioinformatics. Students will attend and critically evaluate scientific seminars, practice professional presentation skills, and engage in scholarly discussions. The course provides training in effective scientific communication and critical analysis of primary research. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Summarize current literature in genomics and explain its relevance to ongoing research. 2. Present scientific findings in a clear and professional format appropriate for an academic audience. 3. Critique research presentations by identifying strengths, weaknesses, and areas for improvement. 4. Formulate insightful questions and provide constructive feedback during seminar discussions.5. Demonstrate professional communication skills that foster scholarly exchange. Prerequisites: Acceptance into the MS Genomics degree. FA.

**BIOL 6920. Genomics Seminar II. 1 Hour.**
A continuation of Genomics Seminar I, this course focuses on advanced presentation and critical analysis of current research in genomics. Students will present their own research progress, integrate knowledge across seminar topics, and evaluate peer work with attention to scientific rigor. Emphasis is placed on identifying emerging trends in genomics and developing effective communication strategies for diverse scientific audiences. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Integrate knowledge from multiple seminar presentations to identify emerging trends in functional genomics and bioinformatics. 2. Defend their own research progress and methodology in a professional seminar setting. 3. Evaluate peer presentations using established criteria for scientific rigor and communication. 4. Synthesize insights from presentations to identify gaps in the current scientific literature. 5. Demonstrate advanced presentation skills by tailoring content for both expert and interdisciplinary audiences. Prerequisites: BIOL 5910 or BIOL 6910 (Grade C or higher) and admission into the MS in Genomics program. SP.

**BIOL 6930. Research in Progress I. 1 Hour.**
This course provides students with structured opportunities to design, initiate, and present their individual research projects in functional genomics or bioinformatics. Students will deliver regular research updates, receive formative feedback, and refine their research questions and approaches. Emphasis is placed on effective planning, early-stage data collection, and troubleshooting experimental and analytical challenges. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Design a feasible research plan that addresses a specific question in functional genomics or bioinformatics. 2. Demonstrate research progress through written and oral updates that include preliminary data and methods. 3. Apply feedback from faculty and peers to refine research questions, approaches, and goals. 4. Employ effective troubleshooting strategies to resolve early-stage research challenges. 5. Maintain accurate documentation of research methods, data, and analyses in accordance with best practices. Prerequisites: BIOL 5920 or BIOL 6920 (Grade C or higher) and admission to the MS in Genomics program. FA.

**BIOL 6940. Research in Progress II. 1 Hour.**
Building on Research in Progress I, this course emphasizes advanced stages of research execution, data analysis, and interpretation. Students will present ongoing research progress in written and oral formats, integrate feedback from faculty and peers, and prepare for dissemination through manuscripts or conference presentations. The course fosters independence in research and strengthens critical evaluation of experimental outcomes. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Analyze research results using appropriate computational and/or experimental methods. 2. Interpret findings in the context of current scientific literature. 3. Prepare a research manuscript or conference presentation that communicates progress to a professional audience. 4. Troubleshoot technical and analytical challenges encountered during advanced stages of research. 5. Defend research findings and methodologies in a professional forum, demonstrating critical thinking and scholarly independence. Prerequisites: BIOL 6930 (Grade C or higher) and admission to the MS Genomics program. SP.

**BIOL 6990R. Directed Studies. 1-3 Hours.**
This course provides graduate students with the opportunity to earn credit toward the MS in Genomics degree by completing individualized, faculty-supervised study in a specialized topic area that substitutes for a required program course previously completed at another accredited institution. Learning activities and assessments will be tailored to ensure alignment with the programs graduate-level expectations and outcomes. The course emphasizes independent study, critical engagement with primary literature, and demonstration of competencies equivalent to those achieved in the required MS Genomics curriculum. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1. Integrate advanced concepts in functional genomics and bioinformatics relevant to the substituted course requirement. 2. Critically evaluate and synthesize primary research literature within the selected area of study. 3. Demonstrate independent learning and problem-solving skills through directed assignments and/or projects. 4. Apply appropriate methodologies, tools, or analyses to address a defined problem in genomics or bioinformatics. 5. Communicate findings and insights effectively through written work and oral discussion with the supervising faculty member. Prerequisites: Acceptance in the MS Genomics Degree. FA, SP.