Advanced Undergraduate Seminars
2026-2027

<u>Fall 2026</u>

7.341. The Science of Women's Health Research: from Bench to Clinic

Instructor: Yiqiao Zheng (yqzheng@mit.edu, laboratory of Dr. Daniel J. Lew)
Wednesdays, 1 pm – 3 pm (class day and time are flexible and will be defined based on the availability of students and the instructor).

Historically, women's health often has been viewed as merely the health of the women's reproductive system. This view is now being replaced by the recognition of the spectrum of conditions that affect the female body – both physically and mentally. In this seminar course, we will discuss primary research papers that report the science behind the ongoing revolution in care for women, with particular emphasis on breast cancer, endometriosis, Alzheimer's disease and postpartum depression. We will first learn about the identification of the breast cancer susceptibility genes BRCA1/2; the discovery of the link between HER2 amplification and breast-cancer relapse and metastasis; and the translation of these findings for hereditary risk assessments and screening. We will discuss two of the most important risk factor genes in late-onset Alzheimer's disease (AD) – *TREM2* and *APOE* – and how large-scale genetic studies have enabled the identification of rare variants, the dissection of sex-specific risks, and the translational impact of these studies on therapeutic development and clinical trial design. We will examine how postpartum depression – a severe, long-lasting depression that affects more than 10% of mothers after childbirth – differs mechanistically from other forms of depression, and how an animal study led to surprising groundbreaking discoveries concerning the molecular mechanisms behind postpartum depression and to postpartum-depression-specific treatments. We will end with a discussion of endometriosis, a prevalent but poorly understood women's health condition in which tissue that is similar to uterine tissue grows ectopically. We will specifically critique (1) a recent genetics study that supports the reclassification of endometriosis as a multi-system inflammatory disease rather than a localized gynecological condition and (2) a cell biology paper that describes patient-derived organoid models of endometriosis for translational research. This course will include papers that employ methods of cell and molecular biology, biophysics, neuroscience, genetics, and genomics as well as papers describing clinical studies, exemplifying the interdisciplinary approach to modern biomedical research. Students will not only practice discussing the primary research literature with peers and the instructor but also practice both scientific writing and oral presentation, all with a focus on the critiquing of scientific data. By the end of the semester, students should be able to critically analyze a primary research paper, focusing on the overall rationale, experimental design, and interpretation, and also be able to develop rigorous scientific arguments using evidence-based information, conveying that information in writing and orally. This course will include a field trip to AbbVie, a biopharmaceutical company with a long history of women's health research and development and now actively investing in neurological disorders that affect women, including Alzheimer's disease. Students will learn how basic science concepts can be translated to drug discovery and drug production and about the development and regulatory processes required to bring a drug from discovery to market. Students also will hear about career opportunities in the pharmaceutical industry.

7.342 Engineering the Immune System to Combat Pathogens and Cancer

Instructors: Taylor Heim (laboratory of Stefani Spranger) & Brett Pogostin (laboratories of Stefani Spranger, Darell Irvine & Robert Langer),
Thursdays 11 am – 1 pm (class day and time are flexible and will be defined based on availability of students and instructor)

Why do some vaccines provide lifelong protection to viruses while others fade within months? How can a patient's own immune cells be engineered into living drugs capable of eliminating tumors? And how are scientists designing materials at the nanoscale to precisely control where, when, and how strongly the immune system responds? These are among the central questions driving one of the most exciting frontiers in modern biomedicine: the engineering of the immune system. Engineers sometimes lack a deep, mechanistic understanding of immunobiology, while biologists can have minimal exposure to the design principles of bioengineering. This course will bridge these two fields. We will discuss how biomaterial-based delivery platforms, including lipid nanoparticles (which were key in Covid vaccines) and polymeric scaffolds can be used to control the kinetics and localization of antigen presentation, immune cell activation, and immune cell recruitment. We will evaluate how parameters such as antigen persistence and route of administration influence the magnitude and tissue distribution of immunological memory. This course will be discussion-based and will center on the critical reading and analysis of the primary research literature. Students will develop skills in evaluating experimental design and control experiments, interpreting complex datasets, and positioning individual findings within the broader context of the field. Methodologies covered will include mouse models of vaccination and tumor challenge, single-cell fluorescence flow cytometry, and single-cell RNA sequencing for immune profiling, *in vivo* bioluminescence and fluorescence imaging, and techniques for nanomaterial characterization. To connect scientific principles to their real-world translation, we will take a field trip to Moderna, which applies its mRNA platform technology to both vaccines and cancer immunotherapy. At Moderna students will have the opportunity to speak with scientists and engineers about how academic discoveries move from the laboratory bench into clinical development, and to learn about career paths in the biotechnology and pharmaceutical industries. By the end of this course, students will possess a foundational understanding of both the biology of immunology and the engineering strategies used to harness this biology, as well as the critical thinking skills needed to evaluate primary research literature in immunology, vaccinology, biomedical engineering, and biomedicine more broadly. This course will be particularly valuable to students interested in careers in immunology, biomedical research, pharmaceutical science, or medicine, but we welcome all students eager to explore how engineering and biology can be integrated to improve human health.

Spring 2026

No courses scheduled.