BMED 6776 Immunoengineering

Fall 2026

Department, number, and title of course: BMED/ME 6778, Immuno-engineering

Instructor	**Email**
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Designation as a 'Required' or 'Elective' course: Elective; No specific expertise necessary, but immunology/biomaterials knowledge will be used in class. The course will provide the necessary background in immunology.

Course objectives: Fall. (3 credits): The overall aim of this course is to present integration and application of engineering principles, analyses, and methods for quantitative study of the immune system in health and disease, and strategies for therapeutic modulation of immune responses. The course is aimed at integrating students' training in immunology and engineering fundamentals into the understanding and control of immune responses. This course will establish the concepts necessary to develop new engineered therapies or improve existing therapies by controlling immune cells. The topics covered in this course span from biophysical mechanics of immune cells, fluid transport, the interplay of soft/hard tissue mechanics with the immune system, host response to bioprosthetic and mechanical implants, innovative material design to program immune system or evade the immune response, cell engineering, and developing micro-nano scale technologies for detection and/or manipulation of the immune system. The application area encompasses a comprehensive list, including infections, autoimmune disorders, cancer, allergies, implants, musculoskeletal and cardiovascular disorders, aging, obesity, brain disorders, and stem cells, among others.

Recommended Textbook(s) and/or other material for reference: The Immune System: Peter Parham, 4th edition, Garland Science; Material from existing literature, including papers, rubrics, and assignment information, will be provided via Canvas.

Course Goals and Learning Outcomes

Upon successful completion of this course, you should be able to:

- Explain the principles of basic immunology, including innate and adaptive immune responses, and describe how immune cells interact in health and disease.
- Analyze the physical and mechanical properties of immune cells and evaluate how engineering methods can be applied to study molecular interactions and cell regulation.
- Apply micro- and nanotechnologies, biomaterials, and diagnostic tools to engineer immune cells and tissues at multiple scales.
- Assess the role of immunity in conditions such as cancer, aging, transplantation, autoimmunity, and tissue degeneration, and propose engineering-based strategies to address them.
- Design innovative approaches that exploit lymphatic transport, biomaterials, or the tumor microenvironment to improve immune function or therapeutic outcomes.

Class schedule, i.e., number of sessions each week and duration of each session:

Two 75-minute lectures each week.

Course Requirements & Grading

Impact Statement: For each assigned paper, provide a short paragraph (2-4 sentences) summarizing the main point of the paper and its impact/significance. The impact statements must be submitted via Canvas by 8 AM prior to class. For formatting, list SENIOR AUTHOR (in CAPS) followed by the impact statement for each paper. Impact statement papers are assigned to students in groups. Each student is expected to be prepared to lead or discuss the content of the paper. Students can work with each other outside of class on the paper content discussion as long as they submit only their own work.

Class Discussions: Assigned groups will lead class discussions based on assigned readings. This will be graded as class participation. Each student is expected to be prepared to lead or discuss the content of the paper. Students can work with each other outside of class on the paper content discussion. Students must

provide context for reading and critical analysis. A simple presentation of results in papers is not sufficient.

Exams: Questions will assess students' ability to apply concepts from lectures and primary literature to novel problems, integrating mechanistic understanding, material design, and translational thinking. Students will be expected to analyze, predict, and propose experimental or engineering strategies rather than simply recall facts.

Grant Proposal: Each student is required to submit an NIH-style research proposal addressing a significant, fundamental, or device-related biomaterial problem. The proposal must include (i) objective, hypothesis, and specific aims of the proposed research, (ii) a statement of significance and critical review of relevant literature, and (iii) experimental design and methods outlining proposed experiments, including experimental variables and appropriate controls, expected outcomes, and potential problems and alternative solutions. No prior grant-writing experience is required. The course includes structured instruction on proposal fundamentals, including Specific Aims development, research strategy, and review criteria. Students will submit proposal components in stages and receive iterative instructor and peer feedback. By the end of the course, each student will have developed a polished draft component and gained practical experience with the grant review process.

Study Section: Students will be assigned to one of two study sections (chaired by instructors) that will review grant proposals based on NIH merit criteria (see webpage). For each assigned proposal, students will provide a score and present a critique at the panel discussion session (final exam slot). Peer- and instructor-reviewed scores will be factored into the final grade.

Grading: 15% Impact Statement HW

10% Class Participation

40% Exam (20% each)

5% Specific aims draft

20% Grant proposal

10% Study section score

Your final grade will be assigned as a letter grade according to the following scale:

A 90-100%

B 80-89%

C 70-79%

D 60-69%

F 0-59%

Course Policies, Expectations, & Guidelines

Important Policy regarding use of AI:

Impact statement: The use of ChatGPT or other generative AI tools to create or edit your impact statements is not allowed. All submissions must represent your own understanding and original writing. Use of grammar or spelling editing tools is permitted. Any violation of this policy may result in the assignment being rendered invalid (which means you get zero on the assignment). You may, however, use generative AI to search for concepts or background information.

Grant proposal: The use of ChatGPT or other generative AI tools to create or edit your grant is strictly prohibited. All submissions must represent your own understanding and original writing. Use of grammar or spelling editing tools is permitted. Any violation of this policy related to grant writing may result in the assignment being rendered invalid (meaning you get zero on the assignment) and will be considered a violation of academic integrity policy. You may, however, use generative AI to search for concepts or background information.

Recordings of Class Sessions and Required Permissions: Classes may not be recorded by students without the instructor's express consent, unless it is pursuant to an accommodation granted by the Office of Disability Services. Class recordings, lectures, presentations, and other materials posted on Canvas are intended solely for the education of students currently enrolled in the course. Students may not record or share

the materials or recordings, including screen captures or automated bots, without the instructor's permission.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code and the student Code of Conduct.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also email me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and/or Participation

While attendance will not be the sole factor in determining your grade, active class participation is an important part of the learning experience. Our discussions, group work, and in-class activities are designed to help you engage with the material in ways that go beyond what can be learned through readings or assignments alone. Frequent absences can also affect your peers, as much of our work involves interaction, exchange of ideas, and group discussions. Your presence enriches the class environment for everyone.

I will track attendance informally and note participation in discussions and activities. Participation may be reflected in your final grade through participation points. If you must miss class due to illness, travel, or other unavoidable reasons, please notify me in advance whenever possible. I can then guide you to resources that will help you stay current with the material.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

I understand that life can sometimes interfere with coursework, and my goal is to be fair while also keeping the course on track.

- **Assignments:** Assignments are due on the posted date and time. Late submissions may be accepted within 24 hours with a penalty of up to 25% or grade and up to 48 hours with a penalty of 50%, unless prior arrangements are made. Beyond that window, late work will not normally be accepted. If you anticipate a conflict, please reach out as early as possible so we can discuss options.
- **Exams:** Exams are expected to be taken at the scheduled time. Make-up exams will only be offered for Institute-approved absences (such as field trips, athletic events, or religious observances) or in cases of documented emergencies (such as illness or family emergencies). Please notify me in advance if you know you will have a conflict.
- **Institute Exceptions:** Georgia Tech recognizes certain exceptions, including approved Institute activities, religious observances, and other official commitments. These will always be honored, provided you inform me in advance. I also encourage students to be mindful of events like the All-Majors Career Fair and off-campus interviews, and I will do my best to plan accordingly.

This policy is designed to help you stay on track while also allowing some flexibility when unexpected challenges arise. The earlier you communicate with me about potential conflicts, the more options we will have.

Inclement Weather and Digital Learning Days: In the event of severe weather or other emergencies, course activities will follow Georgia Tech guidance; updates will be communicated via official Institute channels and Canvas. If classes transition to a Digital Learning Day, scheduled activities will continue remotely using Canvas and other approved instructional tools, unless otherwise announced.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgment, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek.

Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Undergraduate Student Academic Success Resources: A list of resources for undergraduate students' academic success and information about advising can be found at Success at Tech.

- Academic Support: The Office of Learning and Academic Success Initiatives (a division of the Office of Undergraduate Education & Student Success, Academic Success & Advising) provides free support for your courses. Students can attend scheduled supplemental review (PLUS) sessions, stop by Drop-In Tutoring, or schedule a one-on-one appointment through Knack. To explore what options work best for you, please visit us online at success.gatech.edu/tutoring, email us at tutoring@gatech.edu, or come see us at Clough Undergraduate Learning Commons, Suite 283.

Graduate Student Academic and Professional Success Resources: A list of resources for graduate students is given on the Office of Graduate and Postdoctoral Education website. Specific information for current graduate students includes

- Academic Resources such as the Communications Center, Language Institute, Library, Catalog, Registrar, resources for conducting research, Advocacy and Conflict Resolution resources, and how to manage unexpected situations that may impact your academic performance;
- Student Resources such as Campus Services, Child Care/Family programs, Health & Wellness, Career Services, and the Student Resource Guide; and
- Professional Development, such as the programming from the Career Center and other professional development resources and events.

Student Well-Being: At Georgia Tech, we are concerned about your overall physical, social, and mental well-being. A comprehensive list of wellness-related resources has been compiled and maintained by the Office of the Vice President for Student Engagement and Well-being (student-resource-guide (gatech.edu)

More resources on supporting student well-being on the syllabus and beyond are available through the Learning Well Initiative.

Course Materials

Lecture	**Topic**
Lecture 1	Intro to Immuno-Engineering: A concept beyond implant pathology
Lecture 2	Immunology Crash Course: Immune organs; B cells, T cells, Dendritic Cells, Macrophages, etc.
Lecture 3	Immunology Crash Course: Innate vs Adaptive Immunity; Engineered approaches to derive immune cells from stem cells
Lecture 4	Engineered approaches to develop primary immune organs
Lecture 5	Engineered approaches to develop secondary immune organs — **HW 1 Assigned**
Lecture 6	Biomaterials-based immuno-engineering for vaccines against infections and cancers
Lecture 7	Biomaterials-based immuno-engineering for vaccines for tolerance
Lecture 8	In-class paper discussion on immune organs — **HW 2 Assigned**
Lecture 9	Biomaterial Immuno-modulation via Dendritic Cell Adhesion
Lecture 10	In-class paper discussion on lymphatics–biomaterials–vaccine
Lecture 11	Neutrophils and immunoengineering
Lecture 12	Biophysics and mechanical regulation of immune cells — **HW 3 Assigned**
Lecture 13	Gut Microbiome & vaccines
Lecture 14	In-class paper discussion on biophysics & immune regulation
	Exam 1
Lecture 15	Human organoids with an autologous tissue-resident immune compartment
Lecture 16	Role of innate/adaptive immunity in injury, repair & tissue degeneration **HW 4 Assigned**
Lecture 17	Engineered approaches to regulate inflammation
Lecture 18	HW 4 Discussion on Macrophages and Immunotherapy
Lecture 19	Spatial Omics and Immunoengineering
Lecture 20	Engineered approaches to regulate inflammation in Osteoarthritis & RA
Lecture 21	Engineering micro/nanoscale diagnostic tools for detecting immunological changes
Lecture 22	In-class paper discussion on point-of-care diagnostics
Lecture 23	Intro to Cell Manufacturing
Lecture 24	**Exam 2**
Lecture 25	Grant Proposal & Study Section – I
Lecture 26	Grant Proposal & Study Section – II
Lecture 28	Grant Proposal & Study Section – III (Final Class)