

BIOE 498/598 TC1: Technologies for Cancer Diagnosis and Therapy

Meeting time: Tuesdays and Thursdays, 2:00 – 3:20 PM

Location: Everitt Lab, 2310

Credit hours: 3 (498) or 4 (598)

CRN: 56513 (498) or 65893 (598)

Semester: Fall

Instructor Information

Name Professor Yang Liu

Contact Information liuy46@illinois.edu

Office Hours By appointment

Course Description

Technologies for Cancer Diagnosis and Therapy introduces how engineering principles are applied to detect, characterize, and treat cancer across scales—from molecular assays and imaging systems to therapeutic delivery and adaptive treatment monitoring. Baseline cancer biology knowledge is reinforced through assigned readings so in-class time can focus on how technologies generate, analyze, and act on clinically meaningful signals. Students compare strengths and limitations of diagnostic and therapeutic platforms, practice distinguishing causal from correlative evidence, and synthesize what they learn in a concise NIH-style R21 exploratory proposal.

This course is organized around **four core thematic areas**:

1. **Cancer-Biology Foundations** – Topics on cancer hallmarks, molecular drivers, and tumor microenvironment biology that frame engineering problems.
2. **Diagnostic Technologies** – Molecular, radiological, optical, and digital-pathology platforms for detecting and characterizing cancer.
3. **Therapeutic Technologies** – Drug-delivery engineering, immuno-engineering, radiation-based interventions, and personalized-treatment decision tools.
4. **Cancer Models and Decision Technologies** – Patient-derived organoids, xenografts, and computational/digital twin models for predicting therapy response; companion diagnostics that guide personalized treatment selection.

Two additional cross-cutting components are **executed throughout class lectures and assignments**:

- **Experimental Evidence & Causal Reasoning** – Evidence Clinics that teach students to distinguish causal from correlative data and apply those ideas in mini-talks and assignments.
- **R21 Exploratory Proposal Development** – An exploratory R21 NIH-style proposal that integrates cancer biology, technology, and rigorous experimental design.

There is a wide range of materials available for this class. In-class time will focus on key concepts, discussions, mini-talks, and projects. Students are expected to complete assigned readings and watch preparatory videos before each class using the content on the course website.

Course Objectives

1. **Use** correct terminology from cancer biology, clinical pathology, and oncology to frame engineering problems.
2. **Identify** how cellular processes, tissue processes, and exogenous events lead to carcinogenesis through measurable engineering readouts and performance specifications.
3. **Analyze** mechanisms, strengths, and limitations of major diagnostic and therapeutic technology classes in relation to clinical decision points.
4. **Distinguish** causal from correlative evidence in cancer technology studies using an Evidence Ladder framework.
5. **Critically evaluate** research proposals and research reports related to cancer technologies in terms of significance, innovation, and approach.
6. **Conceptually design** technologies for cancer, formulated as an NIH R21 research proposal.

Course Format

- Two 80-min classes per week **combining lecture delivery with discussions**. Discussion is a major component of the course. Discussion is a major component of the course.
- Weekly, students are expected to spend ~3 hours in class and about 6 hours outside the class.
- Mini-Talks (Student Presentations)
 - i. Four designated Mini-Talk Days are spaced across the term for the four thematic areas.
 - ii. Groups sign up in Week 2 by theme; first-come, first-served.
 - iii. 10-minute presentation + 2-minute Q&A.

Recommended Prerequisites

- CHEM 232 or equivalent knowledge
- BIOE 206 or equivalent knowledge

Course Website

Course materials: <https://canvas.illinois.edu/courses/72570/modules>

Textbook and Reading Materials

No textbooks are required. We will use published scientific articles as the main sources of learning. The following reference texts are recommended for supplementary reading.

The Biology of Cancer, Robert A. Weinberg (**highly recommended**)

Third edition. New York: W. W. Norton & Company, 2023.

ISBN 9780393887655; ISBN 0393887650

(<https://www.norton.com/books/9780393887655>)

Suggested References:

Biomarkers in Cancer Screening and Early Detection, Srivastava, Sudhir, ed. 1st ed. Hoboken, New Jersey: Wiley Blackwell, 2017. Accessible via Library Online Book (with University NetID and password): https://i-share-uiu.primo.exlibrisgroup.com/permalink/01CARLI_UIU/gpjosq/alma99955106446305899

Tumor models in Cancer Research Teicher, Beverly A

New York: Springer Science; 2010. Accessible via Library Online Book (with NetID and password):

https://i-share-uiu.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma99954905057005899&context=L&vid=01CARLI_UIU:CARLI_UIU&scope=MyInstitution&tab=LibraryCatalog&lang=en

Course Policies

- **Attendance:** Students are expected to attend every class session except in cases of an authorized absence or unavoidable emergency. Attendance will be recorded through in-class surveys and quizzes. For remote class sessions, attendance will be determined from written attendance records or participation documented in the Zoom chat.
- **Course-related communications:** Course announcements will be sent via Canvas Announcements and Discussions; please check these regularly. For general course questions and information, first consult the syllabus. Use the Canvas Discussion forum for all communications related to class. In case of emergencies, email the instructor via email at liuy46@illinois.edu.
- **Policy on Late Homework Submissions:** For late submissions, a 20% grade reduction will apply if submitted within 24 hours after the deadline, and a 50% reduction will apply if submitted within 48 hours. Submissions will not be accepted beyond 48 hours, except under special circumstances approved by the instructor. If you encounter technical difficulties preventing timely

submission, please inform me or TA immediately. This late submission policy applies to all homework assignments.

Approximate Course Schedule (Subject to changes)

Week	Date	Topics
Cancer Biology (Foundation)		
1	8/25	General introduction; the role of technology across cancer care.
	8/27	Overview & hallmarks of cancer.
2	9/01	Molecular drivers & oncogenic signaling (Oncogenes + Signaling).
	9/03	Cancer genome & clonal evolution (driver mutation, heterogeneity).
3	9/08	Cell cycle & cell-fate control
	9/10	Tumor microenvironment
4	9/15	Mini-Talk 1: Cancer Biology Foundations
Clinical Diagnostics		
5	9/17	Case study for clinical diagnosis
	9/22	Clinical specimens: blood tests, bodily fluids; liquid biopsy overview.
6	9/24	Surgical pathology & histopathology workflow
	9/29	Cytopathology & digital pathology, molecular diagnostics
	10/01	Biomarker discovery & validation pipeline
7	10/06	Mini-Talk 2: Cancer Diagnostic Technologies
	10/08	Self-guided journal clubs.
Clinical Oncology (Therapeutics)		
8	10/13	Therapeutics overview; drug classes; intro to drug-delivery engineering
9	10/20	Therapeutic resistance mechanisms
	10/22	Drug discovery and engineering
10	10/27	Cancer immunology
	10/29	Cancer immunotherapy
11	11/03	Mini-Talk 3: Therapeutic Delivery & Resistance.
Personalized Models and Decision Technologies		
12	11/10	Overview of research study design
	11/12	Cancer models for drug discovery
13	11/17	Personalized treatment decision technologies.
	11/19	Mini-Talk 4: Personalized Decision Technologies.
14	11/24	Fall Break – No Class.
	11/26	Thanksgiving – No Class.
Final Presentations (R21 proposal)		
15	12/01	Final presentations
	12/03	Final presentations
16	12/08	Final presentations

Gradings

Category	Assignments	Percentage of Grade
Exam	Final exam	30%
Homework	Problem-solving	10%
	Quiz	5%
Mini-talk and short essay	Presentation (15%)	20%
	Short essay (5%)	
R21 proposals	Proposal presentation	25%
Class participation	Active participation in class discussion	10%

Academic Integrity

The university's policy on Academic Integrity can be found in the *Code of Policies and Regulations Applying to All Students* under Article One, Part IV which can be found at: <https://studentcode.illinois.edu/>.

The following policies support and reinforce that policy.

1. All students are expected to hold the highest standards of scientific and academic conduct. Any form of cheating on any graded work on this course is unacceptable and will be dealt with as outlined below, and in accordance with the University-wide standards in the *Code of Policies and Regulations Applying to All Students*.

2. It is a requirement that all graded work be entirely your own, and that anything you write using the words of other writers be correctly attributed. Some specific points follow:

Artificial intelligence text generation: This course encourages the thoughtful and responsible use of generative AI tools, such as ChatGPT and Copilot, to support learning and strengthen your thinking. These tools may be used to brainstorm ideas, explore alternative approaches, clarify concepts, debug code, improve organization and language, and assist in identifying relevant literature. AI should function as a learning and brainstorming partner—not as a substitute for your own critical thinking.

For graded written work—including homework, the short essay, and the R21-style research proposal—AI may assist with idea development, organization, and revision, but it may not be used to generate all or a substantial portion of the submitted work. Your final submission must reflect your own analysis, scientific judgment, argumentation, and synthesis. You are responsible for evaluating the accuracy of all AI-generated content and for making the final intellectual and writing decisions.

For the short essay and R21 project, all factual claims, methodological details, and references must be verified using peer-reviewed literature or reputable databases and cited according to course guidelines. AI-generated responses are not themselves acceptable sources, and students should never cite a paper they have not personally located and reviewed.

In the mini-talk and final presentation, students should briefly explain how they interacted with AI during the development of their work—for example, how AI was used to brainstorm questions, refine a hypothesis, consider alternative interpretations, or improve the presentation, as well as which suggestions were accepted, modified, or rejected. The goal is to demonstrate thoughtful and critical engagement with AI, not simply its use.

Submitting substantially AI-generated work as one's own, failing to verify AI-generated information or references, or failing to disclose significant AI assistance may result in a substantial grade penalty and may be reported as a violation of the university's academic-integrity policy.

Plagiarism: On all assignments, exams, and presentations, all written and verbally communicated content must be your own words, formulated from your own understanding of the material, and not copied from any other material. If the work you submit resembles that of another work or that from another student/team (including work from previous offerings of this course or other courses), it may be concluded that it was not your original work. Turnitin reports will be used to determine the degree to which submitted materials resemble previously written work. If you use the *ideas and/or opinions* from another author or source, you must provide the appropriate citation. That is, you must, using APA format, place a

parenthetical reference to the source that provided you this information.

Figures, schematics, and graphical content will be required for presentations and essays. These materials may be acquired from the literature or other sources, however *the source must be cited in all cases*, and none of the describing information, including figure legends, may be copied directly. Instead, this information must be paraphrased in your own words. The AI-generated figures are acceptable for illustration purpose.

3. Group work will be an important part of this class. All members must contribute meaningfully to group assignments and presentations. Contributions may be evaluated through peer feedback, documented work, and individual participation. Grades may be adjusted based on each member's contribution, and failure to contribute may result in a reduced grade or a zero for the responsible individual.

Inclusive Community

The Department of Bioengineering is committed to fostering an equitable, inclusive, and anti-racist community where all members feel a sense of belonging. Our departmental and professional environments benefit from the diversity of race, ethnicity, national origin, gender, gender identity, sexuality, disability status, socioeconomic background, age, and religious belief. The success of this course depends on each of us contributing to a respectful and encouraging learning environment—one that supports the open exchange of ideas while ensuring equitable opportunities for every participant. All individuals in this class are expected to maintain an atmosphere in which students, staff, and faculty can contribute without fear of personal ridicule or the use of provocative language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to report these behaviors to the Bias Assessment and Response Team (BART) at <https://bart.illinois.edu/>. Based on your report, BART members will follow up and reach out to students to make sure they have the support needed to be healthy and safe. If the reported behavior violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Disability Related 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, e-mail disability@illinois.edu, or go to <https://www.disability.illinois.edu>. If you are concerned that you may have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnose

a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at <https://odos.illinois.edu/community-of-care/resources/students/religiousobservances/> to request appropriate accommodations. This should be completed in the first two weeks of classes.

Sexual Misconduct Reporting Obligation

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 Office. In response, an individual from the Title IX Office will provide information regarding rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list

of designated University employees who do not have this reporting responsibility and can maintain confidentiality as counselors, confidential advisors, and medical professionals can be found here: <https://wecare.illinois.edu/resources/students/#confidential>. Other information about resources and reporting is available here: <https://wecare.illinois.edu/>.

Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Health Service Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700
- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (815) 720-4953 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

This statement is approved by the University of Illinois Counseling Center.

Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported using the [Public Incident Report Form](#), email (conflictresolution@illinois.edu), or phone (217) 333-3680 to the [Office for Student Conflict Resolution](#) (<https://conflictresolution.illinois.edu/>) for disciplinary action.

Veteran and Military Students

As a military-friendly institution, and per federal regulations and Illinois statutes, the University of Illinois Urbana-Champaign has established policies and procedures to accommodate military-connected students. In addition to the support available at the [Chez Veterans Center](#), members of the National Guard or Reserves and active-duty military personnel with military obligations (e.g., deployments, training, drills) are encouraged to communicate these, in advance whenever possible, to the instructor. For policy details, see the Student Code on [Excused Absences and Departure from the University for U.S. Military or other U.S. National Defense Services](#).