BIOE 424
Preclinical Molecular Imaging
Tu/Th 3:30 – 4:50 PM, 112 Transportation Building
Office hours: Tuesdays 5-6 PM (use this link to book a 30-minute meeting)

INSTRUCTOR
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Course Description

This course provides a comprehensive foundation in the principles and applications of preclinical molecular imaging, enabling students to build upon their existing education and experiences, shaping the future of the field and pursuing their professional aspirations. Core topics will include:

1. Imaging physics and instrumentation
2. Molecular probes and contrast agents
3. Molecular interactions
4. Quantitative imaging and computational modeling
5. Clinical translation of imaging strategies

These areas will be explored through four integrated themes:

- **Basics** – fundamental sciences underlying molecular imaging
- **Methodology** – applying basic principles to develop imaging techniques
- **Utility** – evaluating the relevance and impact of imaging approaches
- **Translation** – bridging the gap from preclinical research to clinical practice

Prerequisite(s)
none, but BIOE-205 is recommended.

Credit Hours
3 (undergraduate) or 4 (graduate)

Text(s)
There is no required textbook for the course. All course materials will be posted online on the course website at http://canvas.illinois.edu

Course Objectives

Students will learn about the practical aspects of preclinical molecular imaging, including:

- technology review with a focus on nuclear imaging techniques (PET, SPECT), X-ray CT, optical, and hybrid multimodal imaging systems
- development and evaluation of molecular imaging probes
- development, optimization, and use of image acquisition protocols
- image processing and quantitative analysis, including computational modeling
- imaging applications in oncology, neuroimaging, and cardiovascular system
- ethical aspects of preclinical imaging
- domestic and international regulatory issues and policies

Grade Distribution

Homeworks:	2 x 10% = 20%
Quizzes:	7 x 5% = 35%
Final exam:	1 x 30% = 30%
Project presentation:	1 x 15% = 15%

Letter Grade Distribution

>= 93.00	A
90.00 - 92.99	A-
87.00 - 89.99	B+
83.00 - 86.99	B
80.00 - 82.99	B-
77.00 - 79.99	C+
73.00 - 76.99	C
70.00 - 72.99	C-
67.00 - 69.99	D+
63.00 - 66.99	D
60.00 - 62.99	D-
<= 59.99	F

Course Policies

General

- Computers can be and are encouraged to be used unless instructed not to do so.
- The final exam is an open-book, open-notes exam.
- The final project grade will be based on the group presentation (15%).
- Grades will be maintained on the course website (http://canvas.illinois.edu).
- Students are responsible for tracking their progress using the online grade book.

Assignments

- Students are expected to work independently. Offering and accepting solutions from others constitutes plagiarism, a severe offense, and all involved parties will be penalized in accordance with the University of Illinois Student Code (Article 1).
- Discussion among students is encouraged, but when in doubt, direct your questions to the instructor.
- Late assignments will not be accepted, except under reasonable circumstances such as illness, emergencies, or other extenuating situations.

Attendance and Absences

- Regular class attendance is expected of all students at the University. See Article 1 of the Student's Code.
- Selected content recordings and all class materials will be uploaded to the course website at http://canvas.illinois.edu.
- Students are responsible for all missed work, regardless of the reason for the absence. It is also the absentee's responsibility to get all missing notes or materials.

DRES Accommodations

- If a student has DRES (Disability Resources and Educational Services) accommodations, documentation must be submitted to the course instructor by the end of the third week of class.
- If a student believes that they need DRES accommodations, they should contact DRES at disability@illinois.edu.

Course Recordings

- Students are welcome and encouraged to make audio recordings of course lectures.
- The material recorded is the intellectual and copyrighted property of the University of Illinois Board of Trustees and may be made for personal use only.
- Video recordings of any kind are strictly prohibited.
- Posting audio recordings or transcriptions on social or electronic media platforms is strictly prohibited.

Statement on Academic Integrity

- Science cannot exist without honesty. The faculty and staff in the Department of Bioengineering require students, as scientists-in-the-making, to hold the highest standards of scientific and academic conduct. Any form of cheating on any graded work in courses is unacceptable and will be dealt in accordance with the University-wide standards in the Code of Policies and Regulations Applying to All Students and Honor Code (https://bioengineering.illinois.edu/academics/honor-code).

Data for Research Disclosure

- Any and all results of in-class and out-of-class assignments and examinations are data sources for research and may be used in published research. All such use will always be anonymous.

Weekly Schedule

WEEK	CONTENT
1	**Introduction to the course. Image fundamentals**. How is the image generated? What are the essential image features and parameters? What are simple image manipulation tools?
2	**Image filters.** Introduction to image filters in spatial and frequency domains. In-class demonstration of image filters
3	**Introduction to molecular imaging.** Concepts of molecular imaging and imaging modalities. Molecular imaging research example: multiscale imaging of angiogenesis.
4	**X-ray computed tomography imaging.** Fundamentals, basic instrumentation, contrast agents, applications
5	**Review session. Introduction to positron emission tomography (PET).** Midterm review session. PET fundamentals, radioactive decay modes, radioisotopes. HOMEWORK 1 DUE
6	**Discussion week** Discussion on a group project and homework assignments. Rebuttal. Reading assignment: Sinusas, A. J.; Thomas, J. D.; Mills, G. *The Future of Molecular Imaging*. JACC. Cardiovasc. 2011, 4, 799 – 806
7	**Positron emission tomography (PET).** PET spatial resolution, instrumentation, and applications.
8	**Single-photon emission computed tomography (SPECT).** SPECT fundamentals, instrumentation, and applications.
9	**Optical imaging (fluorescence, bioluminescence, Cerenkov luminescence).** Fundamentals, instrumentation, and applications.
10	**Animal handling.** Use of animals in research: handling, animal models, surgical procedures, colony management, ethical concerns.
11	**Review session. Introduction to image analysis.** Midterm review session. Image data and image creation. HOMEWORK 2 DUE
12	**Image processing and quantification. Partial volume and spillover effects.** Reading assignment: Soret, M.; Bacharach, S. L.; Buvat, I. *Partial-Volume Effect in PET Tumor Imaging*. J. Nucl. Med. 2007, 48, 932 – 945
13	**Thanksgiving break.** NO CLASS
14	**Pharmacokinetic modeling.** Imaging probe kinetics and mathematical modeling
15	**Final project presentations.** Presentations of the final group projects
16	**Final exam review session (Q & A).**