ECE599 – BIOELECTRONIC SYSTEMS & DEVICES

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Classes: TR 12:00-13:20, Weniger 287

Office Hours: TBD, or by appointment, in KEC 4097

Website: Assignments and handouts will be available on the course website in Canvas. Check website regularly for announcements and schedule updates.

COURSE DESCRIPTION

Modern electronics are transforming traditional applications in the life sciences, such as high-throughput DNA sequencing, point-of-care diagnostics, and continuous medical monitoring. These advances hold great promise for improving medical care and extending basic biological understanding. This course explores the multidisciplinary intersection of electronics and biology, primarily from an applications perspective.

The course material will provide an in-depth look at both engineering techniques and practical considerations for emerging bioelectronic technologies. Topics will include: electrical and physical interfaces with biological systems, protein and DNA biosensors, device micro- and nanofabrication techniques, implantable electronics, and CMOS-based biosensor platforms. We will focus on applications in DNA sequencing, molecular diagnostics, ubiquitous monitoring, medical electronics, and lab-on-chip integration methods.

The course is structured as a graduate seminar and will emphasize critical reading and technical analysis of recent literature, including related presentations, discussions, and reviews. We will survey a wide variety of exciting new technologies for electronics in biology and medicine, from device to system to application.

COURSE AIMS AND OBJECTIVES

The course has three specific aims:

• to provide a solid foundation for graduate students to understand current and emerging applications of electronics toward challenges in the life sciences;
• to explore the advantages and limitations of current techniques in bioelectronics, providing the tools necessary to analyze future emerging bioelectronic platforms; and
• to encourage technical analysis, synthesis, and presentation of findings of multidisciplinary technology development.

On completion of this course, student should be able to:

• describe common techniques used for bioelectronic systems, such as integrated electronics, micro- and nanofabrication, transduction modalities, and functionalized sensor interfaces;
• critically evaluate bioelectronic platforms to identify key performance criteria, strengths, and weaknesses in the context of real-world applications;
• characterize the state of the art in particular bioelectronic topics and to discern future development directions;
• communicate technical analyses outcomes via discussion and presentation; and
• appreciate the transformative potential of electronics in biology and medicine.
COVERED TOPICS

The course will begin with fundamental building blocks required for reading and analysis of bioelectronics and biosensor literature. This will include structure and function of biomolecules, methods of signal transduction, basics of diagnostic testing and infrastructure, and a brief overview of modern semiconductor fabrication.

The course will proceed with the exploration of specific technologies and techniques through reading, student presentations, and class discussion. This phase of the course will require significant participation of all students, as well as outside preparation and reading.

A schedule of course topics is outlined below. Please keep in mind that this is a preliminary listing, and topics and ordering may be updated as the course progresses to better serve the needs and interests of the students.

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<thead>
<tr>
<th>Week</th>
<th>Topic(s)</th>
<th>Notes</th>
<th>Class Format</th>
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<tr>
<td>0</td>
<td>Course Introduction</td>
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<td>Lectures, Class Discussions</td>
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<tr>
<td>1</td>
<td>Biomolecular structure and function overview</td>
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<td>2</td>
<td>Transduction mechanisms; Semiconductor fabrication</td>
<td>Presentation groups and topics selected (R 10/6)</td>
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<td>3</td>
<td>Single molecule sensing techniques (e.g. nanotube, nanopore, nanocantilever)</td>
<td>Due (T 10/11); Research Topic Selection</td>
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<td>4</td>
<td>Ensemble sensing techniques (e.g. electrochemical, ISFET, FBAR)</td>
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<td>5</td>
<td>High-throughput DNA Sequencing</td>
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<td>6</td>
<td>Lab-on-chip Integration and Microfluidics</td>
<td>Due (R 11/3); Research Report Update</td>
<td>Student Presentations, Short Lectures, Class Discussions</td>
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<td>7</td>
<td>Electronic interfaces with living systems (e.g. vitals monitoring, wearable devices)</td>
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<td>8</td>
<td>Implantable bioelectronic systems (e.g. neurostimulation, prostheses, power)</td>
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<td>9</td>
<td>Getting technology out of the lab (e.g. commercialization, regulation, IP)</td>
<td>Due (T 11/22); Research Report</td>
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<td>10</td>
<td>Final Project Presentations</td>
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<td>Student Presentations</td>
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COURSEWORK AND READING MATERIAL

A detailed list of readings will be provided in subsequent handouts as the course progresses. Readings will comprise journal articles, conference proceedings, and online articles. Outside reading will require a consistent effort on the part of the student, and attending lectures is not a substitute for reading the assigned material. You will benefit most from this course by reading in advance of lectures, attending all lectures, and actively participating in class discussions.

IN-CLASS RESEARCH PRESENTATIONS

Students or groups of students (depending on class size) will be assigned a relevant journal paper to read and analyze in detail. The format will be similar to a conference presentation, however each member of the group will present a specific section of the assigned paper. All other students will provide structured feedback on the group presentation. Specific guidelines, scheduling, and paper assignments will be provided.
REVIEW ARTICLE OUTLINE ASSIGNMENT (FINAL RESEARCH REPORT)

The course material will focus on a curated set of applications and techniques in bioelectronics, and students will have an opportunity to explore an additional research topic of their choosing in much greater depth and breadth. This will include analysis of a challenge or application (What is the problem?), identification of research teams in the field and analysis of approaches (Who is solving it and how?), and synthesis of material to identify future trends (Where is the field headed next?).

This exploration will culminate in a comprehensive outline for a hypothetical review paper, encompassing many approaches and solutions to the selected topic, drawn from published sources identified by the student. Suggested topics and assignment details will be provided in a separate handout.

ASSESSMENT OVERVIEW

20% Class Participation (attendance, presentation feedback, discussion, etc.)
40% Research Presentations
40% Assignments and Research Report

ACADEMIC INTEGRITY

Honesty and original contribution are expected for all work in this course. Students must adhere to the Oregon State University Student Conduct Code; any form of academic misconduct will be reported immediately.

ACADEMIC ACCOMMODATIONS

Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at 541-737-4098.

RELIGIOUS HOLIDAYS

Oregon State University strives to respect all religious practices. If you have religious holidays that are in conflict with any of the requirements of this class, please see me immediately so that we can make alternative arrangements.