BEE 4590/6590  
Biosensors and Bioanalytical Techniques  

Fall Semester 2008  
105 Riley-Robb Hall  

Antje Baeumner  
318 Riley-Robb Hall  
ajb23@cornell.edu  

Lectures: Tuesday, Thursday 1.25 – 2.40 p.m.  
Office hours By appointment
1. INTRODUCTION

Modern research problems are frequently so multidimensional that it is difficult to delineate each of the contributing scientific subdisciplines. One of the best examples of this multidimensionality lies in research dealing with bioanalytical sensors. At the same time, applications of biosensors cut across the analytical landscape from the environment to the brain. Various biosensing devices have been designed utilizing almost every type of basic instrumental technique for measurement. Each analytical problem requiring a specific type of biosensor is unique, yet there are integrating principles of design and operation that bring some degree of cohesion to the field as a whole.

Accurate measurement of biologically related substances has been a major goal in analytical sciences throughout the twentieth century. Bioanalytical problems are among the most challenging due to the variety of substances in biological samples, the complex molecular structures and time-dependent concentrations. Most of the original biochemical protocols, many of which are still in use, require isolation of components from natural environments and separations of complex mixtures. In some cases model compounds and artificially prepared solutions are used as an alternative to coping with complex structures and mixtures. Oftentimes a method, such as microbiological assay, designed for acquisition of information about a physiological process is not easily translated into a quantitative method for determination of individual analytes. Biosensors, as discrete analytical devices, are capable to measure analytes selectively, often in a natural matrix, without prior separation of multicomponent samples, often producing quantitative data within minutes. In recent years, micro- and nanofabrication techniques, the fast growing biochemical knowledge, genetic engineering and the finding and preparation of new materials enabled the development of novel biosensors, multianalyte biosensors, microfabricated integrated biosensing systems.

Thus, this course will provide the students with an understanding of the scientific and engineering principles of biosensors and bioanalytical techniques. The course will address selected topics from simple biosensors to micro/nanofabricated microTotal Analysis Systems. The different biorecognition elements, ranging from antibodies and enzymes to whole cells, tissues, genetically engineered proteins, single-chain antibodies and aptamers, will be covered, as well as possible physicochemical transducers such as electrochemical, optical, thermal and mass based principles. The biosensor’s application in environmental analysis, food safety, and medical diagnostic will be explored using specific examples such as DNA microarray sensors, glucose sensors, the bananatrode, enzyme electrodes, nucleic acid based sensing systems for pathogen analysis etc. In the last quarter of the semester students will theoretically design a biosensor incorporating the knowledge gained throughout the semester.
2. TIME SCHEDULE
1) 08/28 (R)  Introduction to Biosensors
2) 09/02 (T)  Bioanalytical Challenges
3) 09/04 (R)  Bioanalytical Challenges II, Designing for Performance
4) 09/09 (T)  Designing for Performance II
5) 09/11 (R)  Mann Library
6) 09/16 (T)  Developing a Bioselective Layer I, homework due
7) 09/18 (R)  Developing a Bioselective Layer II
8) 09/23 (T)  Electrochemical Biosensors I, guest lecturer Prof. R. Durst
9) 09/25 (R)  Electrochemical Biosensors II
10) 09/30 (T)  Electrochemical Biosensors III, Optical Biosensors I
11) 10/02 (R)  paper reviews
12) 10/07 (T)  paper reviews
13) 10/09 (R)  Optical Biosensors II
14) 10/14 (T)  FALL BREAK
15) 10/16 (R)  Optical Biosensors III
16) 10/21 (T)  paper reviews
17) 10/23 (R)  paper reviews
18) 10/28 (T)  Micro Total Analysis System (μTAS) review paper due
19) 10/30 (R)  Micro Total Analysis Systems (μTAS) II,
20) 11/04 (T)  paper reviews
21) 11/06 (R)  paper reviews
22) 11/11 (T)  Comparison to other analytical methods
23) 11/13 (R)  Other Transduction Principles
24) 11/18 (T)  Project presentations
25) 11/20 (R)  Project presentations
26) 11/25 (T)  Prelim
27) 11/27 (R)  THANKSGIVING
28) 12/02 (T)  Project presentations
29) 12/04 (R)  Project presentations, final design project reports due
3. ASSIGNMENTS FOR LECTURES

a) A few short assignments will be handed out during classes.

b) As preparation for the overall class, it is recommended to review the following topics:
- enzymes in general, enzyme kinetics, catalytic center
- antibody structure, binding specificity
- nucleic acid, nucleotides, complementary sequences, DNA vs. RNA

Books appropriate for the review are
Stryer, L: Biochemistry

c) Biosensor article review
You will be handed an article describing a biosensor developed by a research team in the field of biosensors. Your task will be to write a critical review of that article and to present your findings in class.

d) Biosensor idea presentation
You will be given an analyte of interest for which you have to theoretically design an appropriate biosensor. Resources for this design project will be all of the class handouts as well as appropriate biosensor articles literature that you are expected to find and reference in the presentation of your biosensor idea. You will have to write a report describing your biosensor and providing quantitative measures of the sensor and also give a presentation on the design. In addition, you have to include information on the required approval steps for the commercialization of your biosensor.

N.B: It is expected all work you submit must be your own work – not a duplicate of someone else’s work. In some cases you will work in prearranged groups of 2 - 3 students. In this case, it will be important to demonstrate, who in the group contributed which parts to the assignment, you can, for example, include one paragraph describing the group dynamics and distribution of your work. If there is evidence that you have copied work from another student, all parties involved will receive a zero for that assignment. (Please also refer to the section of academic integrity in this syllabus for more information)
4. ATTENDANCE, EXAMS, AND GRADES

Text
There is no single textbook available that covers the range of scientific and engineering concepts explored in this course. Important handouts will be frequently provided at lecture time. Since there is no complete text, attendance at lecture is very important.

Books on biosensors for additional information
Alice Cunningham “Introduction to Bioanalytical Sensors” (1998)
Elizabeth Hall “Biosensors” (1991)

Prelim
One prelim will be held Tuesday, November 25th, in class. The exam will cover all topics of class.

Grades will consist of the following:

- 5% homework assignments, participation
- 35% final exam
- 25% literature article review
- 35% biosensor design

7. ACADEMIC INTEGRITY
Your individual work is expected in exams, homework assignments and case studies. Misuse of information is a serious university offense and is regarded as a violation of academic integrity.

“A Cornell student's submission of work for academic credit indicates that the work is the student's own. All outside assistance should be acknowledged, and the student's academic position truthfully reported at all times. In addition, Cornell students have a right to expect academic integrity from each of their peers. (taken from the Cornell University Statement of Academic Integrity). For additional reading, please refer to the following webpage:
http://www.cornell.edu/UniversityFaculty/docs/main.html