Engineering Faculty Document No. 35-03
February, 2004

TO: Engineering Faculty
FROM: The Faculty of Agricultural and Biological Engineering
RE: New Course

The faculty of the Department of Agricultural and Biological Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

**ABE 560/BME 521 – Biosensors: Fundamentals and Applications**

Sem. 2, Class 3, cr 3.

**Prerequisites:** Undergraduate level course work in basic cell biology or microbiology, general chemistry, and mass transfer.

**Description**:
The course is intended to provide a broad introduction to the field of biosensors as well as an in depth and quantitative view of device design and performance analysis. The student should leave the course with a solid understanding of the current state of the art as well as a basic skill set for continuation into advanced biosensor work and design. Topics are selected to emphasize biomedical, bio-processing, environmental, food safety, and bio-security applications.

**Reasons:**
A number of students across campus are engaged in biosensors research. The specific research areas of the students vary substantially from fundamental materials chemistry to microbiology to device design and are being applied to agricultural, food process, biomedical, environmental, and bio-security applications. This class is intended to bring these and other interested students together to formalize the basic fundamentals of biosensors and to gain a broad understanding of the current state of the art. While this need is immediate, we project a long term need for the course, as biosensors are predicted to remain an important research topic in the future. In addition, as the technology advances, we are likely to see an increased role of biosensors in industry.

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Head, Department of Agricultural and Biological Engineering

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**Suggested reference and/or textbooks**:
Written materials will be provided from various sources including class notes, peer-reviewed literature (primarily from the journals Biosensors & Bioelectronics and Analytical Chemistry) and selected excerpts from text references including:

Bilitewski, U. and Turner, A.P.F. 2000. Biosensors for Environmental Monitoring. Harwood Academic Publishers, The Netherlands. ISBN: 90-5702-449-7.
Ligler, F.S. and Rowe Taitt, C.A. 2002. Optical Biosensors: Present & Future. Elsevier, The Netherlands. ISBN: 0-444-50974-7.
Yang, V.C. and T.T. Ngo. 2000. Biosensors and Their Applications. Kluwer Academic/Plenum Publishers, New York, NY. ISBN: 0-306-46087-4.

**Course Learning Objectives:**
At the end of the course the students will be able to:
1. define the fundamental components of any biosensor,
2. define the major performance characteristics of any biosensor and design an experiment to measure that characteristic ,
3. evaluate a sensor based on standard performance criteria and appropriateness for an application,
4. given a specific biosensor application, identify the key design criteria and suggest and an appropriate biosensor approach which is most likely to meet those design criteria,
5. compare the relative advantages and disadvantages of the major approaches to biosensor design,
6. communicate the most relevant challenges facing the biosensor research field and given a particular challenge suggest a reasonable approach to finding a solution to the challenge,
7. describe what challenges are shared among and what challenged are unique to the major biosensor application areas.

**Syllabus:**

| Week | Topic | |
|---|---|---|
| 1 | Introduction to Biosensors | course overview, class survey, definitions, motivation, biological inspiration, types of sensors, target analytes, various recognition, signals, and device types, history of field |
| 2 | Basic Design Considerations | calibration, dynamic Range, signal to noise, sensitivity, selectivity, interference |
| 3 | Recognition / Transduction | enzyme sensors |
| 4 | Recognition / Transduction | affinity sensors: antibodies, oligo-nucleotides<br>measuring binding in affinity sensors, SPR, quartz crystal microbalance, FRET |
| 5 | Recognition / Transduction | membrane protein sensors: ion channels, receptors |
| 6 | Recognition / Transduction | whole cell sensors – bacteria, yeast, mammalian cells |
| 7 | Recognition / Transduction | non-biological and bio-mimicry: molecularly imprinted polymers, non-biological organic molecules, electro-chemiluminescence, pH sensors, artificial receptors |
| 8 | Immobilization | immobilization: adsorption, encapsulation -(hydro-gel, sol-gel glass, etc.), covalent attachment, diffusion issues |
| 9 | Device Integration | optical fiber sensors, planar wave-guides |
| 10 -11 | Device Integration | micro-scale and nanoscale: BioMEMS, nanowires, quantum dots, magnetic beads, PEBBLE sensors |
| 12 | Special Considerations | measuring complex samples, multi-analyte detection, continuous measurements, reagentless biosensors |
| 13 | Special Considerations | implantable sensors, biocompatibility issues |
| 14 | Applications | agricultural, food safety, food processing : state of the field, market potential, unique design criteria and needs, current sensors in use |
| 15 | Applications | biomedical applications, bio-security, environmental : state of the field, market potential, unique design criteria and needs, current sensors in use |
| 16 | | Final Exam |

**Grading:**

| | |
|---|---|
| Attendance | 60 pts |
| Exam 1 | 60 |
| Exam 2 | 60 |
| Exam 3 | 60 |
| In Class Presentation | 100 |
| Final Exam | 100 |
| | 440 pts |

**Grading Scale:**

| | |
|---|---|
| A | > 87 % |
| B | 78 – 87 % |
| C | 68 – 77 % |
| D | 58 – 68 % |
| F | < 58 % |