

Course Title: Bioen 490

UW General Catalog Course Description:

BIOEN 490 Engineering Materials for Biomedical Applications (3)

Combined application of principles of physical chemistry and biochemistry, materials engineering, to biomedical problems and products. Applications include implants and medical devices, drug delivery systems, cell culture processes, diagnostics, and bioseparations. Offered: jointly with CHEM E 490; A.

Instructor: Horbett, Thomas A.

Instructor's Detailed Course Description:

Bioen 490 – (3 credits). This course will provide an overview of the field of biomaterials. The student will learn the history and design principles behind the classes of biomaterials used today in medical devices used as implants in the body or in contact with bodily fluids. Ultimately, the student will obtain the tools necessary to design, analyze, and characterize biomaterials for new applications. The course focuses on the materials in biomedical applications. The major classes of materials along with their properties, characterization, biological responses, specific clinical applications are presented. Articles from the current literature are used to highlight ongoing research and development efforts to improve biomaterials and devices. Near the beginning of the course, students make presentations of on biomaterials used in a specific clinically used device as way to become familiar with the wide variety and great impact of biomaterials and devices used in humans. At midterm, the students present an analysis of failure mechanisms of the device they described earlier, and how the failures might be addressed by redesign. In a term paper, the students propose a specific redesign of the device to overcome one or more of the failure mechanisms of the current version of the device.

Prerequisites by Topics: Cell biology, Organic chemistry, Physical Chemistry

Required Textbook: Biomaterials Science, 2nd Edition (2004). Edited by B. D. Ratner, A. S. Hoffman, F. Schoen, and J. Lemons. ISBN 0125824637 2004. Elsevier Academic Press

Course Objectives:

The objectives of the course are to provide the students with:

1. Knowledge of chemical and mechanical properties of materials currently used in devices used in contact with the body, their large impact on human health, and the major bodily reactions to the devices (h, j, l)
Assessed by: exams.
2. The ability to apply principles in mathematics, science and engineering to the design and evaluation of biomaterials and biomedical devices (c,m)
Assessed by: failure mechanisms presentation, term paper, and exams.
3. An overview of current limitations of biomedical devices and strategies being studied in both academia and industry to address these limitations (h, j)
Assessed by: exams, presentation on biomaterials in current devices, term paper.
4. The opportunity to present their findings of biomaterials used in current devices and their analysis of design limitations of current devices in two oral presentations to their peers and to write a proposal to overcome one or more design limitations of current devices in a written document (g)
Assessed by: biomaterials in current devices and failure of device presentation, term paper.

Topics Covered:

History; relevance and impact; Materials in selected clinical devices (presentations by students in class); Metallic biomaterials: chemical compositions, corrosion/fretting, mechanical properties, osteoinductivity, bone cements; Bioceramics and bioglasses and carbons; natural biomaterials; special terminology; Polymeric biomaterials, chemistry

and properties, including polyurethanes and plasma deposited polymers; biomaterials for tissue engineering; biological reactions to implants: blood clotting; foreign body reaction; Failure of devices (presentations by students in class); Surface analysis of biomaterials; Biomaterials in drug delivery; Stents, blood compatibility testing, heparinized surfaces; protein adsorption, foreign body reaction; toxicological testing; device related infection. Biological correlations.

Class Schedule:

- Lectures 1 hr 20 min/lecture, meet twice a week

Computer Use:

Students will use computers to prepare their homework, final papers and class presentations.

Laboratory Projects:

No labs.

Design Project:

A final term paper is required, worth 20% of the grade. The term paper is developed throughout the course, as follows. At the beginning of the course, students are given a list of currently used biomedical devices that are used in contact with the body, each student chooses one device, and is asked to make a brief presentation. The students must find at least one manufacturer of the device, and find out as much as they can about what type of materials are used in the device and why they were chosen. Only devices actually on the market and being used clinically may be studied. In the second phase of term paper development, students make a presentation on the known failure mechanisms of their chosen biomedical device. A "failure mechanism" is why the device sometimes fails in clinical use, e.g. aseptic loosening in hip implants or thrombosis of cardiovascular stents. All known failure mechanisms for the device are reviewed. This exercise is intended to familiarize the students with shortcomings of current devices so that they are prepared to propose improvements in the device in their

term paper. The final phase of term paper is to propose a solution to one or more of the known device failure mechanisms and methods to test whether the proposed solution works. The instructions for this term paper are as follows.

Requests for proposals: The TAH-NIH, a special IRG at the mock NIH organized by the instructor for the benefit of those in Bioengineering/ Chemical Engineering 490, is calling for proposals targeting research aimed at improving the performance of biomaterials in existing clinical devices. The proposal should focus on improvements in the device you presented in class (biomaterials used and failure mechanisms). Your proposal should seek to improve the function and/or biocompatibility of the biomaterials used in the devices. Successful applications will focus on a specific medical device with previously identified failure modes, including adverse host responses that limit its function or lifetime in the body. A strategy for improving performance of the implant by proposed new materials should be proposed, and an experimental program for showing the new materials perform better and overcome deficiencies in current devices. The proposal must include: Abstract and Specific Aims (1 page); Background (2-3 pages), including an economic assessment and discussion of societal impact of the proposed system; Design and Methods (2-5 Pages); Literature citations (no limit)

Course Outcome and Assessment:

Specific outcomes in Bioen 491 and their assessment mechanisms to be used by the department for **program assessment** are:

☐ (c) *an ability to design a system, component, or process to meet desired needs.*

Students' ability will be assessed by their term paper project, in which they will design a novel biomaterial to overcome a known failure mechanism of a currently used device.

☐(g) *an ability to communicate effectively.* Written communication will be assessed

by written reading reports on assigned reading, oral presentations of biomaterials used in devices and failure mechanisms of devices, and the term papers.

□(j) *knowledge of contemporary issues*. Students will be evaluated on their understanding of economic and societal forces driving biomaterial and biomedical device development through oral presentations of failures of devices, and in the background section of the term paper. Students will also be evaluated on their knowledge of current state-of-the-art approaches to improved biomaterials and devices through exams and the term paper.

□ (m) the capability to apply adv. mathematics, science, and engineering to solve the problems at the interface of engineering and biology. Students will be evaluated on their ability to apply advanced science and engineering through the term paper.

Additional outcomes and their assessment mechanisms considered of **high relevance** to ABET criteria by the department for Bioen 491 are:

□ (h) Education necessary to understand impact of engineering solutions in global and societal context. The number and cost of implanted biomedical devices is discussed for all types of devices presented in this class. This is assessed through the oral presentation of failure mechanisms (relative frequency of various modes is required) and the term paper background section.

□ (l) *an understanding of biology and physiology* Students will be evaluated on their understanding of the bodily reactions to biomaterials through exams.

Those specific outcomes and their assessment mechanisms considered of **medium relevance** by the department for Bioen 491 are: none

Relationship of Course to Departmental Objectives:

Bioen 490 is designed to introduce biomaterials and biomedical devices to upper division undergraduates and graduate students. The course reflects the interdisciplinary nature of biomaterials science by covering the chemistry of biomaterials used in currently used devices, mechanical aspects of orthopedic devices, and economic and human health impact of biomaterials and devices. The course includes guest lecturers from the bioengineering department with special expertise relevant to biomaterials, including polymer and surface science, biomaterials in drug delivery, and biomaterials for tissue engineering. Through this training, the students are expected to become able to design and evaluate improved biomaterials for a specified clinical device.

In summary, Bioen 490 complies with the departmental objectives by:

- strengthening and applying students' knowledge in physics, chemistry, engineering and biology to design and improve biomaterials and devices.
- strengthening students' ability to communicate through written and verbal media
- using design principles from nature to solve medical problems and create biomedical devices and materials.
- further development of technical knowledge, awareness, and leadership abilities to address domestic or global issues in human health.