BME 422 – Biomaterials Characterization

3 Credits, 3 Contact hours
Instructor: Michael Jaffe, Ph.D.

TEXT
Lecture notes and class handouts

Recommended " Biomaterials Science, An Introduction to Materials In Medicine", Buddy D. Buddy D. Ratner et al., Elsevier Science and Technology (2004) ISBN 0125824637

Prerequisites
BME 420, MTSE 301

COURSE DESCRIPTION
The goal of BME 422 is to provide students with knowledge of the materials characterization techniques that are appropriate or unique to biomaterials, what these techniques measure and the underlying scientific principles on which they are based. The course provides BME students with tools to relate characterization methods back to the relevant science and forward to what technique is appropriate to the solution of a given problem. Students upon course completion are in a position to choose between techniques in the solution of a given problem and will be capable of discussing characterization issues with instrument experts and biomedical problem solvers. For example, the course will discuss the quantum mechanical origins of spectroscopy, the relationship of spectroscopic behavior to molecular characteristics of a material, and the differences in approach to the chemical and physical characterization of synthetic and biological polymers. It is not expected that the students will become expert in these techniques or the background science in detail, only that they have a strong underpinning for future problem solving.

LEARNING OUTCOMES
Characterization of Materials: The ability to relate/choose characterization data relevant to the process-structure-property-performance behavior of a biomaterial. Specifically, an understanding of the importance of size scale, from the atomic to the macro, in the characterization of biomaterials, the ability to relate chemical, biological or morphological features to appropriate characterization methods and an understanding of the importance of test environment to the relevance of results to biological performance. The necessity of understanding technique precision and the need to establish the statistical relevance of data before drawing conclusions is emphasized.

Chemical Characterization: Knowledge of the various wet chemistry and spectroscopic techniques that are utilized to define the chemical composition of synthetic and biological biomaterials. Understanding of the classical and quantum mechanical principles from the the techniques derive.

Scattering and Imaging Methods: Knowledge of the utility and limitations of modern imaging and scattering (diffraction) techniques appropriate to biomaterials. An understanding of the principles upon which these techniques are based.

Mechanical, Thermomechanical and Thermal Analysis Techniques: Knowledge of the techniques most commonly used to define the mechanical and thermal attributes of biomaterials. An understanding of the thermodynamic and kinetic principles upon which the techniques and subsequent data evaluation are based.

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Surface Characterization: An understanding of the inherent differences between bulk and surface properties of biomaterials. Knowledge of the various techniques that are utilized in biorelevant surface characterization. .

Biological Testing: An overview of the techniques that are used to characterize the interactions of biomaterials with the biological environment, including proteins, nucleic aces and cells. Test requirements for FDA approval will be reviewed and related to the principles of materials characterization.

Outcome # 1. Students will understand the relationship between biomaterials characterization data and expected performance in a biological environment		
Strategies & Actions	**Program Outcomes**	**Assessment Methods**
The quantification of process-structure-property relationships to specific medical devices is emphasized in all lectures. The importance of test environment and statistical significance is stress throughout.	A, C, D, E, G, J, K, L, O	Tests, written and oral presentations
Outcome # 2. Students will be familiar with the scientific origins, data generated and limitations of modern materials characterization techniques with emphasis on expected or observed biological performance		
Strategies & Actions	**Program Outcomes**	**Assessment Methods**
Wet chemical, spectroscopic, imaging, mechanical and thermal techniques will be discussed with emphasis on biological relevance and solutions are highlighted.	A, C, D, E, G, J, K, L, O	Tests, written and oral presentations
Outcome # 3. Students will understanding the difference between surface and bulk materials characterization and the relevance of each to performance in a biological application/environment		
Strategies & Actions	**Program Outcomes**	**Assessment Methods**
The inherent differences between surface and bulk material thermodynamics and kinetics will be defined in lectures, emphasizing the relationships between surface behavior and materials/biological environment.	A, C, D, E, G, J, K, L, O	Tests, written and oral presentations
Outcome # 4. Students will have knowledge of the interaction of biomaterials with cells and the molecules of the biological environment. Students will have knowledge of the rational and methods of FDA required testing for biomaterials approval.		
Strategies & Actions	**Program Outcomes**	**Assessment Methods**
The key issues of the interaction of biomaterials with the biological environment	A, C, D, E, G, J, K, L, O	Tests, written and oral presentations

will be discussed in lectures. Techniques used to monitor the interaction of biomaterials with cells and biological molecules will be described. Specific FDA related testing and requirements will be reviewed.		
Outcome # 5. Students will understand how biomaterials related biomedical problems may be solved by the application of appropriate materials characterization techniques		
Strategies & Actions	**Program Outcomes**	**Assessment Methods**
Lectures, student assignments and examinations will emphasize the relationship of biomaterials characterization to the solution of biomaterials choice in medical device design and the identification of the origins of medical device performance failures.	A, C, D, E, G, J, K, L, O	Tests and written and oral presentations

ABET Outcomes expected of graduates of BME BS program by the time that they graduate:

(P) an ability to apply knowledge of mathematics, science, and engineering
(Q) an ability to design and conduct experiments, as well as to analyze and interpret data
(R) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(S) an ability to function on multi-disciplinary teams
(T) an ability to identify, formulate, and solve engineering problems
(U) an understanding of professional and ethical responsibility
(V) an ability to communicate effectively
(W) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(X) a recognition of the need for, and an ability to engage in life-long learning
(Y) a knowledge of contemporary issues
(Z) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
(AA) an understanding of biology and physiology
(BB) the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology
(CC) an ability to make measurements on and interpret data from living systems
(DD) an ability to address problems associated with the interaction between living and non-living materials and systems