

BMED/MSE 4751 Introduction to Biomaterials

Credit: 3-0-3

Prerequisite(s): MSE 2001

Catalog Description

Introduction to different classes of biomaterials (polymers, metals, ceramics) and physiological responses to biomaterial implantation. Topics include material properties, host response, and biomaterial characterization techniques.

Text

J.S. Temenoff and A.G. Mikos. Biomaterials: The Intersection of Biology and Materials Science. Upper Saddle River, NJ: Pearson Prentice Hall, expected c 2008. (Currently available in class-notes form.)

Objectives

To provide a broad-based introduction for undergraduates to different types of biomaterials (metals, ceramics, polymers) and the body's natural responses to biomaterial implantation. Emphasis will be placed on how basic principles in chemistry and physics result in structural and functional differences in biomaterial types. The second half of the course will center on how biomaterial properties affect biological responses. Characterization techniques for both material properties and biological responses will be included in each section where appropriate.

Outcomes

By the end of the course the students will understand the:

1. structure-properties relationships in ceramic, metal, and polymer biomaterials (Program Outcomes 1, 2)
2. biological environment and mechanisms within the 'host' that interacts with implanted biomaterials and ultimately determine their function in vivo (Program Outcomes 1, 2)
3. basic principles and applications of characterization techniques for surface and bulk properties of materials, as well as biological response to materials (Program Outcomes 2, 4)
4. basic biomedical applications of ceramic, metal, and polymer biomaterials (Program Outcomes 9)

Topical Outline

Materials science of biomaterials

1. Materials for biomedical applications
 - Types of biomaterials - metals, ceramics, synthetic & naturally-derived polymers
 - Important properties & characterization of biomaterials
 - Principles of chemistry - atomic structure; ionic, covalent and metallic bonds
2. Chemical structure of biomaterials
 - Crystal types (metals, ceramics); polymerization methods
 - Principles of bulk analysis techniques

3. Physical properties of biomaterials
 - Crystallinity and thermal transitions
 - Principles of DSC
4. Mechanical properties of biomaterials
 - Comparison of properties between material types
 - Introduction to mechanical testing procedures
5. Biomaterial degradation
 - Corrosion; polymer hydrolysis
 - Biodegradable materials
6. Biomaterial processing
 - Strengthening techniques (cold working, drawing, etc.)
 - Shape-forming techniques (casting, extrusion, etc.)
 - Sterilization methods
7. Surface properties of biomaterials
 - Introduction to physical chemistry of surfaces; Surface modification techniques
 - Principles of surface analysis techniques & relationship to bulk analysis techniques

The biology of biomaterials

1. Protein interactions with biomaterials
 - Thermodynamic principles governing protein adsorption
 - General protein structure (primary to tertiary); protein adsorption – Vroman effect
 - Protein rearrangement on surfaces; Principles of assays for protein type and amount
2. Cell interactions with biomaterials
 - Cellular structure and function of organelles; Components of extracellular matrix
 - Cell cycle and cell differentiation, discussion of cell phenotype
 - Models of cell adhesion, spreading and migration
 - Overview of cytotoxicity assays, DNA and RNA assays and immunostaining
3. Biomaterials and thrombosis
 - Overview of extrinsic and intrinsic coagulation cascade
 - Role of platelets, endothelium
 - Assays for thrombogenicity of biomaterials (*in vitro*, *in vivo*, *ex vivo*)
4. Biomaterial implantation and acute inflammation
 - Innate vs. acquired immunity; Types of leukocytes
 - Overview of inflammation up to 1 day (macrophage maturation)
5. Wound healing and the presence of biomaterials
 - Resolution after biomaterial implantation
 - Introduction to *in-vivo* assessment of biocompatibility (ISO standards, choice of model, means of assessment)
6. Immune response and biomaterials
 - Humoral vs. cellular immunity
 - Overview of antigen presentation and leukocyte maturation
 - B cells - types, characteristics of antibodies; T cells - types
 - Overview of the complement cascade; Hypersensitivity and biomaterials
7. Infection, tumorigenesis and calcification of biomaterials
 - Overview of steps to infection and role of biomaterial surface
 - Types of bacteria; Definitions of tumorigenesis, carcinogenesis, etc.
 - Chemical vs. foreign-body carcinogenesis
 - Mechanisms of pathologic calcification