INTRODUCTION

Introduction to Biomaterials,
BIOCOMPATIBILITY

The concept of Biocompatibility

Biocompatibility and the relationship to standards; meaning and scope of biocompatibility testing

Biomaterials and the innate response

Adaptive immune responses to biomaterials

Leukocyte-biomaterial interactions in vitro

Protein interactions with biomaterials

Bacterial adhesion and biomaterial surfaces

Anti-inflammatory properties of metals

Integrin activated reactions to metallic implant surfaces

Nanostructured surfaces and cell behaviour

Nanoparticles and biocompatibility

Sterilization of biomaterials of synthetic and biological origin
MATERIALS

Metals

Metals for use in medicine

Electrochemical behavior of metals in biological milieu

Shape memory alloys for use in medicine

Bactericidal properties of metals
Ceramics

Inert ceramics

Alumina

Zirconia

Carbons, carbon films and diamond

Ceramic films

Dental ceramics
Bioactive ceramics
Bioactive Ceramics
Bioactive glass ceramics
Bioactive Ceramics – physical chemistry
Calcium phosphate coatings
Bioactive layer formation on metals and polymers
Bioactivity – mechanisms
Bioceramics and gene therapy
Bioceramics and nanospheres
Bioactive ceramics – cements
Bioactive glass composite cements
Composite bioactive ceramics – polymers
Phosphate glasses
Copper doping of calcium phosphate ceramics
Silicon containing apatites
**Polymers**

*Fundamentals and Structure–Property–Processing Relationships*

Polymers at Surfaces

Carbohydrate Polymers

Electrospinning and Polymer Nanofibers–Process Fundamentals

Micro and nanoparticle synthesis and fabrication
Hydrogels

Concept and Theory

Stimuli-responsive hydrogels

Electro-Active Hydrogels

Molecular imprinting hydrogels

Superporous hydrogels for drug delivery systems

Dynamic Hydrogels
Nanomaterials

Biocompatibility considerations related to nanomaterials
Nanoscale Design of Biomaterials
Carbon Nanotube and fullerenes materials
Nanofibers
Polymer Nanocomposites for Biomedical Applications
Nanostructures, topography, block copolymers
Nanoscale Chemistry for Cell Biology
Nanowires for Cell Sensing
ImmunoNanoshells for Cancer Therapy
Biologically Inspired and Biomolecular Materials and Interfaces

Biologically Inspired Toolbox

Oligopeptide Assemblies and Biomaterials

Bioinspired Adhesives

Biomineralization and New Materials

Engineered Viruses for Gene Therapy

Molecular self-assembly using peptide amphiphiles (2D and 3D)

Artificial and Natural Protein Polymers – Synthesis and Characterization

Peptoids – Synthesis, Characterization, and Nanostructures

Self-Assembled Monolayers for Cell Biology

Phage as templates for hybrid materials and mediators for nanomaterial synthesis

Extracellular matrix-like biomaterials

Extracellular matrix to biofunctionalize metals

Materials for artificial stem cell microenvironments
Materials of Biological Origin - Materials Analysis and Implant Uses

Bone as a material

Materials of Biological origin

Silk

Elastin Biopolymers

Chitosan

Hyaluronic Acid

Collagen

Collagen-GAG Materials

Fibrin

Extracellular matrix as a biomimetic biomaterial - Biological matrices for tissue regeneration

Decellularized scaffolds

Xenogeneic tissues for the skeletal system

Bacterial cellulose

Cytoskeleton and the Cell
METHODS OF ANALYSIS

**Surface and other instrumental analysis**

Surface Analysis and Biointerfaces: UHV Techniques

Atomic Force Microscopy

Characterization of Biological Interfaces

Proteomic and Advanced Biochemical Techniques to Study Protein Adsorption

Ellipsometry Applied Towards Biomaterials

Advanced biophysical methods of analysis

Plasmon enhanced Raman spectroscopy

New developments in Synchroton-CT
**Mechanical analysis**

Fracture mechanics of ceramics as related to bioceramics use

Mechanical behavior of bone cement, including fracture mechanics

Thin films – mechanical properties

Microindentation
**Computational analyses and modeling**
Finite element analysis – bone tissue

Cardiac Mechanics

Fluid Mechanics - Transport and diffusion analyses as applied in biomaterials studies

Computational methods related to reaction chemistry

Protein Adsorption
**Biological and tissue analyses**

Cell culture systems for biomaterial delivery across biological barriers

Histological analysis

Immunohistochemistry

Fluorescence Imaging of cell-biomaterial interactions

Molecular Imaging

Microarrays in biomaterials research

Gene expression and quantitative PCR

Flow cytometry

Protein structure determination
In vivo and ex vivo imaging

Infrared and Raman microscopy

CT and MRI imaging of bone density

Nanoparticles for biological imaging

Fluorescence imaging with quantum dot bio-probes

Near Infrared fluorescence imaging in vivo

Imaging techniques for mineralization

Imaging and diagnosis of biological markers
Micro-Fluidics – MEMS

Materials to Control and Measure Cell Function

BioMEMS devices

Biotechnology Processing Engineering
**Biosensors**

Intracellular Sensing

Biosensors based on sol-gel derived materials

Hydrogel based sensors

Carbon Nanotube-based Sensor: Overview

Conjugated polymers for biosensor devices

Implantable continuous glucose sensors
SURFACE ENGINEERING

Engineering surfaces

Peptide and Protein Modified Surfaces

Combinatorial methods to create designer protein interfaces

Non-fouling Interfaces

Patterned Biointerfaces

Effect of engineered surfaces on molecules and cells … define (numerical, theoretical ?)

Molecular Biomimetic Designs for Controlling Surface Interactions

Surface Engineering using Peptide Amphiphiles

Growth Factor and Protein Modified Surfaces and Interfaces

Tethered antibiotics

Engineering Interfaces for Infection Immunity
DELIVERY OF DRUGS, GENES AND OTHER BIOLOGICAL MOLECULES

Polymer Synthesis and Structural Design for Drug and Gene Delivery

Drug Delivery – Introduction

Biodegradable Polymers as Drug Delivery Systems

Smart polymeric micelles as nanocarriers for gene and drug delivery

Polymer-DNA complex

Conjugate polymer

Nano-particles

Materials for Vaccines and Immunotherapy

Nanoparticles for Nucleic Acid Delivery

Synthetic “Smart” Polymeric Carriers for Intracellular Delivery

Self-Assembled Prodrugs

Delivery by Heparin conjugation

Bioinspired pH-Responsive Polymers for the Intracellular Delivery of Biomolecular Drugs

Polymeric drugs
**Inorganic and hybrid controlled release systems**

Sol gel processed oxide controlled release systems - Overview

Mechanism of controlled release sol-gel system: diffusion and degradation

Mesoporous silica materials

Encapsulation of Cells (Cellular delivery) using sol-gel system

Layered double hydroxides as controlled release materials

Porous Metal – organic – frameworks as new drug carriers

Zeolites as controlled release carriers

Hybrid nanoparticles for targeted delivery

Entrapment of bioactive molecules in metals
Applications and preclinical studies

Introduction - Current status of clinical use and preclinical studies

Delivery by enzymatic cleaving – preclinical studies

Targeted delivery for cancer cell

Gene delivery

Nanofiber for drug delivery

Cell-demanded Delivery of Growth Factors
TISSUE ENGINEERING

Fundamentals

Tissue Engineering – Introduction

Scaffolds

Scaffolds – Perfusion - Bioreactor design

Engineering Scaffold Mechanical and Mass Transport Properties

Bioactive ceramics and bioactive ceramic composite based scaffolds

Scaffolds and angiogenesis -
Relationship to selection of scaffolds

Soft materials and the effect on cell function

Quantifying Integrin-Ligand Engagement and Cell Phenotype in 3D scaffolds

Effect of stress on cell function

Tissue engineering and selection of growth factors and cytokines

Tissue engineering and selection of cells -

Scaffold materials for hES Cell Culture and Differentiation

Cell encapsulation

Engineered bioactive molecules

Rotating wall vessels for cell culture

In vivo Bioreactors
Tissue engineering – Musculoskeletal; Cranial and Maxillofacial

Bone Tissue Engineering Concepts
Calcium phosphate and bone induction
Tissue Engineering Treatments in Oral, Maxillofacial and Cranial Surgery
Tissue Engineering of the Temporo Mandibular Joint
Autologous, vascularized bone grafts
Cartilage Tissue Engineering
Chondrocyte transplantation and selection
Tissue Engineering of Meniscus and Annulus Fibrosus
Intervertebral disc
Ligaments and Tendons
Tissue Engineering of muscle tissue
Tissue engineering - Cardiovascular

Vascular Tissue Engineering

Cardiac Patch/Cell Sheet Engineering (cellular)

Tissue engineering of artificial vessels

Tissue Engineering of Heart Valves

Materials for Cardiac Cell Transplantation

Cardiac Cell Transplantation
Tissue Engineering and Neurology and Neurosurgery

Peripheral nerve regeneration

Nerve tissue engineering

Biomaterials for central nervous system regeneration
Tissue engineering concepts for plastic surgery

Skin Tissue Engineering
Fibrocartilage regeneration
Tissue Engineered Airway
Adipose tissue engineering
Finger
Organ Engineering

From tissue to organ engineering
Kidney tissue engineering
Liver Tissue Engineering
Thymus Tissue Engineering,
Organ printing

Systems Biology and Relationship to Biomaterials and Tissue Engineering

Systems Biology and the Relationship to Biomaterials and Tissue Engineering
Orthopaedic Surgery

Joint replacement

Current and projected use of joint prostheses

Bone Cement

Polyethylene

Ceramic joint prostheses – clinical results – worldwide

Porous Coatings in Orthopaedics

Wear - Hip joint arthroplasty

Wear – Knee joint arthroplasty

Effect of wear particulates

Fretting Corrosion

Metallic dissolution product

Metallic dissolution product - Clinical data, relevance

Spine

Trends in materials for spine surgery

Injectable bone cements for spinal column augmentation - Materials for kyphoplasty / vertebroplasty

Biomaterials for intervertebral disc regeneration

Nucleoplasty

Wear - Total intervertebral disc prostheses

Experimental studies in spinal fusion
Fracture fixation, Bone grafting; Infection

Materials in fracture fixation

Synthetic bone grafts

Cellular Selection for Bone Tissue Grafting

Implant use and infection

Current Developments in the Treatment of Osteomyelitis

Other

Materials in Tendon and Ligament Repair
Dentistry, and Oral and Maxillofacial Surgery

Materials for use in Oral & Maxillofacial Surgery

Materials in Dental Implantology

Implant Surface Roughness

Materials in prosthodontics: fillings, crowns, bridges

In situ excavated Bioactive Glass granules

Dental Graft Materials
Cardiology and Cardiovascular Surgery

Cardiac Patch (synthetic without cells)
LVAD/Artificial Heart
Cardiac Valves (synthetic)
Cardiac Valves (biological)
Venous Filters, coagulation coils
Staples and clips for vascular anastomoses
Intravascular Stents: History, overview
Drug Eluting Stents
Biodegradable Stents
Vascular Grafts
Stents in Carotid Intervention
Neurology and Neurosurgery
Cerebrospinal fluid shunts
Materials for cerebral aneurysms
Biomaterials for spinal cord repair
**Ophthalmology**

Corneal Reconstruction with Cell Sheets

Artificial Cornea

Retina Reconstruction

Crystal lens
**Surgery – Other; Materials in Surgery**

Artificial Kidney

Islet cell transplantation

Surgical Adhesion and its prevention

Suture materials – conventional and stimuli-responsive

Reinforcement of staple lines with buttressing materials

Biomaterials for hernia repair