YEAR IV
SEMESTER - VII

IMPLANTABLE DEVICES

BEG 4B3 BM

Semester VII **Year IV**

Teaching Schedule Hours/Week			Examination Schedule						Total Marks	Remarks
			Final				Internal Assessment			
			Theory		Practical		Theory Marks	Practical Marks		
L	T	P	Duration	Marks	Duration	Marks				
3	1	-	3	80			20		100	

COURSE OBJECTIVE: To introduce various devices which are implanted into the human body during different abnormalities

1. Introduction to Implants and Their Necessity in Human Life: (1 hr)

2. Cardiovascular Implants: (5 hours)

2.1. Heart valves

2.2. Properties of an ideal heart valve

2.3. Types of heart valves

- 2.3.1 Mechanical heart valves (MHVs)
  - 2.3.1.1 Materials used for MHVs
  - 2.3.1.2 Types of MHVs
    - a) Caged ball valve
    - b) Tilting disc
      - *Single leaflet valve*
      - *Bileaflet valve*
- 2.3.2 Bioprosthetic heart valves
  - 2.3.2.1 Allograft valves
  - 2.3.2.2 Xenograft valves
  - 2.3.2.3 Stented bioprosthetic valve

2.4 Prosthetic heart valve sounds/murmurs

2.5 Radiographic appearance of valves

2.6 Vascular grafts

- 2.6.1 Types
  - 2.6.1.1 Biologic grafts
  - 2.6.1.2 Synthetic grafts
    - a) Dacron
    - b) Teflon
    - c) ePTFE
- 2.6.2 Porosity of grafts
- 2.6.3 Surface modification of vascular grafts
- 2.6.4 Tissue engineered vascular graft

2.7 Drug administration systems and vascular access

2.8 Stents, Catheters and Cannulas

2.8.1 Design of a stent
2.8.2 Essential features of a stent
2.8.3 Properties of an ideal catheter
2.8.4 Materials used in catheters
2.9 Pacemakers
2.9.1 Introduction
2.9.2 Components
2.9.3 Working principle
2.10 Inferior venacava filters (IVFs)
2.10.1 Introduction
2.10.2 Materials used in IVFs
2.10.3 List of available IVFs
2.10.4 Working mechanism
2.11 Ventricular assist device and Total artificial heart
2.11.1 Introduction
2.11.2 Components
2.11.3 Working mechanism
2.12 Blood Substitutes
2.12.1 Introduction
2.12.2 Volume expanders
2.12.3 Oxygen therapeutics
2.12.3.1 Pefluorocarbon based: PERFTEC
2.12.3.2 Haemoglobin based: POLYHEME

3. Non-thrombogenic Treatments and Strategies: (3 Hours)

3.1. Overview for the design of non-thrombogenic surfaces
3.2. Surface modification techniques
3.2.1 Heparin coating
3.2.1.1. Introduction
3.2.1.2. Role of heparin for preventing coagulation
3.2.2 Plasma treatments
3.2.3 Laser surface modification
3.2.4 Zirconium oxide and zirconium nitride coating
3.2.5 Endothelialization

4. Dental Implants: (4 hours)

4.1. Introduction
4.2. Designs of dental implants
4.2.1 Endosteal implants
4.2.1.1. Introduction
4.2.1.2. Biomaterials used

4.2.1.3. Staging and osseointegration
4.2.1.4. Components
a) Root forms and Endodontic stabilizers
b) Abutment and denture connector
c) Cylinders
d) Blades
e) Plates, screws and wires
f) Transosseous staples and frames
4.2.2 Subperiosteal implants
4.2.2.1 Introduction
4.2.2.2 Crown, Bridge and Denture restoration
4.2.2.3 Fixed restoration
4.2.2.4 Removable dentures
4.3 Tissue interfaces
4.4 Trends in research and development

5. Plastic Surgery Implant: (4 Hours)
5.1 Introduction and general principles
5.2 Biomaterials used in plastic surgery (PS)
5.3 Application of biomaterials in PS
5.3.1 Craniomaxillofacial reconstruction (CR)
5.3.1.1 Materials used
a) Silicone
b) Acrylic polymers
c) Polyethylene
d) PTFE
e) Metals
f) Hydroxyapatite
5.3.2 Aesthetic/Cosmetic surgery
5.3.2.1 Facial augmentation
5.3.2.1.1 Nasal region
5.3.2.2 Soft (injectables)
a) Collagen fillers
b) Botox fillers
c) Hyaluronic acid
d) Disadvantages of injectables
5.3.3 Breast surgery
5.3.3.1 Introduction
5.3.3.2 Breast augmentation
5.3.3.3 Breast reduction
5.3.3.4 Breast lift

5.3.3.5 Breast reconstruction
5.3.3.6 Saline filled breast implants
5.3.3.7 Silicone gel breast implants
a) Implant shell characteristics
5.3.3.8 Double lumen breast implants
5.3.3.9 Complications
5.3.4 Hand and microsurgery
5.3.4.1 Introduction
5.3.4.2 Materials used
a) Metals
b) Silicone
5.3.4.3 Flexor tendon implants
5.3.4.4 Passive tendon implants
5.3.4.5 Active tendon implants
5.3.5 Burn and wound care
5.3.5.1 Introduction
5.3.5.2 Wound coverage and healing
5.3.5.3 Selection of materials
a) Natural graft materials
b) Synthetic graft materials

6 Orthopaedic Implants: (4 Hours)

6.1 Introduction to bone
6.1.1 Calcified tissues
6.1.2 Elastic properties
6.2 Biomaterials used in bone implant
6.2.1 Metals
6.2.2 Polymers
6.2.3 Ceramics and glasses
6.2.4 Composites
6.3 Knee prosthesis
6.3.1 Components
6.3.2 Loading of knee prosthesis
6.4 Hip implant
6.4.1 Introduction
6.4.2 Bone remodeling
6.4.3 Types of hip prosthesis
6.4.3.1 Cemented fixation
6.4.3.2 Non-cemented fixation
6.4.3.3 Biological fixation
6.4.3.4 Hybrid THR

- 6.4.4 Cemented fixation
  - 6.4.4.1 Introduction
  - 6.4.4.2 Drawbacks of PMMA
- 6.4.5 Non-cemented metal THR
  - 6.4.5.1 Press fit
  - 6.4.5.2 Macrointerlock
  - 6.4.5.3 Microinterlock
  - 6.4.5.4 Drawbacks and overcoming the drawbacks
- 6.4.6 Effects of metal composition on THR
  - 6.4.6.1 Titanium and Co-Cr
  - 6.4.6.2 Bioceramic coated metal THR
- 6.4.7 Weight bearing surfaces in THR
  - 6.4.7.1 Polyethylene
  - 6.4.7.2 Bioceramics

6.5 Ligament reconstruction

- 6.5.1 Introduction
- 6.5.2 Biological grafts
  - 6.5.2.1 Autografts
    - a) Introduction
    - b) Drawbacks
  - 6.5.2.2 Allografts
  - 6.5.2.3 Xenografts
- 6.5.3 Biomaterials used
- 6.5.4 Synthetic grafts
  - 6.5.4.1 Types
    - a) Permanent substitution devices
    - b) Augmentation devices
    - c) Tissue ingrowth devices
  - 6.5.4.2 Synthetic materials used
    - a) PET
    - b) PTFE
    - c) Carbon fibers
    - d) Braided propylene
  - 6.5.4.3 Problems faced
- 6.5.5 New inventions

6.6 Bone grafts and bone substitutes

- 6.6.1 Introduction
- 6.6.2 Bone banking: History
- 6.6.3 Products
  - 6.6.3.1 Proprietary allografts

6.6.3.2 Non-proprietary allografts
6.6.3.3 Properitarty demineralized bone matrix

7 Catheters: (4 hours)

7.1 Introduction
7.2 History
7.3 Uses of catheters
7.4 Ideal catheter
7.5 Materials used in catheters and its clinical uses
7.5.1 Steel needles
7.5.2 Polymers
7.5.2.1 Polyethylene
7.5.2.2 Polyvinylchloride
7.5.2.3 Polyurethanes
7.5.2.4 PTFE
7.5.2.5 Silicone elastomer
7.5.2.6 Hydrogel
7.6 Complication with catheters
7.7 Thrombophlebitis
7.8 Intravascular catheters and thrombosis

8 Biomaterials used in urology: (4 hours)

8.1 Introduction
8.2 Urethral catheters
8.2.1 Introduction
8.2.2 Materials used
8.2.3 Complications
8.2.3.1 Urinary tract infections
8.2.3.2 Formation of calculi
8.2.3.3 Urethral strictures
8.3 Suprapubic catheters
8.3.1 Introduction
8.3.2 Materials used
8.3.3 Comparison with urethral catheters
8.3.4 Disadvantages
8.4 Urethral stents
8.4.1 Introduction
8.4.2 Urethral stent: History
8.4.3 Stent design
8.5 Prostatic stents
8.5.1 Introduction

8.5.2 Design of prostatic stents

8.6 Artificial urinary sphincters (AUS)

8.6.1 Introduction

8.6.2 Components of AUS

8.6.3 Working mechanism

8.7 Penile prosthesis

8.7.1 Introduction

8.7.2 Design of penile prosthesis

8.7.2.1 Inflatable device

8.7.2.2 Malleable device

8.7.2.3 Three piece design

8.7.3 Working mechanism

8.8 Testicular imlants

8.8.1 Introduction

8.8.2 Materials used

8.8.3 Working mechanism

8.9 Ring pessaries

8.9.1 Introduction

8.9.2 Falling over of the womb

8.9.3 Materials used

9 Prosthesis of Drug Delivery: (4 Hours)

9.1 Introduction

9.2 Drug delivery and biomaterials

9.2.1 Controlled release of drugs

9.2.2 Incorporation of drugs in implantable devices

9.3 Controlled release systems

9.3.1 Introduction

9.3.2 Mechanism of drug release

9.3.3 Type of system

9.3.3.1 Monolithic devices

9.3.3.2 Membrane controlled devices

9.3.4 Selection of device type

9.3.4.1 Reservoir devices

9.3.4.2 Transdermal systems

9.3.4.3 Water penetration controlled systems

a) Osmotic systems

b) Swelling controlled devices

9.3.4.4 Chemically controlled devices

a) Drug covalently attached to polymer backbone

b) Drug contained within a biodegradable core

c) Drug dispersed on a bioerodible matrix

⇒ *Drug release determined by diffusion*

⇒ *Drug release determined by erosion*

9.3.4.5 Regulated systems

a) Externally regulated

⇒ *Regulated drug release by ultrasound*

⇒ *Regulated drug release by magnetism*

b) Self regulated

9.4 Using prosthesis for drug delivery

9.5 Importance of drug delivery through implants

9.6 Drug delivery from a vascular graft

9.7 Methods of drug binding

9.7.1 Adsorption to the surface of the prosthesis

9.7.2 Entrapment of drugs in polymers

9.7.3 Incorporation of drugs into the bulk phase of polymers

9.7.4 Covalent attachment of drugs

9.8 Characteristics required for drug incorporation

9.9 Targeted drug delivery

9.10 MEMS drug delivery systems

10 Different kinds of Artificial Organs: (8 Hours)

10.1 Introduction

10.2 Artificial pancreas

10.3 Artificial liver

10.4 Artificial heart and lung

10.5 Artificial skin

10.6 Artificial reproductive organs

10.7 Artificial vision

10.8 Artificial hearing implant

11 Introduction to Tissue Engineering: (4 Hours)

11.1 Introduction

11.2 General principle

11.2.1 Objectives

11.2.2 Tissue engineering triad

11.2.3 Tissue engineering scaffolds

11.3 Culturing of cells

11.3.1 Types of cell culture

11.3.1.1 Monolayer

11.3.1.2 Suspension

11.3.1.3 Three-dimensional

- 11.3.2 Cells sources
  - 11.3.2.1 Primary cells
  - 11.3.2.2 Passaged cells
  - 11.3.2.3 Stem cells
- 11.4 Importance of tissue engineering
  - 11.4.1 Birth defects
  - 11.4.2 Burn victims
  - 11.4.3 War injuries
  - 11.4.4 Sports injuries
- 11.5 Bioreactors
  - 11.5.1 Introduction
  - 11.5.2 Types of bioreactors
    - 11.5.2.1 Spinner flask
    - 11.5.2.2 Rotating flask
    - 11.5.2.3 Hollow fibre
    - 11.5.2.4 Perfusion
    - 11.5.2.5 Controlled mechanics
- 11.6 Current challenges

12 Implants and Device Failure: (2 Hours)

- 12.1 Introduction
- 12.2 Mechanics of biomaterial breakdown
  - 12.2.1 Mechanical
  - 12.2.2 Physiochemical
  - 12.2.3 Biochemical/Chemical reaction
  - 12.2.4 Electrochemical
- 12.3 Potential causes of implant failure
  - 12.3.1 Materials
  - 12.3.2 Testing of materials
  - 12.3.3 Design
  - 12.3.4 Fabrication
  - 12.3.5 Sterilization method
  - 12.3.6 Testing of implant
  - 12.3.7 Packaging and shipping
  - 12.3.8 Clinical handling and surgical procedure
  - 12.3.9 The patient
  - 12.3.10 Abnormal responses

Chapters	Lectures (in hrs)	Question Type	Marks
Unit 1: Introduction to Implants and Their Necessity in Human Life	**1**	**Short**	**0-5**
Unit 2: Cardiovascular Implants	**5**	**Long:1-2**	**10-20**
Unit 3: Non-thrombogenic Treatments and Strategies	**3**	**Long-1/ Short**	**0-10**
Unit 4: Dental Implants	**4**	**Long-1/ Short**	**5-10**
Unit 5: Plastic Surgery Implant	**4**	**Long: 1-2/ Short**	**10-15**
Unit 6: Orthopaedic Implants	**4**	**Long: 1/ Short**	**10-15**
Unit 7: Catheters	**4**	**Long: 1/ Short**	**5-10**
Unit 8: Biomaterials used in urology	**4**	**Long: 1/ Short**	**10-15**
Unit 9: Prosthesis of Drug Delivery	**4**	**Long: 1/ Short**	**10-15**
Unit 10: Different kinds of Artificial Organs	**8**	**Long: 1-2 (Choice)**	**10-20**
Unit 11: Introduction to Tissue Engineering	**4**	**Short**	**5**
Unit 12. Implants and Device Failure	**2**	**Short**	**5**
Total	**47**		**80**