Chapter 4
Biomaterials
Outline:

• 4.1 Introduction
• 4.2 Classes of biomaterials
• 4.3 Applications of biomaterials
• 4.4 Characteristics of biomaterials
• 4.5 Development of biomaterial devices
• 4.6 Examples of biomaterials
Learning outcomes:

• Define biomaterials.
• Describe the characteristics and applications of biomaterials.
4.1 Introduction

• Biomaterial is a **nonviable** material used in a medical device, intended to **interact** with biological systems.
4.1 Introduction

• A biomaterial
  • is used to make devices to replace a part of a function of the body in a safe, reliable, economic, and physiologically acceptable manner.
  • is any substance (other than a drug), natural or synthetic, that treats, augments, or replaces any tissue, organ, and body function.
  • has a particular lifespan in the human body.
4.1 Introduction

• The need for biomaterials stems from an inability to treat many diseases, injuries and conditions with other therapies or procedures:
  • replacement of body part that has lost function (total hip, heart)
  • correct abnormalities (spinal rod)
  • improve function (pacemaker, stent)
  • assist in healing (structural, pharmaceutical effects: sutures, drug release)
4.2 Classes of biomaterials

• **Metals**
  • stainless steel, cobalt alloys, titanium alloys

• **Ceramics**
  • aluminum oxide, zirconia, calcium phosphates

• **Polymers**
  • silicones, poly(ethylene), poly(vinyl chloride), polyurethananes, polylactides

• **Natural polymers**
  • collagen, gelatin, elastin, silk, polysaccharides
4.3 Applications of biomaterials

<table>
<thead>
<tr>
<th>Organ/Tissue</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>heart</td>
<td>pacemaker, artificial valve, artificial heart</td>
</tr>
<tr>
<td>eye</td>
<td>contact lens, intraocular lens</td>
</tr>
<tr>
<td>ear</td>
<td>artificial stapes, cochlea implant</td>
</tr>
<tr>
<td>bone</td>
<td>bone plate, intramedullary rod, joint</td>
</tr>
<tr>
<td></td>
<td>prosthesis, bone cement, bone defect repair</td>
</tr>
<tr>
<td>kidney</td>
<td>dialysis machine</td>
</tr>
<tr>
<td>bladder</td>
<td>catheter and stent</td>
</tr>
<tr>
<td>muscle</td>
<td>sutures, muscle stimulator</td>
</tr>
<tr>
<td>circulation</td>
<td>artificial blood vessels</td>
</tr>
<tr>
<td>skin</td>
<td>burn dressings, artificial skin</td>
</tr>
<tr>
<td>endocrine</td>
<td>encapsulated pancreatic islet cells</td>
</tr>
</tbody>
</table>
4.4 Characteristics of biomaterials

<table>
<thead>
<tr>
<th>Property</th>
<th>Desirables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocompatibility</td>
<td>Noncarcinogenic, nonpyrogenic, nontoxic, nonallergenic, blood compatible, non-inflammatory</td>
</tr>
<tr>
<td>Sterilizability</td>
<td>Not destroyed by typical sterilizing techniques such as autoclaving, dry heat, radiation, ethylene oxide</td>
</tr>
<tr>
<td>Physical characteristics</td>
<td>Strength, elasticity, durability</td>
</tr>
<tr>
<td>Manufacturability</td>
<td>Machinable, moldable, extrudable</td>
</tr>
</tbody>
</table>
4.4 Characteristics of biomaterials

• **Biocompatibility**: The ability of a material to perform with an appropriate host response in a specific application.

• **Host response**: the reaction of a living system to the presence of a material
4.4 Characteristics of biomaterials

- Host Reactions to Biomaterials
  - Thrombosis
  - Hemolysis
  - Inflammation
- Infection and Sterilization
- Carcinogenesis
- Hypersensitivity
- Systemic Effects
4.5 Development of biomaterial devices

• The various steps involved in the development of biomaterial devices are:
  • Identifying a need
  • Device design
  • Material Synthesis
  • Material Testing
  • Fabrication
  • Sterilization and Packaging
  • Device Testing
  • Clinical Use
4.6 Examples of biomaterials

Heart Valves
4.6 Examples of biomaterials

Dental Implants
4.6 Examples of biomaterials

Intraocular Lenses
4.6 Examples of biomaterials

Vascular Grafts
4.6 Examples of biomaterials

Hip-Replacing
4.6 Examples of biomaterials
THANK YOU