


Review To general Definitions in Biomaterials/ Lecture 1

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BIOMATERIALS- INTRODUCTION

Bio material- *It is a **non viable material** used in a medical  device, intended to interact with biological system.*

A **biomaterial** is defined as any systemically, pharmacologically inert substance or combination of substances utilized for implantation within or incorporation with a living system to supplement or replace functions of living tissues or organs.

BIOMATERIALS- INTRODUCTION

- ✚ The ability to replace or augment damaged organs, or blood vessels or tissues in part or as a whole has improved the scope of human life.
- ✚ In addition, a variety of extracorporeal devices, such as the heart, lung and blood dialysis machines are used commonly in medical technology.
- ✚ The availability of human organs is difficult which has paved the way for the use of synthetic materials .

FUNCTIONS OF BIOMATERIALS

The functions of implants fall in to one of the categories:

- + Load bearing or transmission
- + The control of fluid flow in order to stimulate normal physiological function or situation
- + Passive space filling either for cosmetic reasons or functional reasons or functional reasons or functional reasons
- + Generation of electric stimuli and transmission of light and sound.

✚ The only alternate to artificial implants is transplantation of organs such as heart, kidney etc., but this effort has been hindered due to *social, ethical and immunological problems*.

✚ ***Biocompatibility*** is the ability of material to perform within an appropriate host response in a specific application.

✚ ***Biocompatibility*** in other words is the quality of not having toxic or injurious effects on biological systems.

- ✚ Each biomaterial has a particular lifespan in the human body.
- ✚ Examples of specific applications include a hemodialysis membrane, a urinary catheter or hip-joint prosthesis.
- ✚ Hemodialysis membrane might be in contact with the patient's blood for 3 hours.
- ✚ The catheter may be inserted for a week after which it starts infecting.

BIOMATERIALS FOR APPLICATIONS

Skeletal system

- Joint replacements -Titanium, stainless steel, polyethylene
- Plate for fracture fixation - Stainless steel, cobalt-chromium alloy
- Bone cement - Poly(methyl methacrylate)
- Artificial tendon and ligament-Teflon, Dacron
- Dental Implants-Titanium,alumina,calcium phosphate

Cardiovascular system

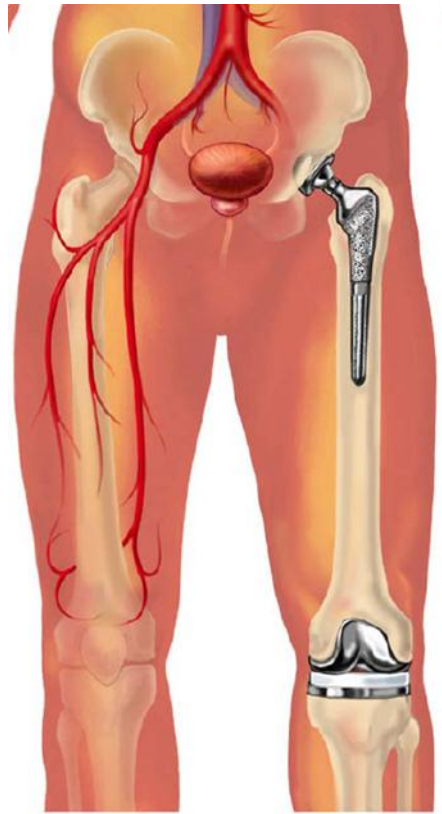
- Blood vessel prosthesis - Teflon, Dacron, Polyurethane
- Heart valve - Reprocessed tissue, Stainless steel, carbon
- Catheter - Silicone rubber, Teflon, polyurethane

Organs

- Artificial Heart - Polyurethane
- Artificial Kidney - Cellulose, polyacrylonitrile
- Heart Lung Machine - Silicone rubber

Senses

- Cochlear replacement -Platinum electrodes
- Intraocular lens - Poly(methyl methacrylate) ,hydro gel
- Contact Lens - Silicone-acrylate,hydrogel
- Corneal bandage – Collagen,hydrogel



TYPICAL BIOMATERIAL APPLICATION





GLASS CERAMIC COCHLEAR IMPLANTS

SUBJECTS INTEGRAL TO BIOMATERIALS

- Toxicology

- Healing

- Mechanical and Performance requirements

HEALING

- ✦ Special processes are invoked when a material or device heals in the body.
- ✦ Injury to tissue will stimulate the well-defined inflammatory reaction sequence that leads to healing.
- ✦ Where a foreign body (e.g., an implant) is present in the wound site (surgical incision), the reaction sequence is referred to as the "foreign body reaction."
- ✦ Furthermore, this reaction will differ in intensity and duration depending upon the anatomical site involved.

TOXICOLOGY

- ✦ A biomaterial should not be toxic, unless it is specifically engineered for such requirements.
- ✦ Since the nontoxic requirement is the norm, toxicology for biomaterials has evolved into a sophisticated science.
- ✦ It deals with the substances that migrate out of biomaterials.
- ✦ It is reasonable to say that a biomaterial should not give off anything from its mass unless it is specifically designed to do so.

MECHANICAL AND PERFORMANCE REQUIREMENTS

- + Biomaterials that have a mechanical operation must perform to certain standards and be able to cope with pressures.
 - + It is therefore essential that all biomaterials are well designed and are tested.
 - + Biomaterials that are used with a mechanical application, such as hip implants, are usually designed using CAD
-) Computer Aided Design(

HISTORICAL DEVELOPMENT OF BIOMATERIALS

- ✚ Some of the earliest biomaterial applications were as far back as ancient Phoenicia where loose teeth were bound together with gold wires for tying artificial ones to neighboring teeth.
- ✚ In the early 1900's bone plates were successfully implemented to stabilize bone fractures and to accelerate their healing.
- ✚ While by the time of the 1950's to 60's, blood vessel replacement were in clinical trials and artificial heart valves and hip joints were in development.

✚ 600 B.C	Samhita	Nose construction
✚ 1893-1912	W.A.Lane	Steel screws for fixation
✚ 1912	W.D.Sherman	Use of Vanadium steel plate
✚ 1938	P.Wiles	First total hip replacement

 1952	A.B.Voorhees	Blood Vessel
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 1953	A.Kantrowitz	Intraortic balloon pumping
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 1960	M.I.Edwards	Heart valve
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 1980	W.J.Kolff	Artificial Heart
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HEART VALVE PROSTHESIS

- ✚ Heart valves open and close over 40 million times a year and they can accumulate damage sufficient to require replacement in many individuals.
- ✚ More than 80,000 replacement valves are implanted each year in the United States .
- ✚ There are many types of heart valve prostheses and they are fabricated from carbons, metals, elastomers, plastics, fabrics and animal or human tissues



Generally, almost as soon as the valve is implanted, cardiac function is restored to near normal levels and the patient shows rapid improvement.



In spite of the overall success seen with replacement heart valves, there are problems that may differ with different types of valves; they include induction of blood clots, ‘ degeneration of tissue, mechanical failure, and infection.

ARTIFICIAL HIP JOINTS

- ✚ After 50 or more years of cyclic mechanical stress, or because of degenerative or rheumatological disease, the natural joint wears out, leading to considerable loss of mobility and often confinement to a wheel chair.
- ✚ Hip-joint prostheses are fabricated from titanium, stainless steel, special high-strength alloys, ceramics, composites, and ultra high-molecular-weight polyethylene.

- ✚ With some types of replacement hip joints and surgical procedures that use polymeric cement, ambulatory function is restored within days after surgery.
- ✚ For other types, a healing period is required for integration between bone and the implant before the joint can bear the full weight of the body.
- ✚ After 10-15 years, the implant may loosen, necessitating another operation.

DENTAL IMPLANTS

- ✚ The widespread introduction of titanium implants has revolutionized dental implantology.
- ✚ These devices form an implanted artificial tooth anchor upon which a crown is affixed.
- ✚ One of the primary advantages originally cited for the titanium implant was its osseous integration with the bone of the jaw.
- ✚ Loss of tissue support leading to loosening along with infection remains an issue in the topic of Dental implants.

INTRAOCULAR LENSES

- ✚ A variety of intraocular lenses (IOLs) have been fabricated of poly methyl methacrylate, Silicone elastomer, soft acrylic polymers, or hydro gels and are used to replace a natural lens when it becomes cloudy due to cataract formation.
- ✚ Good vision is generally restored almost immediately after the lens is inserted and the success rate with this device is high.
- ✚ IOL surgical procedures are well developed and implantation is often performed on an outpatient basis.

STEPS INVOLVED IN THE DEVELOPMENT

The various steps involved in the development of biomaterial devices are

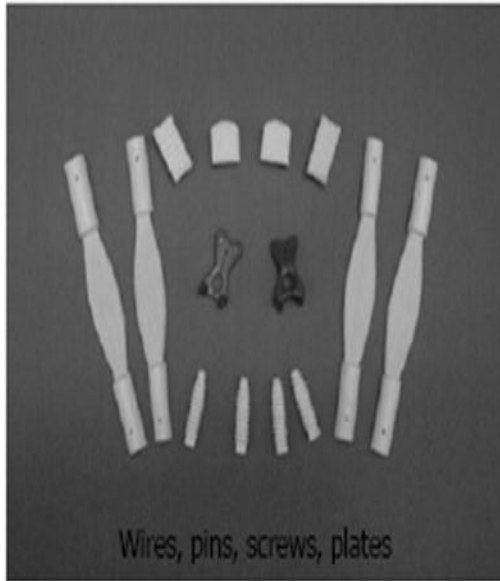
- + Identifying a need
- + Device design
- + Material Synthesis
- + Material Testing

STEPS INVOLVED IN THE DEVELOPMENT

- + Fabrication
- + Sterilization and Packaging
- + Device Testing
- + Clinical Use

EXAMPLES

Hard tissue: long bone



Hard tissue: long bone



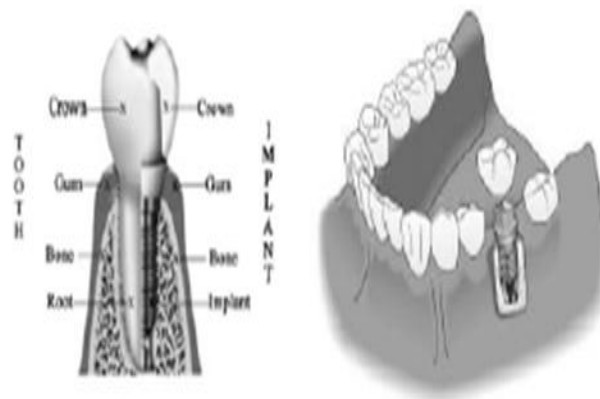
Hard tissue:
Total hip
arthroplasty



Hard tissue: joint



Hard tissue: dental implants



- Subperiosteal
- Endosteal

Hard tissue: dental sealant



Soft tissue: skin/maxillofacial



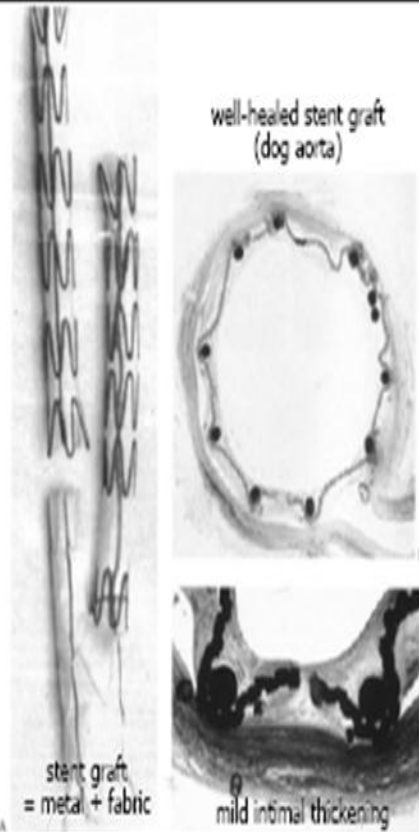
Soft tissue: plastic surgery



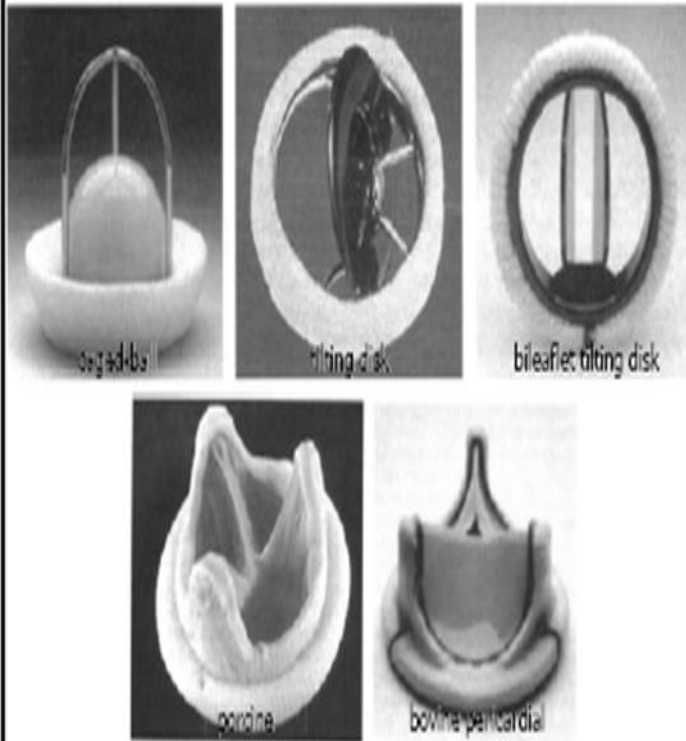
Soft tissue: blood vessel



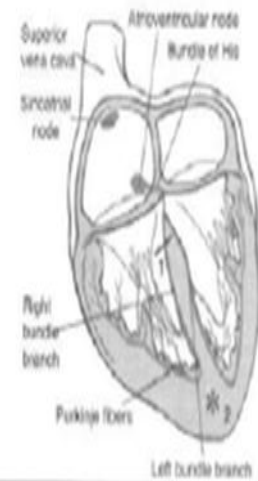
Soft tissue:
Stent grafts



Soft tissue: (modern) heart valves



Cardiac pacemakers



- 1 Bradycardia/heart block (disruption of conduction)
- 2 Tachycardia (ectopic, irritable focus)

Powered by batteries (service life: 5-12 yr)