

BIOMATERIALS

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DEFINATION

- Biomaterial is used to make devices to replace a part or a function of the body in a safe, reliable, economic and physiologically acceptable manner [Hench and Erthridge, 1982,*2].
- Materials of synthetic as well as of natural origin in contact with tissue, blood, and biological fluids, and intended for use for prosthetic, diagnostic, therapeutic, and storage applications without adversely affecting the living organism and its components” [Bruck , 1980].

History

Historically, biomaterials consisted of materials common in the laboratories of physicians, with little consideration of materials properties.

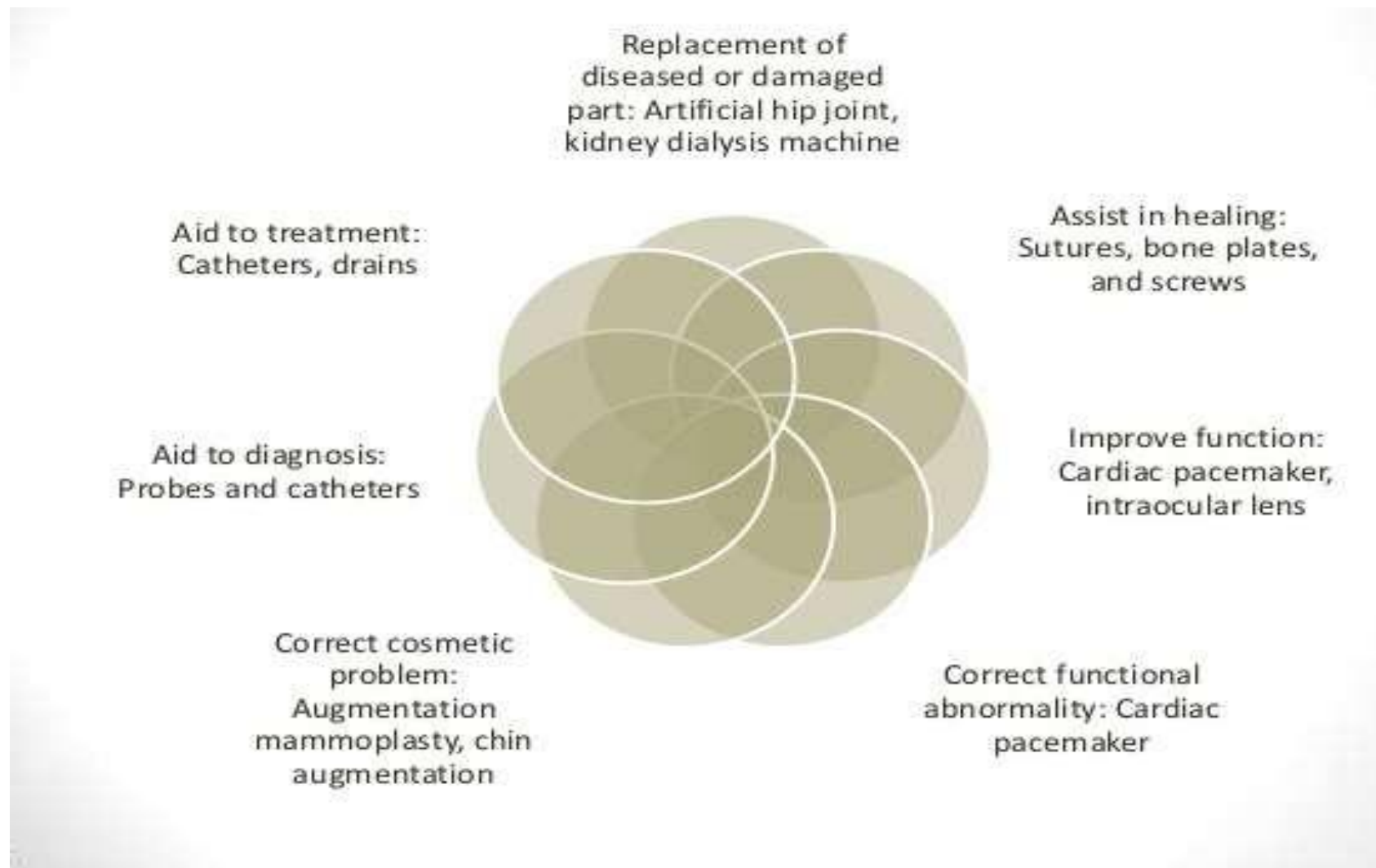
❑ Early biomaterials:

- **Gold:** Malleable, inert metal [does not oxidize], used in dentistry.
- **Iron, Brass:** High Strength Metals, rejoin fractured femur.
- **Glass:** Hard ceramic, used to replace eye [cosmetic].
- **Wood:** Natural composite, high strength to weight, used for limb prostheses.
- **Bone:** Natural composite.

HISTORY

- 1860's :** Lister develops aseptic surgical technique .
- 1900's:** Bone plates used to fix fractures.
- 1930's:** Introduction of S.S, cobalt chromium alloys.
- 1938 :** First total hip prosthesis .
- 1940's:** Polymers in medicine: PMMA bone repair, cellulose for dialysis, nylon sutures.
- 1952 :** Mechanical heart valve .
- 1953 :** Dacron [polymer fiber] vascular grafts .
- 1958 :** Cemented [PMMA] joint replacement.
- 1960 :** First commercial heart valve .
- 1970's :** PEO protein resistant thin film coating .
- 1976 :** FDA amendment governing testing & production of biomaterials / devices (06/26/14) .
- 1976 :** Artificial heart.

USES OF BIOMATERIALS



THE OPTIONS AND LIMITATIONS

❑ **Transplantation**

- Critical donor shortage
3000 livers annually for 30000 people in need.
- Disease Transmission
HIV
Hepatitis
Other transmittable diseases.

❑ **Surgical Reconstruction**

Not always possible Complications .

☐ Mechanical Devices

➤ Engineering approach

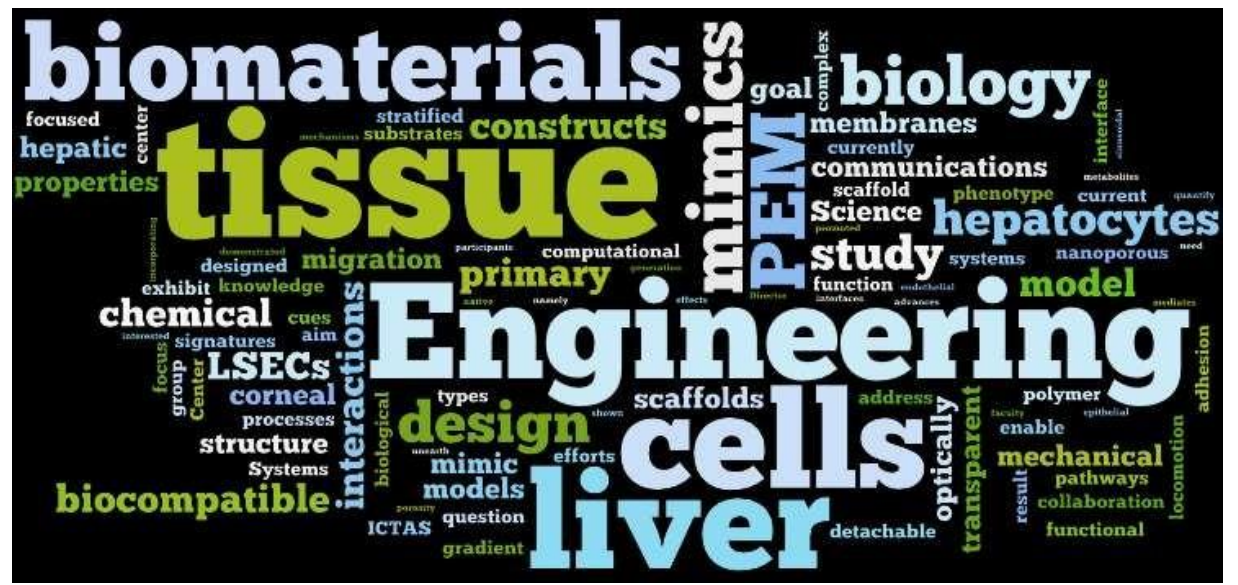
- New tissues systems

Limited by

- Complexity of the human body.
- Multiple functions.
- Living components versus non living components

Materials

- Tissue based.
- Polymers.
- Metals.
- Ceramics.



COMMONLY USED BIOMATERIALS

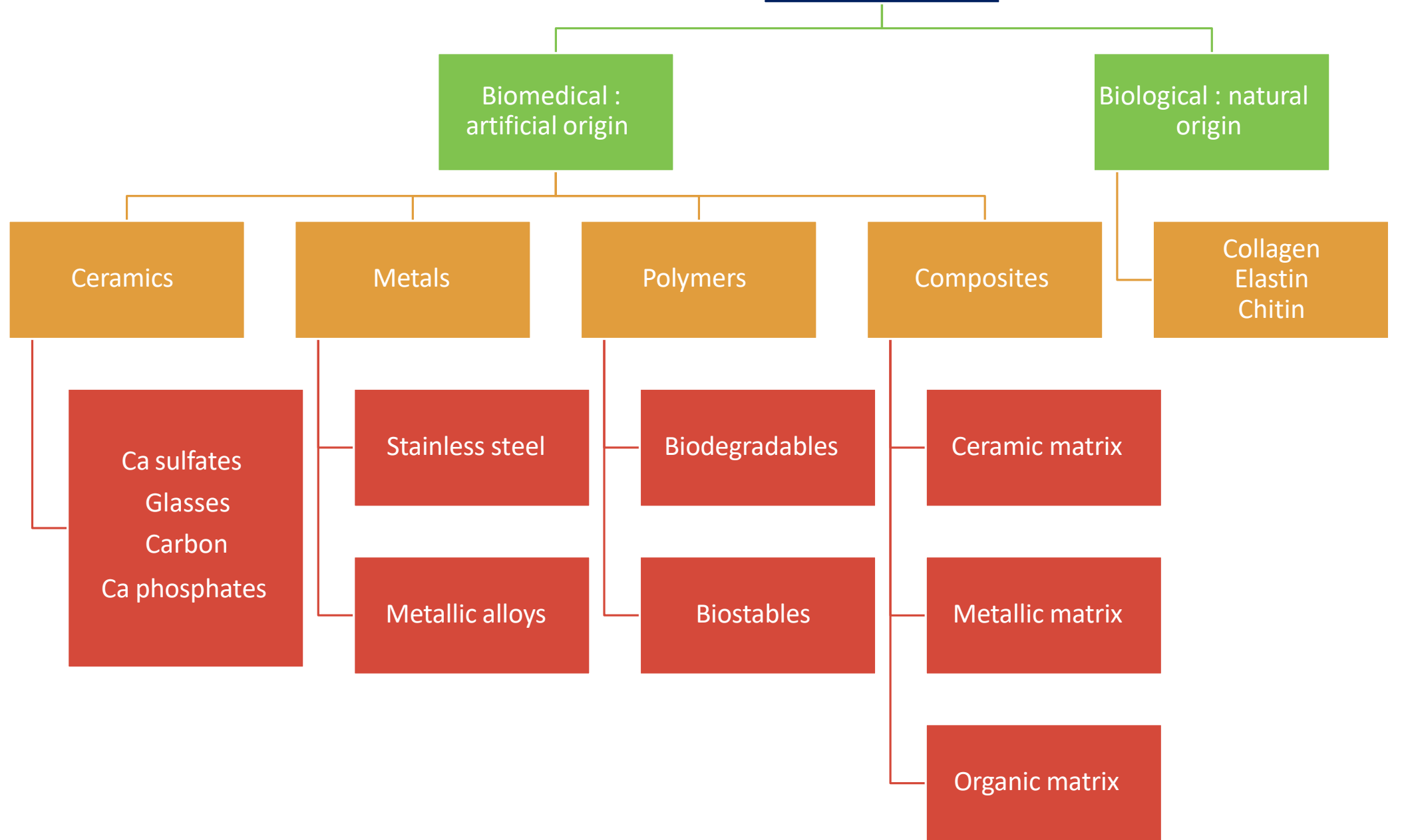
- MATERIALS

- Silicone rubber
- Dacron
- Cellulose
- Hydrogels
- Stainless steel
- Titanium
- Alumina
- Hydroxyapatite
- Collagen (reprocessed)

- APPLICATIONS

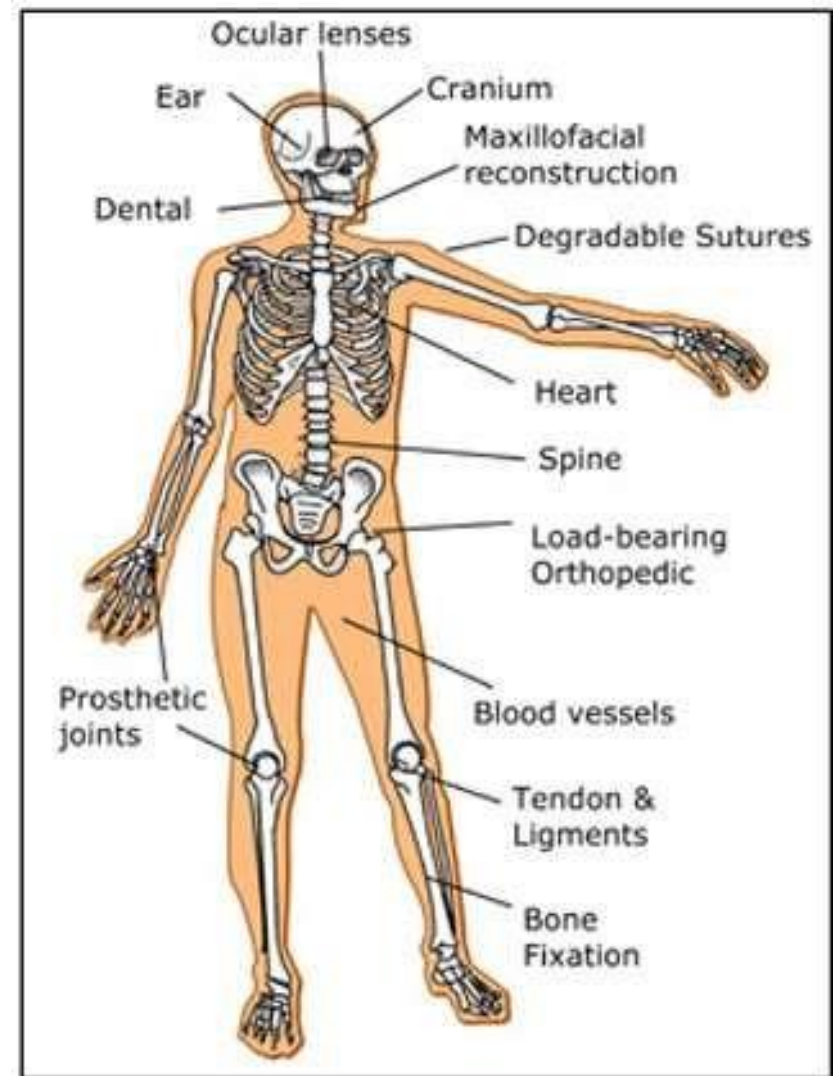
- Catheters, tubing
- Vascular grafts
- Dialysis membranes
- Ophthalmological devices, Drug Delivery
- Orthopedic devices, stents
- Orthopedic and dental devices
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- Orthopedic and dental devices
- Ophthalmologic applications, wound dressings

Biomaterials



SIGNIFICANCE OF BIOMATERIALS

- Replace diseased part – *Dialysis*
- Assist in Healing – *Sutures*
- Improves Function – *Contacts*
- Correct Function – *Spinal rods*
- Correct Cosmetic – *Nose, Ear*
- Aids – *Probes / Catheters*
- Replace rotten – *Amalgam*
- Replace dead - *Skin*



CHARACTERISTICS OF BIOMATERIALS

- **Physical Requirements**

- Hard Materials.
- Flexible Material.

- **Chemical Requirements**

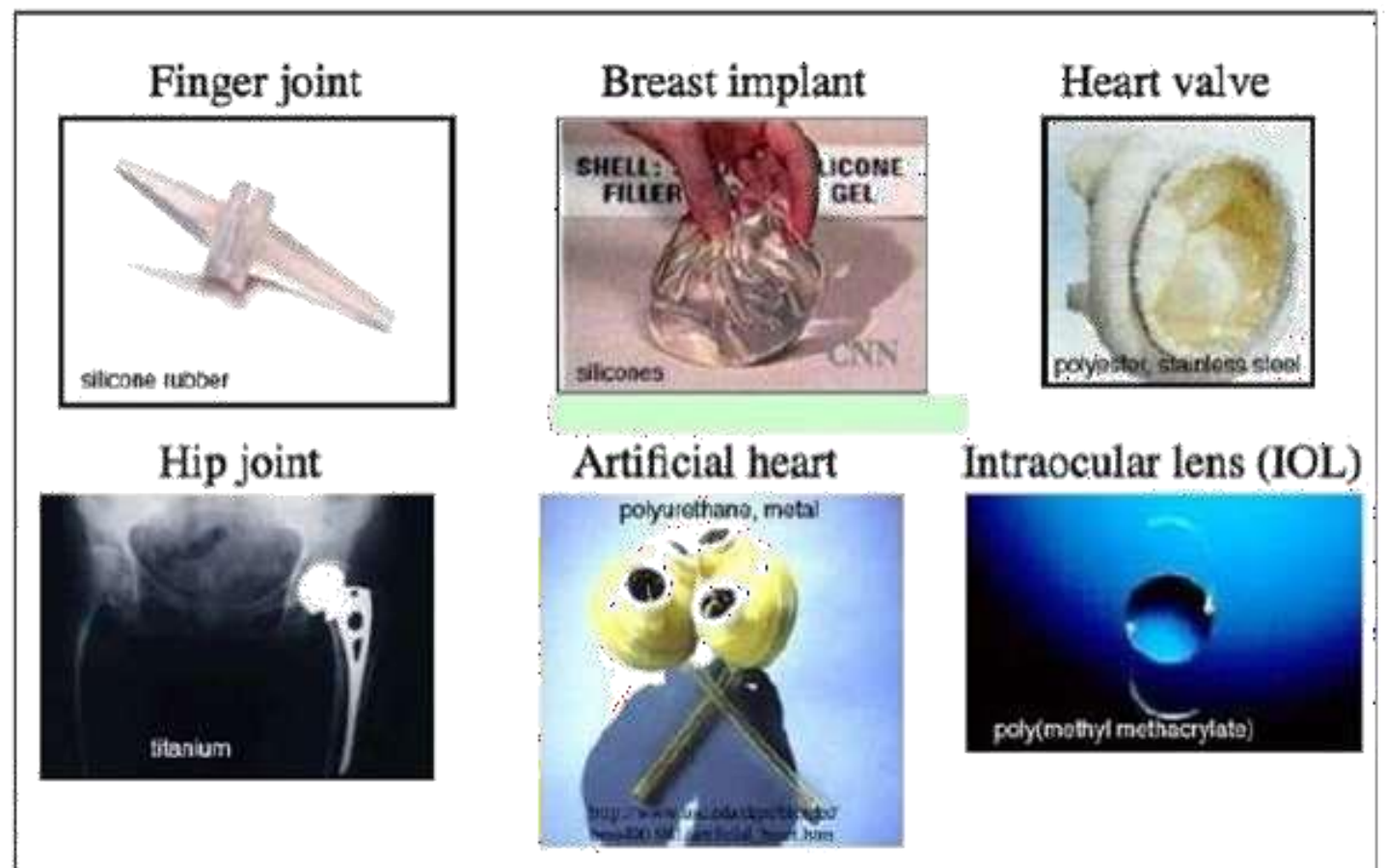
- Must not react with any tissue in the body
- Must be non-toxic to the body.
- Long-term replacement must not be biodegradable.

FEATURES OF BIOCOMPATIBLE MATERIALS

- Absence of **carcinogenicity** (the ability or tendency to produce cancer)
- Absence of **immunogenicity** (absence of a recognition of an external factor which could create rejection)
- Absence of **teratogenicity** (ability to cause birth defects)
- Absence of **toxicity**

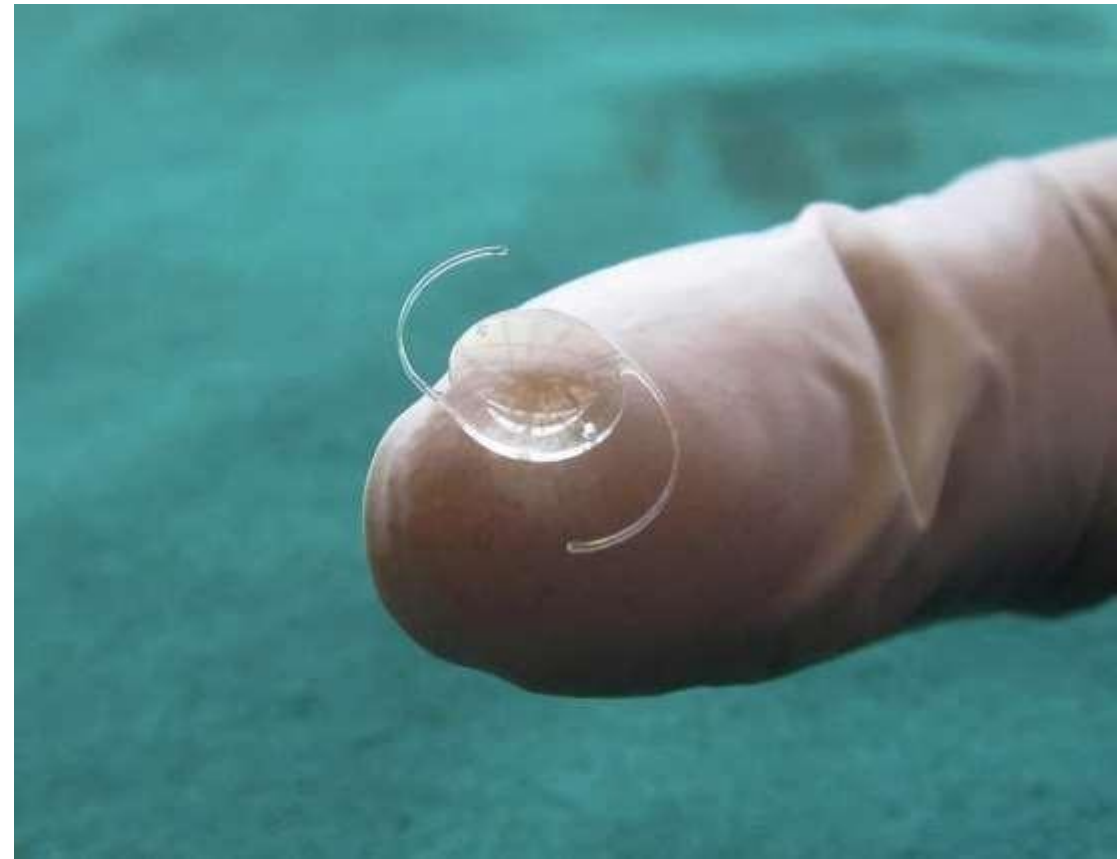
EXAMPLES OF BIOMATERIAL APPLICATIONS

- Heart Valve
- Dental Implants
- Intraocular Lenses
- Vascular Grafts
- Hip Replacements



INTROCULAR LENSES

- By age 75 more than 50% of population suffers from cataracts.
- Made of PMM, silicone elastomer, and other materials.
- 1.4 million implantations in the United States yearly.
- Good vision is generally restored almost immediately after lens is inserted.



HEART VALVE

- Fabricated from carbons, metals, elastomers, fabrics, and natural valves.
- Must not React With Chemicals in Body .
- Attached By Polyester Mesh .
- Tissue Growth Facilitated By Polar Oxygen -Containing Groups.
- Almost as soon as valve implanted cardiac function is restored to near normal .
- Bileaflet tilting disk heart valve used most widely .
- More than 45,000 replacement valves implanted every year in the United States.

DENTAL IMPLANT

- Small titanium fixture that serves as the replacement for the root portion of a missing natural tooth.
- Implant is placed in the bone of the upper or lower jaw and allowed to bond with the bone.
- Most dental implants are: pure titanium screw-shaped cylinders that act as roots for crowns and bridges, or as supports for dentures.
- Capable of bonding to bone, a phenomenon known as "osseointegration".
- Bio-inert, there is no reaction in tissue and no rejection or allergic reactions.



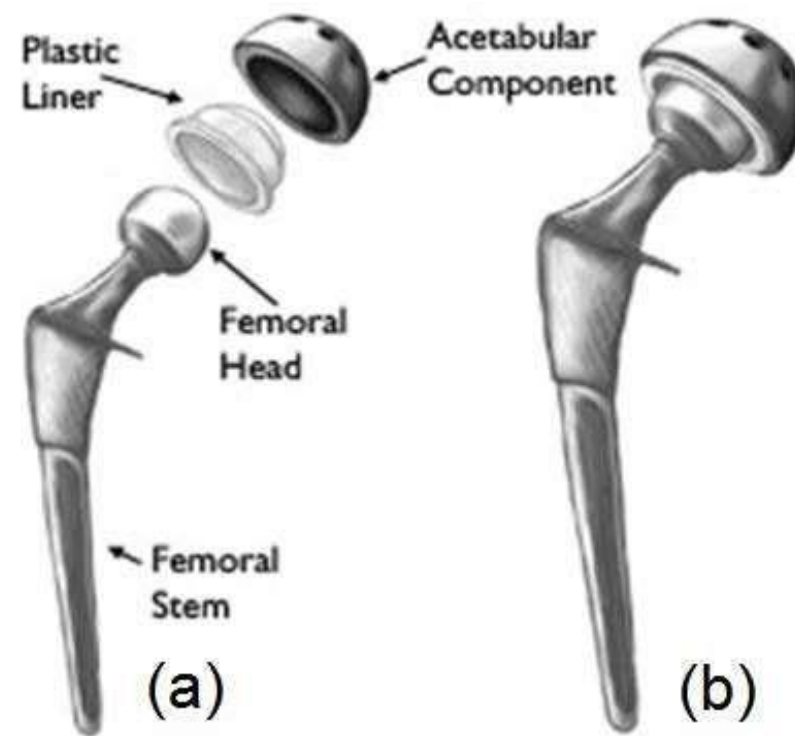
VASCULAR GRAFTS

- Must Be Flexible.
- Designed With Open Porous Structure.
- Often Recognized By Body As Foreign.
- Achieve and maintain homeostasis.
- Good structure retention.
- Adequate burst strength.
- High fatigue resistance.
- Poly(ethylene terephthalate) —PET or Dacron.
- Good handling properties.
- Biostable.



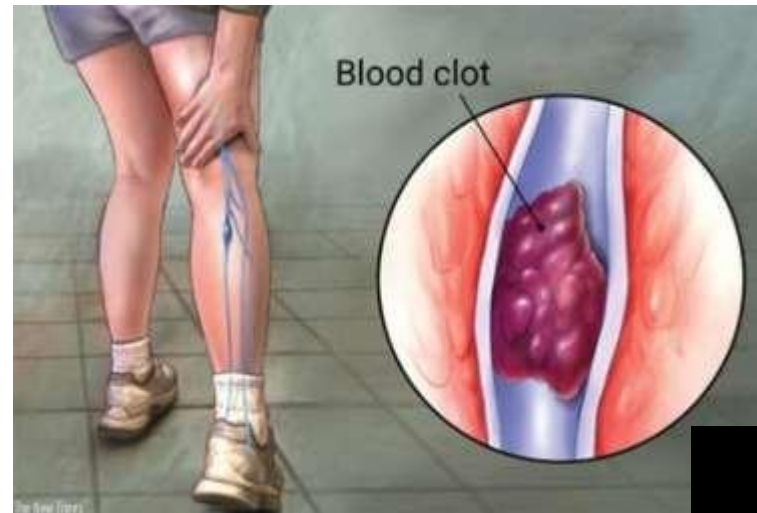
HIP REPLACEMENT

- Most Common Medical Practice Using Biomaterials.
- Corrosion Resistant high-strength Metal Alloys.
- Very High Molecular Weight Polymers.
- Thermoset Plastics.



Host Reactions to Biomaterials

- Thrombosis
- Hemolysis
- Inflammation
- Infection and Sterilization
- Carcinogenesis
- Hypersensitivity
- Systemic Effects



What are some of the Challenges?

- To more closely replicate complex tissue architecture and arrangement in vitro.
- To better understand extracellular and intracellular modulators of cell function.
- To develop novel materials and processing techniques that are compatible with biological interfaces.
- To find better strategies for immune acceptance.

Future Scope (Surgical Robotics)

- Instead of manipulating surgical instruments, surgeons use their thumbs and fingers to move joystick handles on a control console to maneuver two robot arms containing miniature instruments that are inserted into ports in the patient. The surgeon's movements transform large motions on the remote controls into micro-movements on the robot arms to greatly improve mechanical precision and safety.
- A third robot arm holds a miniature camera, which is inserted through a small opening into the patient. The camera projects highly magnified 3-D images on a console to give a broad view of the interior surgical site.
- UCI Medical Center's Vinci Surgical System is currently approved for gall bladder, prostate, colorectal, gynecological, esophageal and gastric bypass procedures.

THANK YOU