Biomaterials

Biomaterials Science: An Introduction to Materials in Medicine addresses the properties and applications of materials(synthetic and natural) that are used in contact with biological systems. These materials are commonly called biomaterials.

Biomaterials, an exciting field with steady, strong growth over its approximately half century of existence, encompasses aspects of medicine, biology, chemistry, and materials science. It sits on a foundation of engineering principles. There is also a compelling human side to the therapeutic and diagnostic application of biomaterials.

Biomaterial is a material intended to interface with biological systems to evaluate, treat, replace any tissue, organ or function of the body. **Also biomaterial** is a nonviable material used in a (medical) device, intended to interact with biological systems (bio functionality).

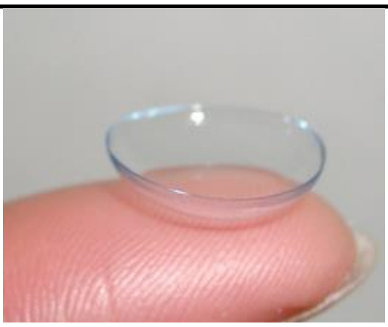
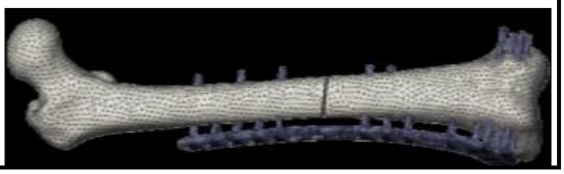
A **biomaterial** is any substance that has been engineered to interact with biological systems for a medical purpose - either a therapeutic (treat, augment, repair or replace a tissue function of the body) or a diagnostic one. As a science, **biomaterials** is about fifty years old. The study of biomaterials is called **biomaterials science** or **biomaterials engineering**. It has experienced steady and strong growth over its history, with many companies investing large amounts of money into the development of new products. Biomaterials science encompasses elements of medicine, biology, chemistry, tissue engineering and materials Engineering .

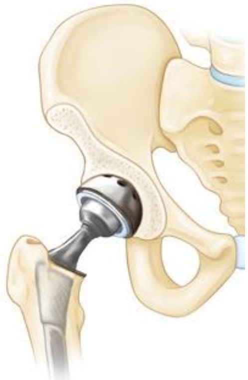
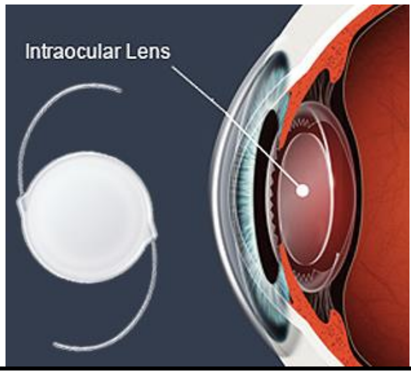
A variety of devices and materials are used in the treatment of disease or injury. Common examples of biomaterials include suture needles, catheters, fixation plates, teeth fillings, etc.

Biocompatibility: is acceptance of an artificial implant by the surrounding tissues and by the body as a whole. Or it is the ability of a material to perform with an appropriate host response in a specific application.

Biocompatibility is the ability of a material to perform with an appropriate host response in a specific application .The biocompatibility of materials is of considerable interest because implants and tissue interfacing devices can corrode in an in vivo environment.

The following table represents the time scale over which the host is exposed to materials and devices:

Material	Contact time	
Syringe needle	1-2 s	
Tongue depressor	10 s	
Contact lens	12 hr- 30 days	
Bone screw/plate	3-12 months	

Total hip replacement	10-15 yrs	
Intraocular lens	30 + yrs	

The classes of materials :

Biomaterials can be divided into four major classes of materials: polymers, metals, ceramics (including carbons, glassceramics, and glasses), and natural materials (including those from both plants and animals). Sometimes two different classes of materials are combined together into a composite material,such as silica-reinforced silicone rubber or carbon fiber- or hydroxyapatite particle-reinforced poly (lactic acid). Such composites are a fifth class of biomaterials. What is the history behind the development and application of such diverse materials for implants and medical devices, what are the compositions and properties of these materials and what are the principles governing their many uses as components of implants and medical devices?

A- Metals

B-Polymers

C- Ceramics

D- Composites

E- Natural biomaterials

F – Advance materials

Uses of Biomaterials according to purpose:

Purpose of Uses	Example
Replacement of diseased and damaged part	Artificial hip joint, kidney dialysis machine
Assist in healing	Sutures, bone plates and screws
Improve function	Cardiac pacemaker, intra-ocular lens
Correct cosmetic problem	chin augmentation, orthodontic
Aid to diagnosis	Probes and catheters
Aid to treatment	Catheters, drains

Uses of biomaterials according to organ

Organ	Example
Heart	Pacemaker, artificial heart valve, totally artificial heart
Lung	Oxy-generator machine
Eye	Contact lens, intraocular lens
Ear	Artificial stapes, cochlea implant
Bone	Fixation plates
Kidney	Kidney dialysis machine
Bladder	Catheters and stent

Selection parameters for biomaterials:

A biomaterial used for implant should possess some important properties in order to long-term usage in the body without rejection. The design and selection of biomaterials depend on different properties which are:

1- **Host Response:** is defined as the response of the host organism (local or systemic) to the implanted material or device.

2- **Toxicology :** A biomaterial should not be toxic, unless it is specifically engineered for such requirements (for example, a "smart bomb" drug delivery system that targets cancer cells and destroys them). 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. For example, for polymers, many low-molecular-weight "leachable" exhibit some level of physiologic activity and cell toxicity.

3- **Biodegradability**: It is simply a phenomenon that natural and synthetic biomaterials are capable of decomposing in the body conditions without leaving any harmful substances behind.

4- **Bio functionality:** the bio functionality is playing a specific function in physical and mechanical terms. The material must satisfy its design requirements in service:

- *Load transmission and stress distribution (e.g. bone replacement).*
- *Articulation to allow movement (e.g. artificial knee joint).*
- *Control of blood and fluid flow (e.g. artificial heart).*
- *Space filling (e.g. cosmetic surgery).*
- *Electrical stimuli (e.g. pacemaker).*
- *Light transmission (e.g. implanted lenses).*
- *Sound transmission (e.g. cochlear implant).*

5- **Dependence on Specific Anatomical Sites of Implantation**

- A hip-joint will be implanted in bone space.
- A heart valve will be sutured into cardiac muscle and will contact both soft tissues and blood.
- A catheter may be placed in an artery.

Each of these sites challenges the biomedical device designer with special requirements for geometry, size, mechanical properties, and bio-responses.

6- **Mechanical, Physical and Performance Requirements**

i. Mechanical Performance

Device Properties

A hip prosthesis Must be strong and rigid

A tendon material Must be strong and flexible

An articular cartilage substitute Must be soft and elastomeric

A dialysis membrane Must be strong and flexible

ii. Mechanical durability

A catheter may only have to perform for day.

A bone plate may fulfill its function in 6 months or longer.

A leaflet in a heart valve must flex 60 times per minute without tearing for the lifetime of the patient (for 10 years).

A hip joint must not fail under heavy loads for more than 10 years.

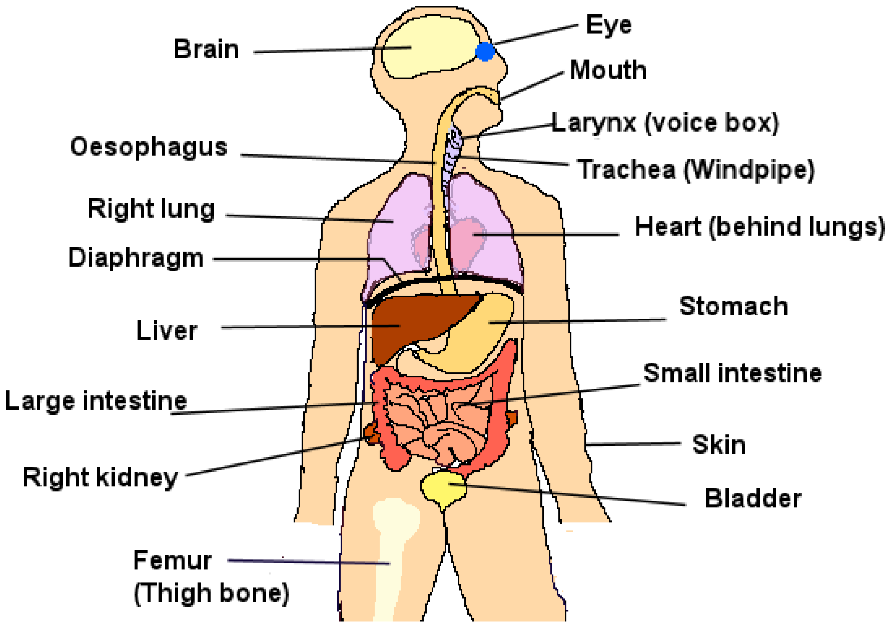
iii. Physical Properties

- The dialysis membrane has a specified permeability.
- The articular cup of the hip joint has high lubricity.
- The intraocular lens has clarity and refraction requirements.

7- Ethics

A wide range of ethical considerations impact biomaterials. Like most ethical questions, an absolute answer may be difficult to come by. Some articles have addressed ethical questions in biomaterials and debated the important points.

Organ of human body ;



The following figure represents all Biomaterials in human body: