**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](https://en.wikipedia.org/wiki/Medicine), [biology](https://en.wikipedia.org/wiki/Biology), [chemistry](https://en.wikipedia.org/wiki/Chemistry), [tissue engineering](https://en.wikipedia.org/wiki/Tissue_engineering) and [materials](https://en.wikipedia.org/wiki/Materials_science) 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.

**The history of the evolution of the biomaterial divided into three stages:**

* **The first stage: Before 1850**

 In this stage were used non-metallic materials such as wood, ivory or metals like iron, gold, silver, copper in the manufacture of artificial limbs and noses. In 1829 were tested using wires lead, gold, silver and platinum in dogs but these materials have failed to achieve the desired result of them. On the other hand, the people were not able to prospect surgeries long to install artificial limbs without anesthesia.

A false toe made of out of wood and leather was found on a 3,000-year-old

mummified body of an Egyptian noblewoman.



* **The second stage: between the years 1850 and 1925**

 In this stage happened rapid development of surgery, which helped to this is the discovery of X-rays by Wilhelm Conrad Rontgen in the early nineteenth century , which revealed for the first time the fact that the problems of the bones.

* **The third stage: began in 1925 and to this day**

Because of the great advances made ​​in the various branches of surgery, happened three major developments on biomaterials:

1 . The development of material and cobalt chrome alloy and steel alloy between the thirties and forties of the twentieth century.

2 . Development of polymers and plastics chemistry between the forties and fifties.

3 . Development of methods of production of penicillin and antibiotics in large quantities, which helped to reduce the inflammation that occurs after surgery.

**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.

 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 goal of using biomaterials:**

 Assisting in

**1- Regenerating**

**2- Repairing**

**3- Supporting**

**4- Replacing**

**The classes of materials**

**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 anddamaged 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).*
1. **Healing**
2. **Appropriate Design and Manufacturability:** Biomaterials should be machine able and moldable.
3. **High corrosion resistance:** corrosion can reduce the life of implant device.
4. **High wear resistance:**
5. **Long fatigue life.**
6. **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.

1. **Mechanical, Physical and Performance Requirements**
2. 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

1. 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.

1. **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:**

