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# REVIEW ARTICLE

# THE CHEMISTRY OF BIONICS AND BIOMIMETICS (REVIEW ARTICLE)

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**ABSTRACT**

The study of functions, characteristics and phenomena observed in the living beings, in order to apply such knowledge in the conception of new techniques and in the creation of new devices and machines. Having parts of the body that are electronic, and therefore able to do things that are not possible for normal humans. For such conception of knowledge we use two terms Bionics and Biomimetics. Bionics is Application of biological information to machines: the study of biological function and mechanics, and their application to machine design. Use of electronically operated replacement organs: the use of electronic devices to replace damaged limbs and organs, the study and the construction of systems that function like (part of) living beings. Biomimicity is imitating their models, or valorizing their knowledge, or changing the paradigm of just extracting, by learning from nature, or by doing the things in the way that nature does. Now these knowledge is grown unto; developing tissue and organ in the lab, creating artificial human, and increasing the live of the human being or even live forever.



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## INTRODUCTION

### 1.1Definition and meaning of terms

### 1.1.1Bionics

The term bionics was coined by Jack E. Steele in 1958 while working at the Aeronautics Division House at Wright-Patterson Air force base in Dayton, Ohio, USA. Possibly originating from the technical term *bion* (pronounced *BEE-on*; from Ancient Greek: βίος), meaning 'unit of life' and the suffix *-ic*, meaning 'like' or 'in the manner of', hence 'like life'. Some dictionaries, however, explain the word as being formed as a portmanteau from *biology* and *electronics*. Also others perceive it as Biology and Tech*nic =Bionic*; bionic= bio + electronic (Wallace etal, 2010, Oxford, 2010). The study of functions, characteristics and phenomena observed in the living beings, in order to apply such knowledge in the conception of new techniques and in the creation of new devices and machines. Having parts of the body that are electronic, and therefore able to do things that are not possible for normal humans (Oxford, 2010 and Gebelein, 1984). Bionics is Application of biological information to machines: the study of biological function and mechanics, and their application to machine design.

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Use of electronically operated replacement organs: the use of electronic devices to replace damaged limbs and organs, the study and the construction of systems that function like (part of) living beings (Encarta, 2009; Subrata, 2014)

The application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. It combines biology and technology with the goal of solving technical problems by means of abstraction, transfer and application of knowledge of biological research, and merges life sciences with technical disciplines. A technology concerned with the application of data about the functioning of biological systems to the solution of engineering problems**.** Term used to describe the scientific study of living things as functional models for technical devices useful to humans, especially when applied to systems engineering. (Wallace *et al*., 2010; Hakim, 2009)

### 1.1.2 Biomimetics

The name biomimetics was coined by Otto Schmitt in the 1950s. Biomimetics or biomimicry is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. The terms "biomimetics" and "biomimicry" derive from Ancient Greek: βίος (*bios*), life, and μίμησις (*mīmēsis*), imitation, from μιμεῖσθαι (*mīmeisthai*), to imitate, from μῖμος (*mimos*), actor. A closely related field is bionics**.**

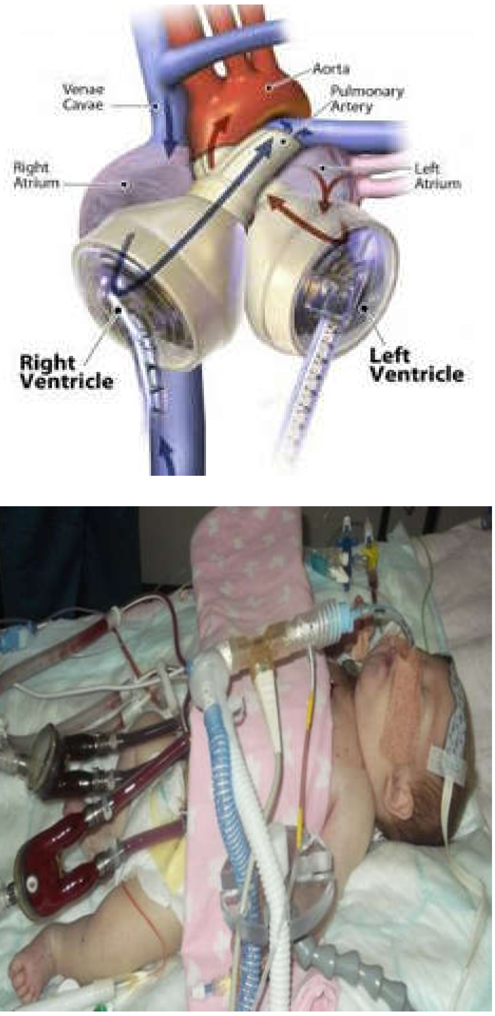



**Figure 1. Implantable Artificial Heart**

**Figure 2. Bionic eye glass**

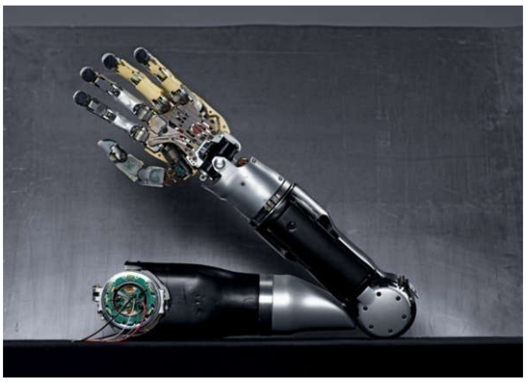


**Figure 3. Bionic Hand**

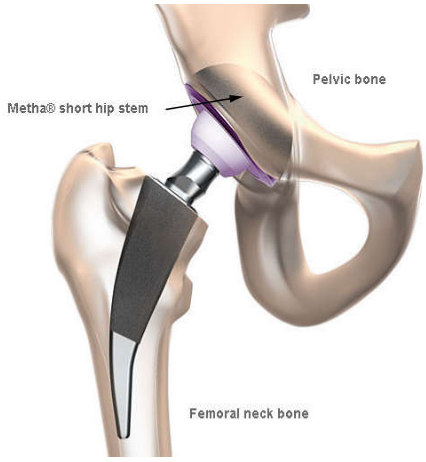



**Figure 4. Bionic Hip**

Biomimicry or biomimetics are more preferred in the technology world in efforts to avoid confusion between the medical term bionics. One of the early examples of biomimicry was the study of birds to enable human flight. Biomimicry was popularized by scientist and author Janine Benyus in her 1997 book *Biomimicry: Innovation Inspired by Nature*. Biomimicry is defined in the book as a "new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems". Benyus suggests looking to Nature as a "Model, Measure, and Mentor" and emphasizes sustainability as an objective of biomimicry. (Bharat, 2009)

**Figure 5A. Biomimicity: lesson from nature**

### 1.1.3When science is inspired by nature

Imitating their models, or valorizing their knowledge, or changing the paradigm of just extracting, by learning from nature, or by doing the things in the way that nature does (Yoseph, 2006; George, 2011).


**Figure 5B. Biomimicity: lesson from nature**

### 1.2 Short History of bionics and biomimetics

### 1.2.1 Bionics

The term bionics was coined by Jack E. Steele in 1958 while working at the *Aeronautics Division House* at Wright-Patterson Air Force Base in Dayton, Ohio. Steele defined bionics as "the science of systems which have some function copied from nature, or which represent characteristics of natural systems or their analogues". During a later meeting in 1963 Schmitt stated, Let us consider what bionics has come to mean operationally and what it or some word like it (I prefer biomimetics) ought to mean in order to make good use of the technical skills of scientists specializing, or rather, I should say, despecializing into this area of research (Wallace etal, 2010; Gowan *et al*., 2014).

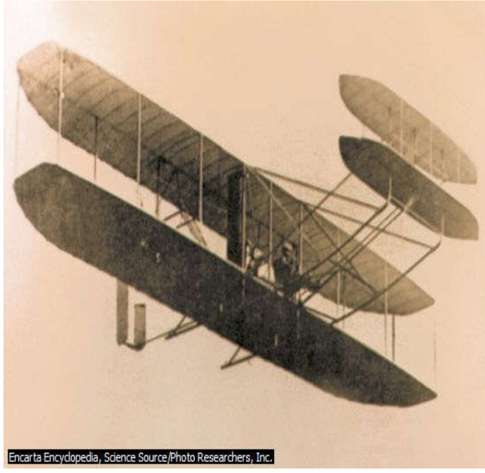




**Figure 6A. Orville Wright *Flyer* in Flight Figure 6B:- Amputating a Leg, 16th Century**

### 1.2.2 Biomimetics

Although never successful in creating a "flying machine", Leonardo da Vinci (1452–1519) was a keen observer of the anatomy and flight of birds, and made numerous notes and sketches on his observations as well as sketches of "flying machines". The Wright Brothers, who succeeded in flying the first heavier-than-air aircraft in 1903, derived inspiration from observations of pigeons in flight (Bharat, 2009 ; Murugan *et al*., 2013).

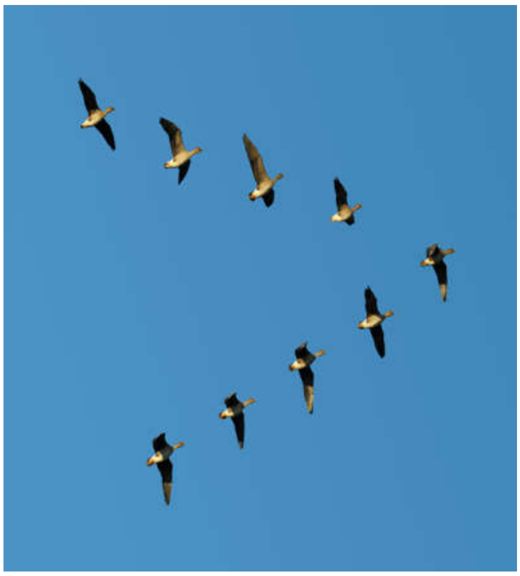


**Figure 7. How science imitates nature**

Mimicking natural methods of manufacture. Imitating mechanisms found in nature. Studying organizational principles from the social behavior of organisms, such as the flocking behavior of birds, optimization of ant foraging and bee foraging, and the swarm intelligence (SI)-based behavior of a school of fish (Raz, 2013).

## 2. Materials used for bionics:-The Biomaterials

Biomaterials are used to make devices to replace a part or a function of the body in safe, reliably, economically, and physiologically acceptable manner. A variety of devices and materials are used in the treatment of disease or injury. Commonplace examples include; suture, needles, plates, teeth fillings, etc (Christina *et al*., 2011; Chandra, 2003).

### Definition of Terms

- **Biomaterial**:-A synthetic material used to make devices to replace part of a living system or to function in intimate contact with living tissue.
- **Biological Material**:-A material that is produced by a biological system.
- **Bio-compatibility**:-Acceptance of an artificial implant by the surrounding tissues and by the body as a whole.

### 2.1 Uses of Biomaterials

**Table 1. Uses of some Biomaterials with specific examples**

| Uses of Biomaterials | 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 functional abnormalities | Cardiac pacemaker |
| Correct cosmetic problem | Mastectomy augmentation, chin augmentation |
| Aid to diagnosis | Probes and catheters |
| Aid to treatment | Catheters, drains |

### 2.2 Biomaterials in Organs

**Table 2. Some Biomaterials applied in Organs**

| Organ | Example |
|---|---|
| Heart | Cardiac pacemaker, artificial heart valve, Totally artificial heart |
| Lung | Oxy-generator machine |
| Eye | Contact lens, intraocular lens |
| Ear | Artificial stapes, cochlea implant |
| Bone | Bone plate, intra-medullary rod |
| Kidney | Kidney dialysis machine |
| Bladder | Catheter and stent |

### 2.3 Materials for Use in the Body

The most common classes of materials used as biomedical materials are; polymers, metals, and ceramics.

These three classes are used singly and in combination to form most of the implantation devices available today (Kwang *et al*., 2007).

#### 2.3.1 Polymers as biomaterials (known as Biopolymers)

There are a large number of polymeric materials that have been used as; implants or part of implant systems. Some of the applications include the use of membranes of ethylene-vinyl-acetate (EVA) copolymer for controlled release and the use of poly-glycolic acid for use as a resorbable suture material. The polymeric systems include; acrylics, polyamides, polyesters, polyethylene, polysiloxanes, polyurethane, and a number of reprocessed biological materials (Rao *et al*., 2014).

### General Applications of Biomaterials in biomedical field

Tissue engineering; Implantation of medical devices; Artificial organs; Prostheses; Dentistry; Bone repair; Drug delivery and targeting into sites of inflammation or tumors; Plastic tubing for intra-venous infusion; Bags for the transport of blood plasma; Catheter.

**Figure 8. Artificial Muscle**

### Specific Applications of Biomaterials

Artificial; heart, pacemaker, heart valves, cardiac assist devices, blood vessels, skin, Muscle, kidney, liver, pancreas, Bladder, bone cement, contact lenses, cornea and eye-lens replacements, external and internal ear repairs, implantable pumps, joint replacements, encapsulations, tissue replacement, sutures. In most of these applications, polymers have little or no competition from other types of materials. Their unique properties are: Flexibility; Resistance to biochemical attack; Good biocompatibility; Light weight; Available in a wide variety of compositions with adequate physical and mechanical properties; Can be easily manufactured into products with the desired shape.

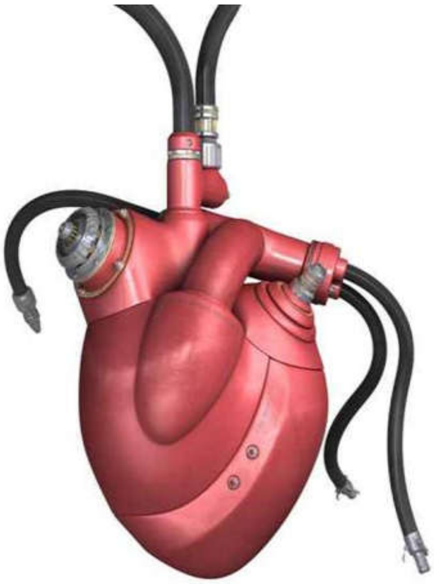


**Figure 9. Artificial Heart**

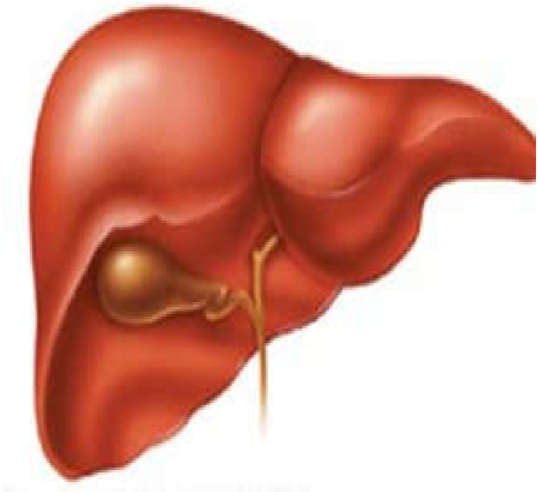
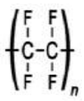


**Figure 10. Artificial Liver**

## Major classes of polymers

### PTFE- Polytetrafluoroethylene

Teflon**; i**s a fluorocarbon–based polymer; a carbon backbone chain, where each carbon has two fluorine atoms attached to it.



**Properties of PTFE**

1-Hydrophobic (Water hating)
2- Biologically inert
3- Non-biodegradable
4- Has low friction characteristics
5- Excellent "Slipperiness"
6- Relatively lower wear resistance.
7- Highly crystalline (94%)
8- Very high density (2.2 kg.m$^{-3}$)
9- Low modulus of elasticity (0.5MPa)
10- Low tensile strength (14MPa)

* The chemical inertness (stability) of PTFE is related to the strength of the fluorine-carbon bond. This is why nothing sticks to this polymer

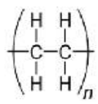
PTFE has many medical uses, including: Arterial grafts (artificial vascular graft); Catheters; Sutures; Uses in reconstructive and cosmetic facial surgery. PTFE can be fabricated in many forms: Can be woven into a porous fabric like mesh. When implanted in the body, this mesh allows tissue to grow into its pores, making it ideal for medical devices, such as vascular grafts; Pastes; Tubes; Strands; Sheets (G.F Cynthia *et al*., 2014; Vartiainen *et al*., 2014).

### Disadvantages of PTFE

PTFE has relatively low wear resistance. Under compression or in solutions where rubbing or abrasion can occur, it can produce wear particles. These can result in a chronic inflammatory reaction, an undesirable outcome.

### A.Polyethylene, (PE)

It is chemically the simplest of all polymers and as a homochain polymer. It is essentially: Stable and suitable for long-time implantation under many circumstances; relatively inexpensive; have good general mechanical properties. So that it has become a versatile biomedical polymer with applications ranging from catheters to joint-replacement.



Polypropylene is widely used in medical devices; sutures; finger joints and oxygen generators.

### C. Poly (methyl methacrylate), PMMA

It is a hard brittle polymer that appears to be unsuitable for most clinical applications, but it does have several important characteristics. It can be prepared under ambient conditions so that it can be manipulated in the operating theater or dental clinic, explaining its use in dentures and bone cement. The relative success in many joint prostheses.

### The disadvantages of PMMA

The exotherm of polymerization; the toxicity of the volatile methylmethacrylate; the poor fracture toughness (Rao *et al*., 2014; Elisabeta *et al*., 2014, Cynthia *et al*., 2014).

### 2.3.2 Metals and Alloys as Biomaterials

The metallic systems most frequently used in the body are: Iron-base alloys of the 316L stainless steel; Titanium and titanium-base alloys, such as; Ti-6% Al-4%V, and commercially pure 98.9%; Ti-Ni (55% Ni and 45% Ti). Cobalt base alloys of four types; Cr (27-30%), Mo (5-7%), Ni (2-5%); Cr (19-21%), Ni (9-11%), W (14-16%); Cr (18-22%), Fe (4-6%), Ni (15-25%), W (3-4%) and Cr (19-20%), Mo (9-10%), Ni (33-37%). Metals are used as biomaterial due to their excellent electrical conductivity, thermal conductivity and mechanical properties. The mobile free electrons as the binding force to hold the positive metal ions together. This attraction is strong, as evidenced by the closely-packed atomic arrangement resulting in high specific gravity and high melting points of most metals. Since the metallic bond id essentially non-directional, the position of the metal ions can be altered without destroying the crystal structure, resulting in a plastically deformable solid (Mullera *et al*., 2007; Nassif *et al*., 2013; Tiel *et al*., 2013).

### Applications of metals and alloys

Some metals are used as passive substitutes for hard tissue replacement such as: Total hip; Knee joints; for fracture healing aids as bone plates and screws; Spinal fixation devices; Dental implants, because of their excellent mechanical properties, and corrosion resistance; vascular stents; Catheter guide wires (Shima *et al*, 2012; Dalibor *et al*., 2015; Li, 2014).

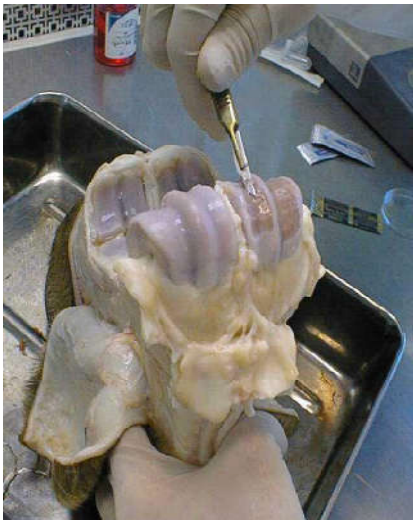


**Figure 11. Artificial knee joint**

**Figure 12. Schematic diagram of artificial hip joint**

**Figure 13. Dental implants**

### 2.3.3 Composite Materials as Biomaterials

Composite materials have been extensively used in dentistry and prosthesis**.** Composites have unique properties and are usually stronger than any of the single materials from which they are made. Examples: Deposited $Al_2O_3$ onto carbon; Carbon / PTFE; $Al_2O_3$ / PTFE; PLA-coated Carbon fibers

### Advantages of Composite materials over homogeneous materials

Those include the ability for the scientist or engineer to exercise considerable control over material properties. This is the potential for stiff, strong, light-weight materials as well as for highly resilient and compliant materials. Some applications of composites in biomaterial applications are: Dental filling composites; Reinforced methyl methacrylate bone cement and ultra-high molecular weight polyethylene; Orthopedic implants with porous surfaces (Lee, 2014; Gupta *et al*., 2016; M.Machovsky,2013).

### Structure of composite materials

The properties of composite materials depend very much upon structure. Composites differ from homogeneous materials in that considerable control can be exerted over the larger scale structure, and hence over the desired properties. In particular, the properties of a composite material depend upon the shape of the heterogeneities, upon the volume fraction occupied by them, and upon the interface among the constituents. The shape of the heterogeneities in a composite material is classified as follows: The particle, with no long dimension; the fiber, with one long dimension; the platelet or lamina, with two long dimensions.

### Types Composites

Isotopic composite material and anisotropic composite material; Particulate Composites and Fibrous Composites (Salernitano *et al*., 2003; Volpato, 2010, Lee, 2014).

### 2.3.4 Ceramics as biomaterials (Bio-ceramics)

Ceramics are used for the repair and restoration of diseased or damaged parts of the musculo-skeletal system. Bio-ceramics may be: Bioinert like Alumina ($Al_2O_3$), Zirconia ($ZrO_2$); Resorbable like tri-calcium phosphate (TCP); Bioactive like

Hydroxyapatite, bioactive glasses, and glass-ceramics; Porous for tissue in-growth (hydroxyapatite-coated metals, alumina) of the jaw bone (Mozafari, 2014; Levingstone *et al*., 2008).

**Applications of Bio-ceramics**

Replacement for hips, knees, Teeth, tendons and ligaments, and repair for periodontal disease, maxillofacial reconstruction, augmentation and stabilization, spinal fusion and bone fillers after tumor surgery. Carbon coatings are thrombo-resistant and are used for prosthetic heart valves.

**Types of Bio-ceramics – Tissue Attachment**

The mechanism of tissue attachment is directly related to the type of tissue response at the implant interface. No material implanted in living tissues is inert; all materials elicit a response from living tissues. Four types of response allow different means of achieving attachment of prostheses to the musculo-skeletal system. The most frequently used ceramic implant materials include aluminum oxides, calcium phosphates, and apatites and graphite. The use of ceramics was motivated by: Their inertness in the body, their formability into a variety of shapes and porosities, their high compressive strength, and some cases their excellent wear characteristics.

Applications of ceramics are in some cases limited by their generally poor mechanical properties: in tension; load bearing, implant devices that are to be subjected to significant tensile stresses must be designed and manufactured with great care if ceramics are to be safely used. Ceramics are used for the repair and restoration of diseased or damaged parts of the musculo-skeletal system. Bioinert like Alumina ($Al_2O_3$), Zirconia ($ZrO_2$); Resorbable like tri-calcium phosphate (TCP); Bioactive like Hydroxyapatite, bioactive glasses, and glass-ceramics; Porous for tissue in-growth (hydroxyapatite-coated metals, alumina) of the jaw bone (Pezzotti, 2014; Majore *et al*, 2006).

**Properties of biomaterials**

**A.Physical Properties**

- Thermal Properties
- Mechanical Properties of Biomaterials

a) **Thermal Diffusivity** (D) is defined by the equation:

$$D = \frac{K}{C_p \rho},$$

Where, K is thermal conductivity;

Cp is heat capacity, and
ρ is density.

**(b) Coefficient of Thermal Expansion (α)** is defined as the fractional increase in length of a body for each degree centigrade increase in temperature

$$\alpha = \frac{\Delta L / L_o}{\Delta T} \quad {}^{o}C^{-1}$$

Where ΔL is the change in length;
Lo is the original length;
ΔT is the temperature change.

For example for amalgam $\alpha = 0.0000025^{o}C^{-1} = 25\ ^{o}C^{-1}$ p.p.m (part per million).

**B.Chemical Properties**

One of the main factors, which determine the durability of a material, is its chemical stability. Material should not dissolve, erode or corrode, nor should they leach important constituents into oral fluids.

**(i) Solubility and Erosion**

The solubility of a material is a measurement of the extent to which it will dissolve in a given fluid, for example, water or saliva.

**Table 3. Advantages and disadvantages of biomaterial type with applicable examples**

| Materials | Advantages | Disadvantages | Examples |
|---|---|---|---|
| Polymers (nylon, silicon Rubber, polyester, PTFE, etc) | Resilient Easy to Fabricate | Not strong Deforms with time May degrade | Blood vessels, Sutures, ear, nose, Soft tissues |
| Metals (Ti and its alloys Co-Cr alloys, stainless Steels) | Strong Tough ductile | May corrode, dense, Difficult to make | Joint replacement, Bone plates and Screws, dental root Implant, pacer, and suture |
| Ceramics (Aluminum Oxide, calcium phosphates, including hydroxyapatite carbon) | Very biocompatible Inert strong in compression | Difficult to make Brittle Not resilient | Dental coating Orthopedic implants Femoral head of hip |
| Composites (Carbon-carbon, wire Or fiber reinforced Bone cement) | Compression strong | Difficult to make | Joint implants Heart valves |

**Table 4. Thermal conductivity of some biomaterials**

| Material | Thermal Conductivity |
|---|---|
| Enamel | $0.92\ W.m^{-1}.^{\circ}C^{-1}$ |
| Dentine | $\cdot.63\ W.m^{-1}.^{\circ}C^{-1}$ |
| Acrylic Resin | $0.21\ W.m^{-1}.^{\circ}C^{-1}$ |
| Dental Amalgam | $23.02\ W.m^{-1}.^{\circ}C^{-1}$ |
| Zinc Phosphate Cement | $1.17\ W.m^{-1}.^{\circ}C^{-1}$ |
| Zinc Oxide Cement | $0.46\ W.m^{-1}.^{\circ}C^{-1}$ |
| Silicate Materials | $0.75\ W.m^{-1}.^{\circ}C^{-1}$ |
| Porcelain | $1.05\ W.m^{-1}.^{\circ}C^{-1}$ |
| Gold | $291.70\ W.m^{-1}.^{\circ}C^{-1}$ |

**Table 5. Coefficient of thermal expansion of some biomaterials**

| Material | Coefficient of thermal expansion(p.p.m.$^{\circ}C^{-1}$) |
|---|---|
| Enamel | 11.4 |
| Dentine | 8.0 |
| Acrylic Resin | 90.0 |
| Porcelain | 4.0 |
| Amalgam | 25.0 |
| Composite resins | 25 – 60 |
| Silicate Cements | 10.0 |

Erosion is a process which combines the chemical process of dissolution with a mild mechanical action. High solubility or poor resistance to erosion will severely limit the effective lifetime of the restoration.

(ii)**Leaching of Constituents**

Constituents of the material may be lost into the oral fluids by a diffusion process commonly referred to as leaching. For example, in some cements containing calcium hydroxide, slow leaching causes an alkaline environment in the base of deep cavities. This has the dual benefit of being antibacterial and of encouraging secondary dentine formation.

**(iii) Corrosion**

It is a term which specifically characterizes the chemical reactivity of metals and alloys. Metals and alloys are good electrical conductors and many corrosion processes involve the setting up of an electrolytic cell as a first stage in the process.

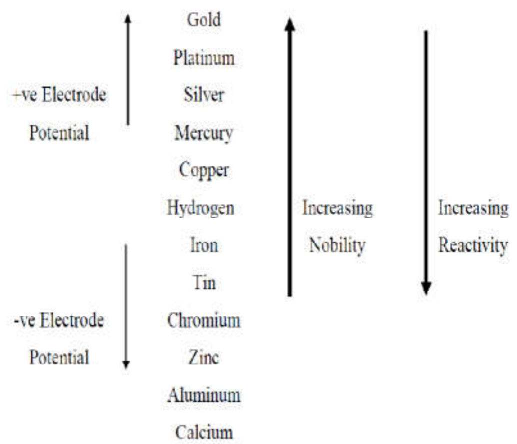



**Figure 14. Reactivity order of metals**

The tendency of a metal to corrode can be predicted from its electrode potential. Materials with large negative electrode potential values are more reactive whilst those with large positive values are far less reactive and are often referred to as noble metals (Yasuniko, 2011).

**3. What Subjects are Important to Biomaterials Science?**
**i.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 destroy them). Toxicology for biomaterials deals with the substances that migrate out of the 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 (Yasuhiko, 2011; Amit *et al*., 2013).

**ii. Biocompatibility**

It is the ability of a material to perform with an appropriate host response in a specific application. "Appropriate host response" includes lack of blood clotting, resistance of bacterial colonization and normal heating. The operational definition of biocompatible "the patient is alive so it must be biocompatible″ (Williams, 2003).

**iii. Functional Tissue Structure and Pathobiology**

Biomaterials incorporated into medical devices are implanted into tissues and organs. Therefore, the key principles governing the structure of normal and abnormal cells, tissues or organs, the technique by which the structure and function of normal and abnormal tissues are studied, and the fundamental mechanisms of disease processes are critical considerations to workers in the field (Yasuhiko,2011; Barre're *et al*., 2008).

**iv. 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. When a foreign body is present in the wound site, the reaction sequence is referred to as the "foreign body reaction". This reaction will differ in intensity and duration depending upon the anatomical site involved (Sharma, 2005; Patel *et al*., 2012).

**v. Dependence on Specific Anatomical Sites of Implantation**

An intraocular lens may go into the lens capsule or the anterior chamber of the eye. A hip-joint will be implanted in bone across an articulating joint 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 (Sharma, 2005; Barre're etal, 2008; Patel etal, 2012, Torsi, 2013).

**vi. Mechanical and Performance Requirements**

Biomaterials and devices have mechanical and performance requirements that originate from the physical properties of the materials. The following are three categories of such requirements:

**a. Mechanical Performance**

**Table 6. Mechanical properties of devices used as bionic organs**

| Device | Properties |
|---|---|
| A hip prosthesis | Must be strong and rigid |
| A tendon material | Must be strong and flexible |
| A heart valve leaflet | Must be flexible and tough |
| An articular cartilage substitute | Must be soft and elastomeric |
| A dialysis membrane | Must be strong and flexible but not elastomer |

**b. Mechanical durability**

A catheter may only have to perform for 3 days. 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.

**c. 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 (Yasuhiko, 2011; Torsi, 2013, Parida *et al*., 2012 Sharma, 2005).

**vii. Industrial Involvement**

A significant basic research effort is now under way to understand how biomaterials function and how to optimize them. At the same time, companies are producing implants for use in humans and appropriate to the mission of the company, earning profits on the sale of medical devices. Industry deals well with technologies, such as packaging, sterilization, storage, distribution and quality control, and analysis.

**viii. Ethics**

A wide range of ethical considerations impact biomaterials. Like most ethical questions, an absolute answer may be difficult to come by.

**ix. Regulation**

The patient demands safe medical devices. To prevent inadequately tested devices and materials from coming on the market, and to screen out individuals clearly unqualified to produce biomaterials. The International Standards Organization (ISO) has introduced international standards for world community (Yasuhiko, 2011; Torsi, 2013; Parida *et al*., 2012; Amogh *et al*., 2010; Pignatello, 2011).

**3. Future Technology on Bionics and biomimitics.**

**a. Growing our own organ……..!**

Now a day's scientists have tried to develop an artificial cell for growing artificial organ. A laboratory based growing organ is an engineered tissue that is implanted or integrated into a human interfacing with living tissue to replace original natural organ, to duplicate or augment a specific function or functions (*https://www.quora.com/Is-it-possible-to-create-an-artificial-human, 02/05/2018* )

**Growing artificial human....**

Biological but unnaturally created humans, ranging from "biological robot" to "clone" to "Plant Person". The important thing is that Artificial Humans look like humans, they move like them, etc. Some may be bullet proof, but you wouldn't be able to tell from touch. Sometimes the only physical indicator is eye-color, which may be red, yellow or purple, or an unusual skin/hair pigment like white. Not always, though, and given the range of eye and hair color in anime, it's not a perfect indicator (http://www.telegraph.co.uk/ science/2017/03/02/ artificial -human-life-could-soon-grown-lab-embryo-breakthrough/, 02/05/2018).

Artificial Humans often have cognitive traits similar to The Spock, such as mathematical skill and a perfect memory on the positive side, they may be unemotional and on the negative side they may suffer from uncreativity and excessive literal-mindedness. Being organic, however, allows some Artificial Humans to have some emotional similarity to humans, often in angst that leads to bonding with the kind-hearted hero(ine) or Kill All Humans. Just like most artificial humanoid characters, Artificial Humans tend to Become a Real Boy over the course of the plot. If the Artificial Human is created with plant-based technology, it may be a type of Plant Person (https://www.mirror.co.uk/lifestyle/ health/scientists-created-artificial-human-blood-11759287, 02/05/2018). Now a day's a group of scientists has created artificial human sperm and eggs using human embryonic stem cells and skin cells.

A group of scientists has created artificial human sperm and eggs using human embryonic stem cells and skin cells. Their final products were not actually working sperm and eggs, but rather germ cells that potentially could mature and become viable for fertility. "Germ cells are 'immortal' in the sense that they provide an enduring link between all generations, carrying genetic information from one generation to the next," When an egg is fertilized by a sperm, it begins to divide into a group of cells called a blastocyst, which is the stage right before the embryo is formed. Some of the cells inside this blastocyst cluster will develop into a fetus, while others eventually become the placenta. Some cells are set up to become stem cells, which will then have the potential to develop into any type of cell in the body.

And some cells in the fetus become primordial germ cells and eventually evolve into the cells of either sperm or eggs, which will allow this offspring to pass their genes on to a future generation. In the study, the researchers identified a single gene known as SOX17, which is directly responsible for ordering human stem cells to become the cells that will turn into sperm and eggs. The scientists say this discovery on its own is surprising, because this gene is not involved in the creation of primordial cells in rodents. In humans, the SOX17 gene is also involved in helping to develop cells of the lungs, gut and pancreas. The scientists harvested these cells by culturing human embryonic stem cells for five days. They then showed that the same process could be replicated using adult skin cells. This doesn't mean men and women will soon be donating skin cells rather than sperm and egg at fertility clinics. Eventually, however, the findings could open the door to more intensive research on human genetics and certain cancers, and could impact fertility treatments sometime in the future. https://www.livescience.com/61089-syndaver-synthetic- humans.html ,02/05/2018

**Figure 15. Artificial Humans in Military Parade**

**b. May be even.......Live forever???? Artificial soul……..**

DYING is an inevitable part of life and there is no way humans will be able to biologically live forever, scientists have confirmed. Scientists have continually looked at ageing as if it were a disease and have tried to cure it. From enhancing certain proteins which protect cells from ageing to extending telomeres – fragments of DNA which cap both ends of each chromosome and protect against the wear and tear of natural ageing – scientists have tried to halt the ageing process. But now, experts say they have conclusive proof there is no way to stop ageing and humans are born to die (https://www.technologyreview.com/s/608173/artificial- human-embryos -are-coming-and-no-one-knows-how-to-handle-them/, 02/05/2018). The possibility of being able to live FOREVER just became one step closer as scientists proved that they can revive cryogenically frozen life. Experts have shown that they can preserve brains and bodies in a state of suspended animation where they freeze an individual to sub-zero temperatures and revive them at a time of choosing in the future. Researchers have so far only achieved this in zebra fish embryos but it is a major breakthrough as 60 years worth of similar testing had proven unsuccessful. The problem was when something is frozen; it expands and destroys cells, so experts had added an anti-freeze solution. However, even with anti-freeze, there were significant issues during the defrosting phase (Morteza *et al*., 2015; Bronzino; Lysaght *et al*., 2011).

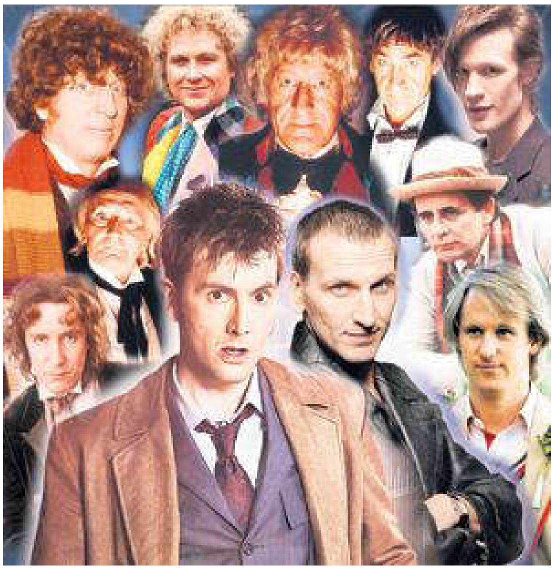


**Figure 16. Live forever**

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