

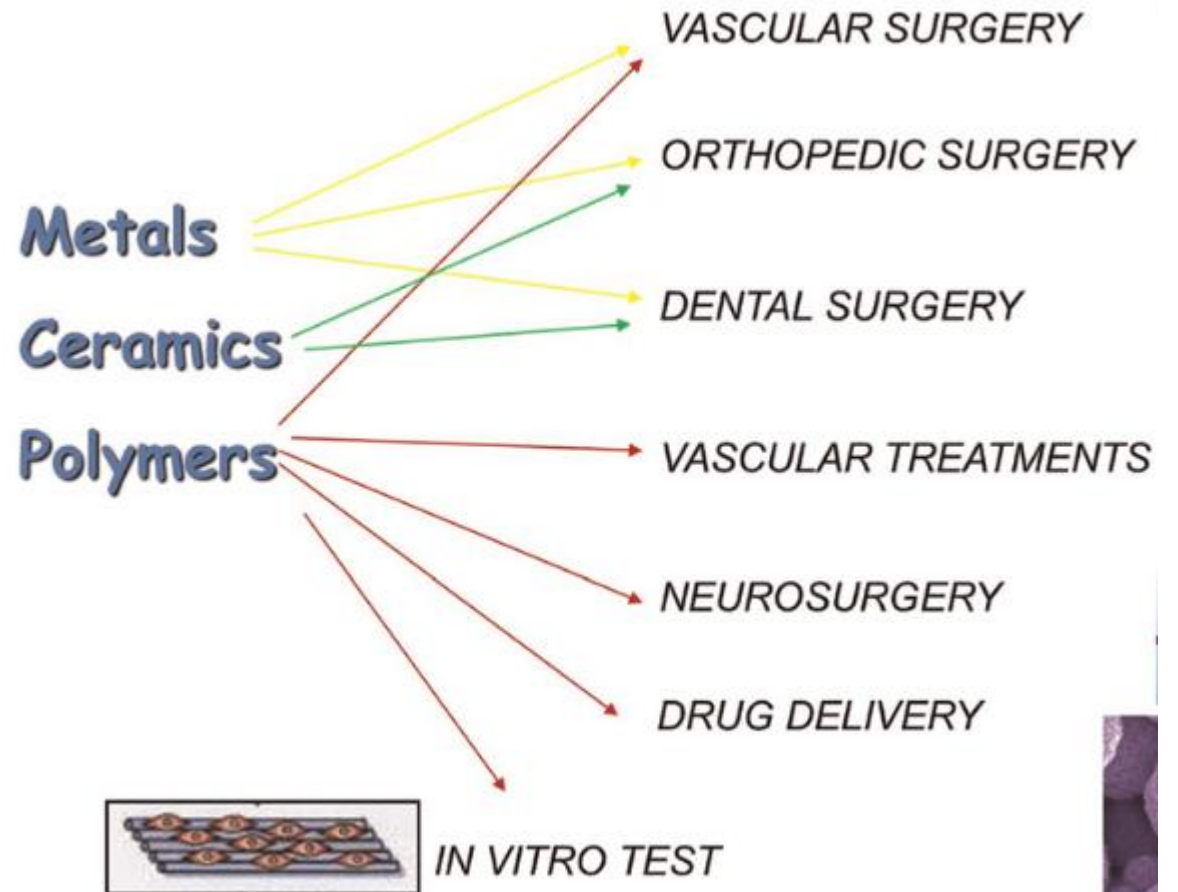
INTRODUCTION TO BIOMATERIALS

ECE 331 – INTRODUCTION TO BIOMEDICAL ENGINEERING

Monday, December 22, 2025

WHAT IS A BIOMATERIAL?

- 1. Biomaterial** is a natural or synthetic that can be used in the body to treat, augment, or replace tissues, organs, or bodily functions **including** materials used in the production of medical devices.
- 2. Biomaterials** are categorized based on their intended function and interaction with the body.



CHARACTERISTICS OF BIOMATERIALS

1. Biocompatible
2. Nontoxic
3. Noncarcinogen
4. Good physical mechanical properties
5. Molded into different shape
6. Resistant to degradation
7. Acceptable strength
8. Resistant to wear
9. Low cost
10. It must be readily available

WHAT DO BIOMATERIAL ENGINEERS DO?

- 1. Biomaterials engineers** study naturally occurring or laboratory-designed substances for use in medical devices or implants.
- 2. Biomaterials Engineers** apply their knowledge of engineering and biology to design, develop and test health systems and products.
- 3. Implantable devices** like pacemakers, defibrillators, and artificial joints must be biocompatible while carrying out complex chemical, mechanical, and electrical functions.



APPLICATIONS OF BIOMATERIALS

Doctors, researchers, and bioengineers use biomaterials for the following broad range of applications:

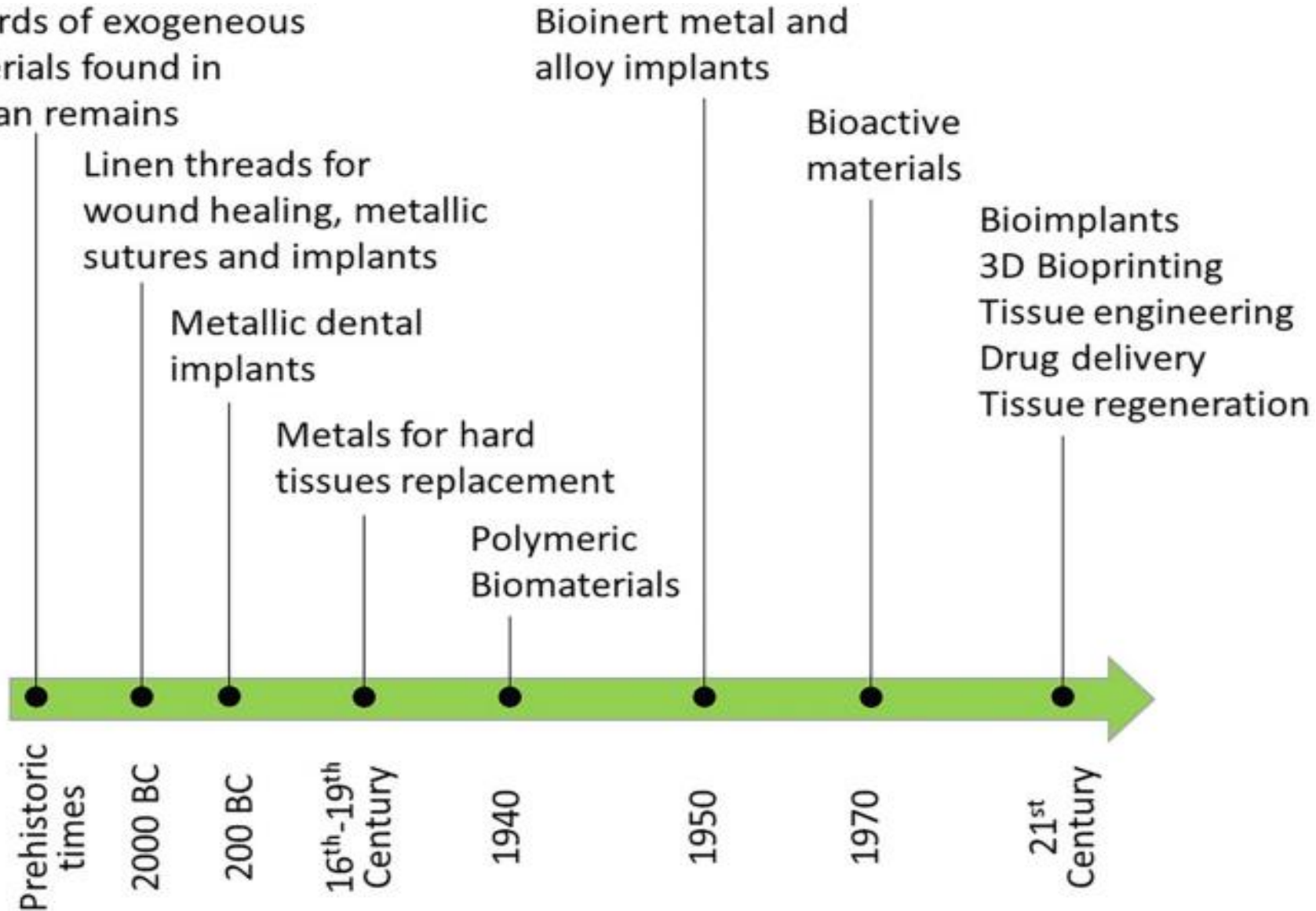
- **Medical implants**, including heart valves, stents, and grafts; artificial joints, ligaments, and tendons; hearing loss implants; dental implants; and devices that stimulate nerves.
- **Methods to promote healing of human tissues**, including sutures, clips, and staples for wound closure, and dissolvable dressings.
- **Regenerated human tissues**, using a combination of biomaterial supports or scaffolds, cells, and bioactive molecules. Examples include a bone regenerating hydrogel and a lab-grown human bladder.
- **Molecular probes and nanoparticles** that break through biological barriers and aid in cancer imaging and therapy at the molecular level.
- **Biosensors** to detect the presence and amount of specific substances and to transmit that data. Examples are blood glucose monitoring devices and brain activity sensors.
- **Drug-delivery systems** that carry and/or apply drugs to a disease target. Examples include drug-coated vascular stents and implantable chemotherapy wafers for cancer patients.

HISTORY OF BIOMATERIALS /01

- Earliest operations were performed by surgeons for restoration of missing parts.
- **Susbruta in 600 B.C.** he repaired injured nose with a patch of living flesh taken off from the region of the cheek.
- **Sicilian Laymen in 1430**, nose construction was done by using skin flap taken from arms.
- **In 19th Century**, modern implant development was seen by repairing long bone and joints.
- **In 1893 – 1912** plate using steel was designed for fracture.
- **In 1930** use of polymers was designed.
- **In 1950**, heart valve implantation was possible only after the development of open heart surgery.
- **In 1944 dialysis** of human beings was discovered.

HISTORY OF BIOMATERIALS /02

Records of exogeneous materials found in human remains



CLASSIFICATION OF BIOMATERIALS

Biomaterials are classified into 4 different types.

1. Metals used for load bearing implants

- Wire, screw, are widely plates, artificial joint for hip, knee, shoulder etc.
- Metal used as stainless steel, titanium and its alloy and cobalt based alloy.

2. Polymers resembles soft-tissues and their application range from facial prosthesis to tracheal tubes, bladder, lens, tendons, etc.

- It can be used as sutures, catheters.

3. Ceramics have been widely used in restorative materials in dentistry. The includes materials for crown (baby), cement, dentures (adult).

4. Composites are used in the field of dentistry as restorative material or dental cement.

- Carbon – carbon and carbon – reinforce polymer composites are used for bone repair and joint replacement because of the low elasticity modulus level.



(a) Hip prosthesis



(b) Ceramic dental implant



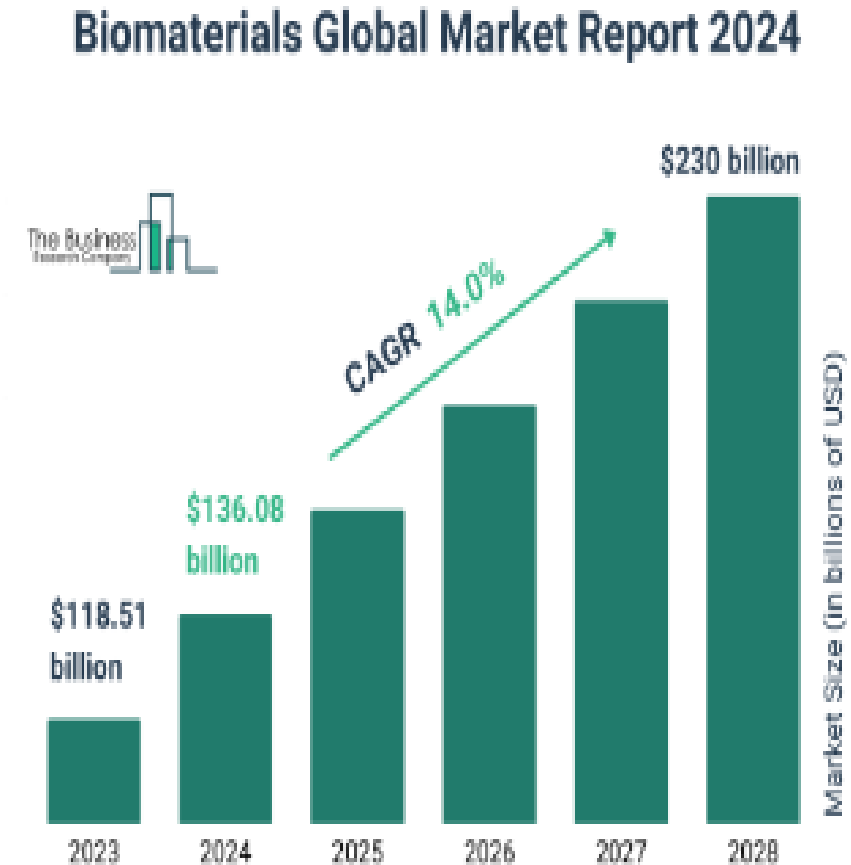
(c) Composite dental bulk fill

GROWING USE OF BIOMATERIALS

1. **In the early days**, relatively few engineering materials such as stainless steel, chromium, etc. were used to make artificial hearts with simple design.
2. Today field of biomaterials has evoked **more than 50 different materials** in various types of complex prosthetic devices.
3. The development of biomaterials used in medical devices as occur in response to growing number of patient afflicted in **traumatic and non-traumatic conditions**

Further Reading:

[Biomaterials Market Report 2024 - Biomaterials Market Research and Growth](#)

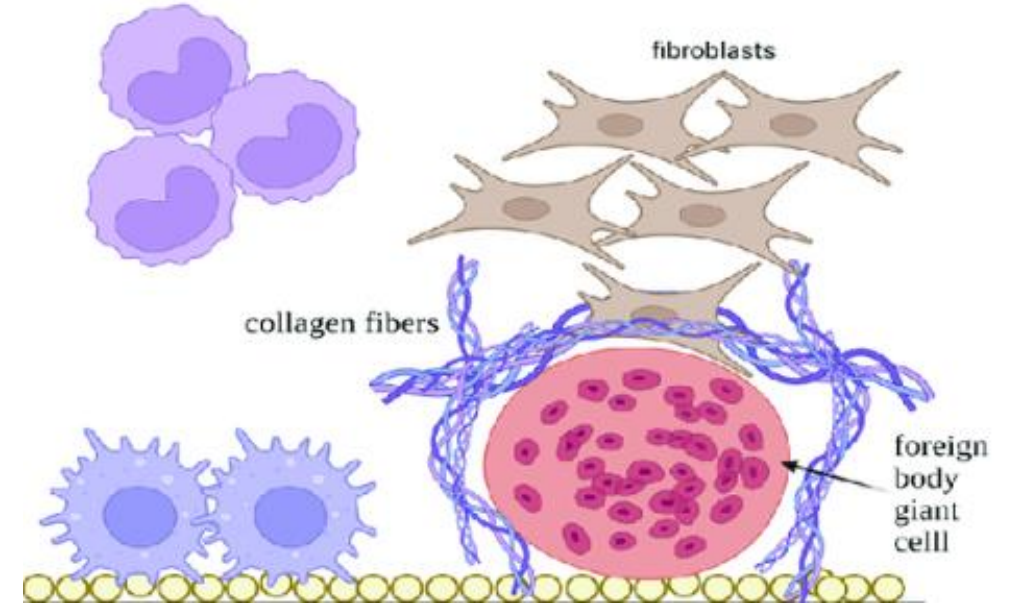


SPECIFIC EXAMPLES OF USE OF BIOMATERIALS

1. **Arthritis** – leading to joint disorder which needs correction.
2. **Total knee and hip replacement** are achieved by using implants that are composites of metal polymer and ceramics
3. **Ophthalmology** includes lens implants, corneal transplant and protective corneal shields.
4. **Facial implants** – purely cosmetic surgery
5. **Oral implants** is of two types: i) artificial teeth or dentures, ii) implants is totally implanted in oral cavity.
6. **Vascular graft** are made of synthetic polymer which are routinely used to replace aorta.
7. **Cancer** a large number of implants are used for reconstructive **surgery of the breast.**

BODY RESPONSE TO IMPLANTS

1. The body normal reaction to foreign material is to reject them.
 - a) **Foreign material may be walled-off** if it cannot be removed from the body
 - b) If the material is particular of fluid, **then it is ingested by the giant cell (macrophage)** and removed.
2. Various mechanism involved in tissue response to implants
 - a) Inflammation (normal wound healing process)
 - b) Cellular response to implants
 - c) Systemic effect of implants
 - d) Blood compatibility
 - e) Carcinogenicity



TISSUE RESPONSE TO IMPLANTS: INFLAMMATION

- 1. Inflammation** is a normal part of your body's response to injuries and invaders (like germs).
- 2. Inflammation** promotes healing and helps you feel better..
- 3. It follows the following steps:**
 - a) Tissues are injured or destroyed.
 - b) Adjacent cell repair them soon after injury
 - c) Construction of capillary occurs
 - d) Dilation of blood vessel occurs

TISSUE RESPONSE TO IMPLANTS: BLOOD COMPATIBILITY

1. **Blood coagulation (clotting)** is the most important factor for the blood compatibility
2. The implant should not damage proteins, enzymes, RBC, WBC and platelets.
3. Sometimes the clot formed inside blood vessel is referred to as thrombus or embolus depending whether the clot is fixed or floating.

TISSUE RESPONSE TO IMPLANTS: CARCINOGENISITY

1. **A substance is carcinogenic** if after inhalation, ingestion, dermal application or injection it induces (malignant) tumours, increase their incidence or malignancy, or shorten the time of tumour occurrence.
2. A variety of chemical substances are known **to induce the onset of cancerous disease in human beings** are known as **carcinogens**.

