# Thi-Qar University

# College of Engineering

# BME Dept

# Biomaterial Science

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## Introduction

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.

## Term Definitions

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.

## Fields of Knowledge to Develop Biomaterials

1- Science and engineering: (Materials Science) structure-property relationships of
synthetic and biological materials including metals, ceramics, polymers, composites,
tissues (blood and connective tissues), etc.

2- Biology and Physiology: Cell and molecular biology, anatomy, animal and human
physiology, histopathology, experimental surgery, immunology, etc.

3- Clinical Sciences: (All the clinical Specialties) density, maxillofacial, neurosurgery,
obstetrics and gynecology, ophthalmology, orthopedics, plastic and reconstructive

**Outline**

surgery, thoracic and cardiovascular surgery, veterinary medicine and surgery, etc.

Introduce the field of biomaterials science and eng g ineering
• Provide introduction to the classification of materials
• Identify and distinguish between the types of atomic bonding

Historical Overview
• What is Materials Science & Engineering
• Classification of Materials
• At i St atomic Structure
• Atomic Bonding

**Mechanical Properties of biomaterials**

- Mechanical Properties of materials (metals, ceramics, polymers and composites) determine the range of their usefulness and establish the service that can be expected.
- MP are also used to help specify and identify engineering materials

When in service, materials are subjected to loads or forces. Thus:

It is also necessary to know the characteristics of the material A need to design materials which can withstand these applied loads without excessive deformation or failure

**Ductility**

- **Is** measure of degree of plastic deformation that has been sustained at fracture.

- Ductile materials can undergo significant plastic deformation before fracture.
- Brittle materials can tolerate only very small plastic deformation.

**Impact Testing: Toughness**

- Toughness (notch toughness) is the ability of a material to absorb energy

1. Material Toughness (slow absorption)

   - Not a readily observable property

   - Defined by the area under the stress-strain curve

2. Impact Toughness (rapid absorption)

   - Ability to absorb energy of an impact without fracturing

- Toughness, ductility and brittleness are related
- **MECHANICAL FAILURE – FATIGUE**
- Fatigue: the weakening or breakdown of a material subject to cyclic stress
- Cyclic stress can be the result of fluctuations in loads, temperature, swelling, chemical environment, etc.

**WEAR**

**Wear** is the erosion of material from a solid surface by the action of another surface.

It is related to surface interactions and more specifically the removal of material from a surface as a result of mechanical action

The science and technology of interacting surfaces in relative motion (Friction/Wear & Lubrication)

- Nature of the surfaces and near-surface regions of a solid.
- Surface parameters which are effective on tribological behaviour.
- Mechanical interaction of surfaces in contact.
  - Friction
  - Wear
- Tribological solutions.

**FRACTURE**

- The mechanical behaviour of a material can be described largely in terms of the materials properties that govern plastic deformation and fracture
- Knowledge and understanding of the relevant properties is the first step toward improving these properties and/or developing new materials with superior properties.
- Plastic deformation occurs by shear, and at much lower shear stresses (or tensile yield stresses) than the theoretical shear stress as a result of *dislocation slip*.
- Fortunately, a number of strengthening mechanisms exist, whereby the yield strength of ductile materials can be enhanced considerably

How do atoms arrange themselves to form solids?

• Fundamental concepts and language

• Unit cells

• Crystal structures

- Face-centered cubic
- Body-centered cubic
- Hexagonal close-packed

• Close packed crystal structures

• Density computations

• Types of solids

Single crystal

Polycrystalline

Amorphous

Crystals are like people, it is the defects in them which tend to make them interesting!” - Colin Humphreys.

• **Defects in Solids**

**0D, Point defects**

vacancies

interstitials

impurities, weight and atomic composition

**1D, Dislocations**

edge

screw

**2D, Grain boundaries**

tilt

twist

**3D, Bulk or Volume defects**

**Atomic vibrations**