



University of Al-Mustaqbal
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Biomaterials

Stage : fourth

LEC (8)

Biomaterials in Medical Imaging

BY

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Introduction

Biomaterials science is considered one of the fundamental branches of biomedical engineering, focusing on the study and design of materials that interact directly with biological systems. According to Joon Park & R.S. Lakes (2007), a biomaterial is defined as any material designed to direct, support, or replace a function of the human body.

In earlier stages, the focus was on using inert materials such as metals and ceramics that provided only mechanical support without interacting with the biological environment. However, this concept has significantly evolved, leading to the emergence of biocompatibility, which refers to the ability of a material to perform its function without causing harmful immune responses.

Callister (2010) emphasizes that material performance depends on the relationship between:

- Structure
- Properties
- Performance

With the advancement of nanotechnology, it has become possible to control these factors at a very fine scale, resulting in materials with enhanced properties and improved interaction with cells and tissues.

1.1 Nanomaterials in Medicine

Nanomaterials represent one of the most important developments in biomaterials, with sizes ranging from 1 to 100 nanometers. At this scale, materials exhibit unique physical and chemical properties compared to their bulk counterparts.

According to materials science principles discussed in Callister (2010), reducing particle size leads to an increased surface area-to-volume ratio, which results in:

- Higher chemical reactivity.
- Improved interaction with biological cells.
- The ability to modify surfaces for binding with biological molecules.

These characteristics make nanomaterials highly suitable for medical applications.

Main Applications:

1. Medical Diagnosis

Nanoparticles are used as contrast agents in imaging techniques, where they can bind to specific cells such as cancer cells, improving early detection.

2. Targeted Therapy

The surface of nanoparticles can be engineered to bind to specific receptors on diseased cells, enabling precise drug delivery and reducing side effects.

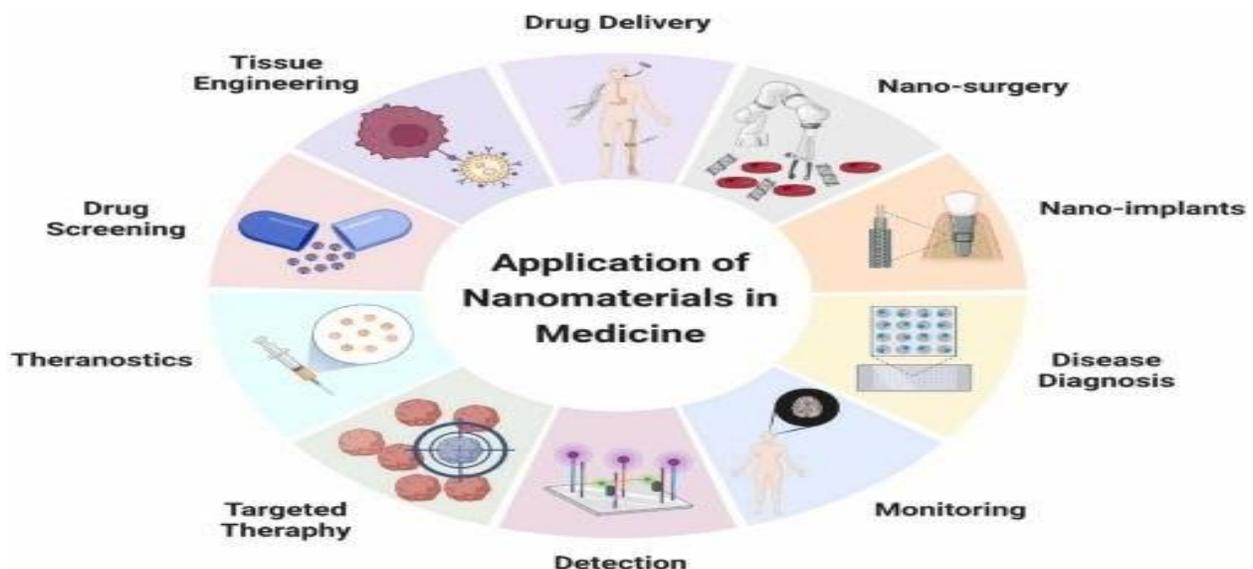
3. Tissue Engineering

Nanomaterials are used to fabricate scaffolds that mimic the extracellular matrix (ECM), supporting cell growth and tissue regeneration.

4. Antimicrobial Applications

For example, silver nanoparticles can destroy bacterial cell walls and reduce infection risks.

*The high surface properties of nanomaterials enhance their biological interaction compared to conventional materials.



1.2 Smart Biomaterials

Smart biomaterials represent an advanced generation of materials that can respond to changes in their surrounding environment rather than remaining static.

According to Park & Lakes (2007), these materials are designed to respond to stimuli such as:

- Temperature
- pH
- Biological signals

Their mechanism of action is based on changes in their molecular structure. Environmental changes lead to molecular rearrangement, resulting in variations in properties such as solubility, shape, or size.

Basic Characteristics :

1. Stimuli-responsive behavior.
2. High biocompatibility.
3. Controlled release capability.
4. Shape memory effect.

Applications :These materials are widely used in drug delivery systems, where drugs are released only under specific conditions. They are also used in medical devices such as stents that expand or change shape within the body.

*Smart biomaterials represent a transition from passive materials to dynamic, responsive systems.

1.3 Drug Delivery Systems

Drug delivery systems are among the most Important applications of biomaterials, aiming to improve therapeutic efficiency and minimize side effects.

In conventional systems, drugs are distributed throughout the body In a non-specific manner, which leads to:

- Effects on healthy cells.

- Loss of a significant portion of the drug before reaching the target.
- The need for repeated dosing.

Modern systems have been developed to control:

- The site of drug delivery.
- The rate of drug release.
- Protection of the drug from degradation.

Types of Drug Delivery Systems:

1. **Conventional Systems:** Based on general distribution of drugs In the body.
2. **Targeted Systems:** Utilize nanoparticles to deliver drugs to specific sites.
3. **Controlled Release Systems:** Use materials such as polymers to release drugs gradually over time.
4. **Smart Systems:** Respond to environmental triggers such as pH or enzymes to release drugs when needed.

*The main goal Is to Increase drug efficacy and reduce toxicity.

1.4 Types of Drug Carriers

Modern drug delivery systems rely on carriers that protect and transport drugs efficiently to their target sites.

Main Types:

1. **Biopolymers:** Biodegradable materials that allow controlled drug release.
2. **Liposomes:** Lipid-based vesicles similar to cell membranes, facilitating drug entry Into cells.
3. **Nanoparticles:** Provide precise targeting due to their small size and modifiable surface.
4. **Dendrimers:** Highly branched molecules with multiple binding sites for drug molecules.

***Main Functions:** Drug protection, Improved solubility, Increased stability

And Precise delivery