Chapter 3
Biomedical Nanotechnology: Why "Nano"?

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ABSTRACT

This chapter aims to provide an overview of recent studies in the field of biomedical nanotechnology, which is described as the combination of biology and nanotechnology. The field includes innovations such as the improvement of biological processes at the nanoscale, the development of specific biomaterials, and the design of accurate measurement devices. Biomedical nanotechnology also serves areas like the development of intelligent drug delivery systems and controlled release systems, tissue engineering, nanorobotics (nanomachines), lab-on-a-chip, point of care, and nanobiosensor development. This chapter will mainly cover the biomedical applications of nanotechnology under the following titles: the importance of nanotechnology, the history of nanotechnology, classification of nanostructures, inorganic, polymer and composite nanostructures, fabrication of nanomaterials, applications of nanostructures, the designs of intelligent drug delivery systems and controlled release systems, bioimaging, bioseparation, nano-biomolecules, lab-on-a-chip, point of care, nanobiosensor development, tissue engineering and the future of biomedical nanotechnology.

BIOMEDICAL NANOTECHNOLOGY

Biomedical nanotechnology, which is defined as the combination of biology and nanotechnology, includes innovations like the improvement of biological processes in nanoscale, the development of specific biomaterials, and the design of accurate

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measurement devices. The design of intelligent drug delivery systems and controlled release systems, tissue engineering, nanorobotics (nanomachines), lab-on-a-chip (LOC), point of care and nanobiosensor development are areas that are focused on the field of biomedical nanotechnology (Gazit, 2013).

How Small is Nano?

The word "nano" comes from the Greek word "nanos" which means "dwarf". A nanometer (nm) refers to one billionth of a meter. To understand the nanoworld better, the units of measure have been defined in Table 1 (Jones, 2005). Size comparisons between very small objects and various examples have been given to clarify the nanoscale (Table 2). For example, a water molecule is about 0.2 nm, DNA is about 2 nm in diameter, proteins are about 1-10 nm, viruses are 10-100 nm, red blood cells are 6000-8000 nm, and a hair is about 100.000 nm.

The Importance of Nanoscale

The concept of "nanotechnology" covers controlling materials at the nanoscale. For instance, the textile materials can be modified to fabricate extraordinary products or drug delivery systems can be manipulated to develop intelligent drug systems. One of the most important reasons why the properties of materials are improved is the surface area-to-volume ratio. As the dimensions of a material decrease, its surface area increases while total volume remains the same (Figure 1). This phenomenon makes nanomaterials exhibit different physical and chemical properties compared to larger particles of the same material. To give an example, when the same amount of sugar cubes and granulated sugar are put in the same amount of water, it is observed that the granulated sugar dissolves much more quickly than the sugar cubes. The reason for this is that the surface area of the granulated sugar is larger than the sugar cubes allowing the granulated sugar to have more contact with the water molecules, therefore the number of sugar molecules interacting with the water molecules is

Table 1. Units of measurements

Unit	Symbol	Explanation
Meter	m	-
Millimeter	mm	1 m = 1,000 mm
Micrometer	μm	1 m = 1,000,000 μm
Nanometer	nm	1 m = 1,000,000,000 nm
Picometer	pm	1 m = 1,000,000,000,000 pm