

# Chapter 1

## Bioengineering / Biomedical Engineering Education

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### ABSTRACT

*Bioengineering/biomedical engineering education is a social process integrating accrued knowledge, expertise, and values pertaining to a fusion of engineering sciences and biomedical sciences that have been disseminated across generations. It has evolved since 1959, and is currently undergoing a healthy global growth. This chapter provides a methodical and comprehensive study on bioengineering/biomedical engineering education. It is addressed to the international bioengineering/biomedical engineering researchers, faculty, and university/college students, as well as, practitioners in bioengineering/biomedical engineering, along with other closely-related governmental, non-governmental, and industrial entities.*

### 1.1. CHAPTER OBJECTIVES

- To provide a formal definition of bioengineering/biomedical engineering and elucidate the role of higher education in this field.
- To provide an in-depth overview on the evolution of bioengineering/biomedical engineering education supported by a thorough literature review.
- To provide a detailed presentation of state-of-the-art curriculum philosophies in bioengineering/biomedical engineering.
- To provide an insight into existing academic curricula in bioengineering/biomedical engineering, supported by a prototype of a modern well-developed undergraduate curriculum in the field.
- To provide educated recommendations about career development in bioengineering/biomedical engineering.

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- To provide an analytical comprehensive study on the world promulgation of bioengineering/biomedical engineering education.
- To provide a forecast of the future of bioengineering/biomedical engineering education.
- To provide a listing of the professional societies and organizations in bioengineering/biomedical engineering.

## **1.2. INTRODUCTION**

Bioengineering/Biomedical Engineering is acclaimed as one of the most advanced fields in science and technology worldwide, and has spurred the advancements in medicine and biology. Recently, healthcare practices have been steered towards new emerging frontiers, including, among others, functional medical imaging, regenerative medicine, nanobiomedicine, enzyme engineering, and artificial sensory substitution. Concurrently, bioengineering/biomedical engineering education has been evolving and proliferating since the late 1950s (Harris *et al.*, 2002; Harris, 2003; Linsenmeier *et al.*, 2002). Today, bioengineering/biomedical engineering education is globally undergoing a healthy growth with 704 programs offered in 6.73% of the world universities (Abu-Faraj, 2010). The first program to be officially launched in biomedical engineering was at Drexel University, Philadelphia, PA, USA, in 1959 at the master's level. This program was soon followed by Ph.D. programs at Johns Hopkins University, Baltimore, MD, USA, and the University of Pennsylvania, Philadelphia, PA, USA (Pilkington *et al.*, 1989). At present, a surge in the development of new curricula in bioengineering/biomedical engineering around the world is witnessed, especially in developing and transitional countries. These programs are to some extent diverse and vary in their academic content, as well as within the different tracks constituting the various areas

of bioengineering/biomedical engineering, which are highlighted in Section 1.3 - Comprehensive Definition of Bioengineering/Biomedical Engineering Education.

Prior to expounding, a word of caution is in order about the use of bioengineering and biomedical engineering terminology within a professional context as there exist some inconsistencies regarding the utilizations of these two terms. To some authorities the term bioengineering is considered as a '*broad umbrella*' that covers biological engineering, biomedical engineering, medical engineering (also known as clinical engineering), as well as biochemical engineering (Pacula, 1990; Domach, 2004). To others bioengineering is regarded as "*a basic-research-oriented activity closely related to biotechnology and genetic engineering*"; whereas, to these authorities, biomedical engineering is the '*broad umbrella*' that encompasses the above areas among others (Bronzino, 2005). Despite these discrepancies introduced by common practice, it should be noted that a great degree of overlap between these two fields exists. In this regard, such ambiguity could be resolved by looking at it from morphological and occupational perspectives. From a morphological approach, the terms bioengineering and biomedical engineering can be differentiated by the absence of the word '*medical*', which is defined in the dictionary as 'the practice of medicine' and that in turn is implemented in both bioengineering and biomedical engineering. Thus, there exists no dichotomy between these two terms, but as a matter of fact they are complementary to one another. From an occupational angle, Harmon stated in 1975 that "Bioengineering is usually viewed broadly as a basic-understanding field which uses the tools and concepts of the physical sciences to analyze biological systems; thus it is largely research oriented and not necessarily related to medical problems" (Harmon, 1975). He added that "While the prime focus of biomedical engineering is on utility, it combines clinical emphasis with strong commitment to basic research". Another expert

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