Chapter 16
Biotechnology: Recent Developments, Emerging Trends, and Implications for Business

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ABSTRACT

Biotechnology utilizes biological systems or living organisms to create, develop, or make products. This chapter reviews the current state of biotechnology and examines its future trends. Currently, biotechnology plays key roles in medicine, agriculture, and industry. In medicine, vaccines which still rely on biological systems for their production, are the best tools to prevent infectious diseases; antibodies and RNA/DNA probes have been crucial in detecting and treating diseases; and genetic editing and gene therapy is making it possible to treat hereditary diseases. In agriculture, biotechnology is generating crops that produce high yields and need fewer inputs, crops that need fewer applications of pesticides, and crops with enhanced nutrition profiles. In industry, biotechnology is being utilized in food processing, metal ore processing, the production of chemicals, and reducing energy consumption and pollution.

INTRODUCTION

Biotechnology is a technology that utilizes biological systems and living organisms or their parts to develop, create or make various products. It is based on biology and can be considered a branch of biology. Although biotechnology is a contemporary buzz word, it has been around for more than 6,000 years since mankind began to use the biological processes of microorganisms to make useful food products, such as bread, beer and cheese, and to preserve dairy products (Arranz-Otaegui, Carretero, Ramsey, Fuller, & Richter, 2018; Dietrich, Heun, Notroff, Schmidt, & Zarnkow, 2012; Salque et al., 2013). In modern times, biotechnology has been playing an even greater role in improving our life and the environment.

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Biotechnology uses living organisms and their parts to produce desired products. Thus, brewing and baking bread (using yeast, a living organism) fall within the concept of biotechnology, while direct utilization of macroscopic biomaterials such as harvesting crops for grains and cutting trees for timbers is not conventionally considered as biotechnology. An important development in the history of the discipline was the use of selective breeding to increase the production of crops and livestock for use as food, and to enhance their appearance, making them more attractive as ornamental plants and pets (Freedman & Wayne, 2017; Piperno, Ranere, Holst, Iriarte, & Dickau, 2009; Purugganan & Fuller, 2009). Darwin (1968) discussed how selective breeding produced desired changes over time in his 1859 book, *On the Origin of Species*. With the discovery of microbes as pathogens and causes of fermentation and the emergence of genetics in the nineteenth century (Bordenave, 2003; Lane, 2015; Weiling, 1991), biotechnology experienced enormous growth and played an increasingly important role not only in agriculture, but also in medicine and industry.

The advent of genetic engineering in the 1970s opened new avenues for the development and application of biotechnology (Jackson, Symons, & Berg, 1972; Jaenisch & Mintz, 1974). Previously, traditional processes usually utilized living organisms in their natural form or modified them by selective breeding. Modern biotechnology involves more advanced modification of biological systems or organisms, because genetic engineering provides new possibilities for making changes in an organisms' genetic material (DNA) to produce desired products unimaginable with traditional breeding. The development of biotechnology is closely related to progress in many different scientific disciplines including biochemistry, cell biology, molecular biology, embryology, genetics, immunology, and microbiology. Many techniques and methods widely today used in biotechnology were invented by researchers in these related disciplines. Today, biotechnology is experiencing exponential growth, with new technologies and products being developed every year in medicine, agriculture, and industry.

The aim of this chapter is to introduce basic concepts of biotechnology, review the current state of the discipline, and examine future trends. The rest of the chapter is organized as follows: the next section introduces biotechnology in medicine; the following section looks at biotechnology in agriculture; the fourth section examines industrial biotechnology; the fifth section introduces bioinformatics; the sixth section looks at the impact of biotechnology on the environment and considers how biotechnology can be used to tackle environmental problems; and the final section summarizes the chapter and its major conclusions.

BIOTECHNOLOGY IN MEDICINE

The two main functions of medicine are the prevention of disease and the treatment of disease and injuries. For both functions, biotechnology has been playing an important role and will play an even greater role in the future. Biotechnology contributes to the progress and success of medicine in the following areas: 1) providing new reagents, new methods and new drugs for the prevention, diagnosis and treatment of disease; 2) providing new materials for medical research that advance our understanding of physiology, immunology, pathology of diseases and pharmacology of drugs, which in turn help in the development of new drugs, new vaccines and new treatments; 3) making it possible to personalize medicine and to cure by gene therapy those diseases that are caused by defective or mutated genes; and 4) making it possible to produce new biomaterials for treatment and transplantation that replace dysfunctional tissues and organs in the body.