Preface

Nanotechnology has been defined as the understanding, application and control of matter and processes at the nanoscale, dimensions typically between 1 and 100 nm. This is the range of biological processes and structures, thus placing nanoscience as the most important area for the development of biotechnology. New technologies for tissue engineering, intracellular transport, therapies, genetic engineering in animals and humans, the development of new vaccines and soil engineering has been dazzled thanks to nanotechnology.

Among nanomaterials, carbon nanostructures have attracted great attention from the scientific community over the past 40 years. The research initiated in the fields of carbon fibers, graphite intercalated compounds and amorphous carbons, generating a wide range of applications related to the unique electrical, thermal and mechanical properties of these materials. In sequence, the fullerenes were discovered and led to the Nobel Prize for chemistry in 1985; carbon nanotubes have generated an avalanche of studies in various areas of knowledge, giving rise to the Kavli Prize for Nanoscience in 2008; graphene launched the field of two-dimensional materials, leading to the Nobel Prize in Physics in 2010. With this avalanche came the mass production of carbon nanotubes and a huge variety of studies, including the noblest application of these nanomaterials, the biomedicine.

This book covers the development of different biomedical technologies based on carbon nanostructures. The focus is on carbon nanotubes, but fullerenes, amorphous carbons and graphene are also addressed. This work put together an interdisciplinary team from the *Research Center for Biotechnological Applications of Carbon Nanotubes*, including medical doctors, biologists, chemists and physicists working on biomedical applications of carbon nanostructures. They built this book that covers therapy, genetic engineering, tissue engineering, soils conditioning, toxicology and the basic aspects of synthesis and processing of carbon nanotubes for biomedical applications, in eight chapters.

The four first chapters are devoted to the use of carbon nanotubes in different biotechnology applications.

Chapter 1 discusses tissue engineering. Carbon nanotubes are among the unique materials that hold potential clinical applications in bone tissue engineering and orthopedic procedures, due to their capacity to accelerate bone regeneration. This chapter summarizes the recent developments in bone repair/regeneration using carbon nanotube composites, and provides insights on the future applications on bone tissue engineering.

Chapter 2 addresses genetic therapy using single wall carbon nanotubes as a delivery system for interfering RNA, to inhibit gene expression. Various strategies available and recent developments are discussed.

Chapter 3 discusses how carbon nanotubes can serve as DNA delivery agents for generation of genetically modified mammals embryos. Several research centers and pharmaceutical corporations use genetically modified animals in the development of new drugs, in the identification of new drug targets, and to test drugs' efficacy and safety. The use of carbon nanotubes as DNA deliver agents can be far simpler and less laborious when compared to other techniques to produce genetically modified mammals.

Chapter 4 verses about vaccines and the development of carbon nanotubes-based immunogens. The consistent use of vaccines is clearly the most cost-effective strategy, both at the individual patient level as well as a public health policy. However, classical vaccine strategies have been incapable to deliver satisfactory levels of immunogenicity and/or safety in several cases. This chapter considers the strategy of using functionalized carbon nanotubes as antigen carriers in vaccine formulations.

The next two chapters address new biotechnologies using other carbon nanostructures.

Chapter 5 discusses how fullerene-based materials can be used as therapeutic agents and contribute to reduce oxidative stress, with focus in the respiratory system diseases and neurodegenerative disorders. Oxidative stress is associated to the development and progression of several pathologies, including the neurodegenerative and pulmonary diseases.

Chapter 6 addresses the study of carbon nanostructures for soil fertility improvement and carbon storage. The work is built on the analysis of the carbon material found in an anthropogenic Amazonian soil that has been considered a potential model for organic matter soil storage, and for generating a sustainable land-use system that is highly efficient, even in the hot and humid tropical regions. Here the nanotechnology tools are being used to elucidate how nature solved the problem of keeping high levels of ion exchange capacity in these otherwise poor soils.

Finally, the two last chapters are devoted to general aspects that have impact on the development of biomedical applications.

Chapter 7 deals with the nanotoxicologic aspects of carbon-based nanomaterials. There are fundamental aspects that make usual toxicology procedures, for example related to chemicals, completely different from the nanotoxicology. In this sense, the carbon nanostructures appear as prototype models for the development of

nanotoxicology in general. The chapter covers results of in vitro and in vivo toxicological assessments of carbon nanostructures.

Chapter 8 is about the synthesis, purification and functionalization of carbon nanotubes, specifically for the biotechnological applications. Therefore, the book ends with what represents the initial steps researchers working in the biomedical applications have to give, which are their synthesis, purification and functionalization.

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Belo Horizonte, Brazil Ado Jorio
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