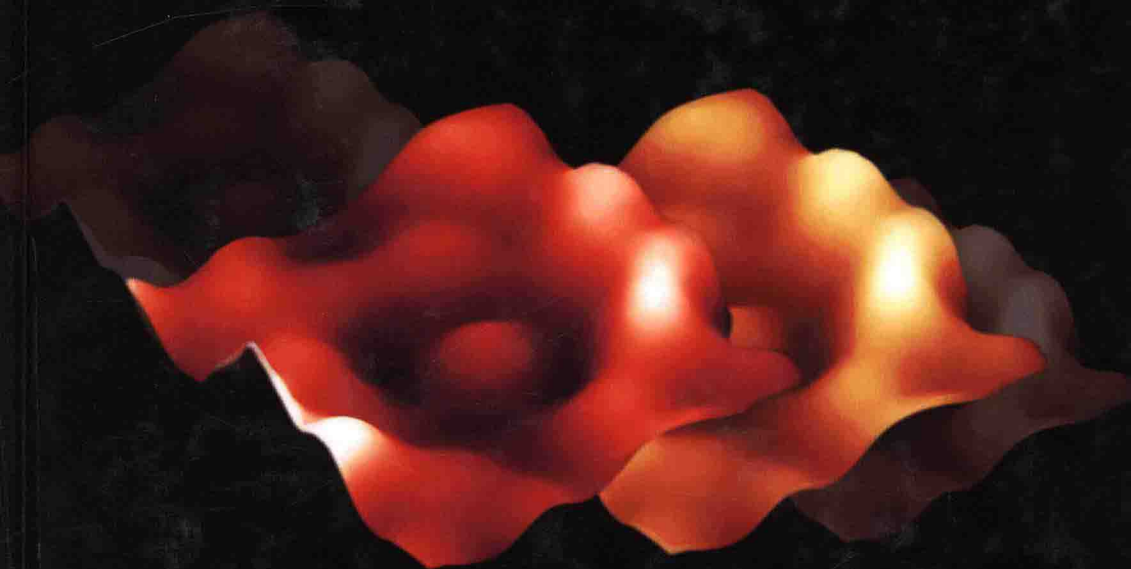


edited by  
Bhanu P. Jena and Douglas J. Taatjes

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# NANOCELLBIOLOGY

Multimodal Imaging in Biology and Medicine



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# NANOCELLBIOLOGY

*Dedicated to my students who have made my journey through science greatly rewarding and filled with excitement.*

**—Bhanu P. Jena**

## Preface

Just as the ultimate goal in biology is to unravel the structure and dynamics of a living cell at the atomic level, so is the major challenge in medicine to treat and ameliorate diseases noninvasively. This requires the targeting, imaging, and destruction of pathogen and diseased cells without harm to healthy cells and tissues. On close examination, however, the above two objectives seem inseparable, and an understanding of cellular structure-function is invaluable to the success in drug design, development, and therapy. Similarly, our understanding of the fundamental life processes or the treatment of diseases greatly relies on key technological advancements, an extraordinary example being the invention of the atomic force microscope (AFM), which gave birth to nanotechnology. In this book, applications of the AFM in the discovery of a new cellular structure, the "*porosome*," in our understanding of cellular and molecular processes, and in the design and development of novel modalities in disease detection and treatment are presented. Similarly, novel approaches to understand molecular evolution, and the surprising involvement of mRNA nanomachines in disease processes, are also discussed.

Secretion is a fundamental cellular process involved in neurotransmission, and the release of hormones and digestive enzymes. Impaired secretion results in diseases such as diabetes and neuronal or digestive disorders. In Chapter 1, a brief commentary is provided on a new cellular structure, the "*porosome*," a secretory nanomachine discovered nearly 16 years ago and demonstrated to be the universal secretory portal in cells. In Chapters 2 and 3, porosomes in hair cells and in brain neurons of different species of mammals are presented. The porosome discovery has clarified our understanding of the generation of partially empty secretory vesicles in cells following secretion, providing a molecular understanding of the process, and resulting in a paradigm-shift in our understanding of cell secretion. In Chapter 4, the biogenesis

of secretory vesicles and their distribution and dynamics, so critical to cell secretion, is elaborated. In Chapter 5, the authors introduce the reader to the application of the AFM in investigating protein assembly, biomineralization, and biomolecular interactions. Similarly, in Chapter 6, using a combination of AFM, fluorescence microscopy, and circular dichroism spectroscopy, the authors provide an insight into amylin aggregation, trafficking, and toxicity. These studies will provide the basis for the treatment of amyloid pathology such as amyloid deposits in type 2 diabetes. As in the case of amyloid pathophysiology, the utilization of the AFM to investigate novel treatment strategies is also in the advance. In Chapter 7, the use of AFM to investigate an autoimmune thrombotic conditions known as the antiphospholipid syndrome is discussed. Biological function of proteins resides in their three-dimensional shape, and an understanding of this three-dimensional protein structure is also essential for the design and development of drugs to regulate the protein. In Chapter 8, a novel approach to determine the molecular evolution of proteins using antibodies as nanoprobe, is presented. Similarly, the interaction of molecules and their assembly and disassembly within cells dictate cellular responses. In cardiac arrest and stroke, brain ischemia resulting from reduced blood flow to the brain leads to brain injury and even death. In Chapter 9, the authors describe a unique buildup of nucleoprotein granules of unknown composition in ischemic brain neurons. An understanding of the structure and composition of these granules promises a new approach for the treatment of brain ischemia. Magnetic nanoparticles have begun to show great promise in targeting, imaging, and destruction of pathogen and diseased cells without harm to healthy tissues. In Chapter 10, the emergence of magnetic nanoparticles for transformative application in medicine and therapy is discussed. Nano gene therapies using nanopolymers and virus-based therapy are rapidly being developed. In Chapter 11, AFM has been used to study DNA release dynamics from biopolymer-based nanosystems. New and novel methods and approaches to evaluate and image both biological and non-biological material are constantly in progress. In Chapter 12, the final chapter, the rapidly developing application of electrical impedance spectroscopy in biology is discussed. It is clear from the studies and findings discussed in this

book that the development of nanotechnology and its use in unraveling fundamental biological principles are key to medical breakthroughs and in the effective diagnosis and treatment of diseases.

**Bhanu P. Jena**  
**Douglas J. Taatjes**



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