Preface

This book represents a great challenge: It introduces the readers to the integration of two of the most important disciplines of the 21^{st} century, biotechnology and nanotechnology. A special effort was made to expose readers from diverse backgrounds to the basic principles, techniques, applications, and great prospects at the intersection of these two key fields. All of this is done without assuming a strong background in either of the two subjects. We will discuss two related fields: "nanobiotechnology" which relates to the application nanotechnological principles and tools to biology, but also "bionanotechnology" which concerns the use of biological principles such as recognition and assembly for nanotechnological applications.

While the 20^{th} century was the century of physics, electronics, and communication, the years to come are considered to be mainly dominated by the biological revolution that already started in the second half of the 20^{th} century as well as nanotechnology, a new and exciting new front that deals with minuscule nanometer-scaled assemblies and devices. Traditionally, miniaturization was a process in which devices became smaller and smaller by continuous improvement of existing techniques. Yet, we rapidly approach the limits of miniaturization using the conventional top-down fabrication tools. One of the key futuristic ways of making tiny machines will be to scale them up from the molecular level. For that purpose, many lessons could be learned about the arrangement of nano-scale machines as occurs in each and every biological system. The living cell is actually the only place in which genuine functional molecular machines, as often described in futuristic presentations of nanotechnology, could actually be found. Molecular motors, ultrasensitive nano-scale sensors, DNA replication machines, protein synthesis machines, and many other miniature devices exist even in the very simple early pre-bacterial cells that evolved more than 3 billion years ago. When we climb higher on the evolution tree, the nano-machines of course become more sophisticated and powerful. Yet, only billions of years after life emerged, we are beginning to utilize the concepts of recognition and assembly that lead to the formation of nano-scale machines for our technological needs. On the other hand many principles and applications of nano-technology that were developed for non-biological systems could be very useful for immediate biological applications such as advanced sensors and molecular scaffolds for tissue engineering as well as long-term prospects such as *in situ* modifications at the protein and DNA levels.

While the fields of nanobiotechnology and bionanotechnology are very new their prospects are immense. The marriage between biotechnology and nanotechnology could lead to a dramatic advancement in the medical sciences. It may well be a place in which many of the current diseases and human disorders will be eradicated. In a reasonable time-scale, cancer and AIDS may be regarded in the same way that polio and tuberculosis are being considered now. Genetic defects could be identified and corrected already even before birth. Nano-scale robots that may be inserted into our body could perform very complicated surgical tasks such as a brain surgery. Nano-machines may even be able to solve problems on the cellular level. Manipulation of the genetic information inside the body in real-time is only one example.

The principles of biological recognition could also serve as the basis for applications that seem to be very far from living systems as we identify them. One of the most obvious directions in the field of nanotechnology will be molecular electronics. The use of the tools of molecular recognition between biomolecules and their ability to self-assemble into elaborated structures could actually serve as an excellent model system for the 21st century nano-engineers. This course of study will link us directly to the one of the most important areas of research and development of the second half of the 20th century, the silicone-based microelectronics. Biology-based nanotechnology may facilitate our ability to overcome many of the limitations of the silicon-based world as we know them today. The field of electronics could be transformed to have complete new and exciting prospects when electronic devices will be made by nano-machines and by govern by molecular self-assembly principles. The world after this bionanotechnologic revolution may be a place where the molecular mechanism of thinking and reasoning will be understood and truly artificial intelligence machines could be manufactured.

It should always be remembered that the new era of nanobiotechnology and bionanotechnology may also lead to a situation in which there will be a very fine line between prosperity and devastation. The role of the scientists and technologists in the years to come will be to ensure the proper usage of these hardly imaginable abilities. We must make sure this revolution will be used for the benefit of mankind and not for its destruction. As those tools are so powerful, their misuse may actually lead to grave consequences.

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