It was almost a half century ago (in 1954) when Richard P. Feynman has foretold first the possibility of a molecular machine which assembles various kinds of molecules automatically and aims to reproduce of itself (self-duplication). K. Eric Drexler has enlarged the Feyman’s concept more in broad by learning the biological systems such as virus and living cells (“Engines of Creation – The Coming Era of Nanotechnology”, Anchor Books, New York, 1986). Their ideas have been realized in the field of information science and technology like computers and telecommunication networks. Namely, miniaturization or downsizing of computer elements realized the integration of circuit and propelled the speed of the calculation as well as the memory of information enormously. This developed significantly the information industry.

Originally, a living cell of itself has a nature of self-duplication (growth or proliferation), self-regulation (metabolism), and evolution. These natures are caused by DNA, RNA, proteins, lipids, and oligosaccharides in a cell, represented by the central dogma of living systems. We can summarize the comparison of characteristics between living systems and artificial ones as shown in Table 1.

Nanotechnology is the creation and utilization of materials, devices, and systems through the control of matter on the nanometer-length scale. Nanobiotechnology, a part of nanotechnology and an integration of biology, chemistry, applied physics, material engineering, and biotechnology, holds considerable promise of advances in emerging area of scientific and technological opportunity and applies the tools and processes of nano/microfabrication to build devices for studying and operating biosystems. Researchers also learn from biology how to create better nano/microscale devices.

Recent developments of various kinds of nanomaterials such as fraren, carbon nanotube, nanomicelle, and biomaterials, as well as single molecule manipulation technologies and fabrication technologies such as NEMS, MEMS, and μ-TAS are remarkable. Due to these developments in nanomaterials and technologies, Feynman’s and Drexler’s dreams have been realized in some extent today. In this sense, we may call this innovative technology as nano/microbiotechnology. This concept is summarized in Fig. 1.
The aims of this book are: first, to scope over the present state of this innovative technology in the world; second, to explain in detail various technologies and materials those are relevant to this technology; and third, to survey this field in the near future so that this book will stimulate researchers of the next generation in the world.

The contents of this book are as follows.

First, we will start with an introduction to nano/microscale biological systems in nature such as self-assembly system of bacteriophage and molecular bio-motors in
living cells. In this chapter, the structures and functions of motor proteins such as myosin, kinesin, and F1-ATPase at the single molecular level will be elucidated. Biotechnology of bacteriophage is explained in the next section.

Second, the nanomaterials and technologies to detect and to characterize the materials will be explained. In this chapter, AFM-based technology to elucidate the mechanical basis of the cellular structure and its interaction with the extracellular matrix including cell-to-cell interaction will be reviewed. The recent advances in the development of fluorescence resonance energy transfer (FRET)-based molecular sensors for Zn\(^{2+}\), second messenger dynamics, and enzyme activation/activity in living cells, tissue, and organisms will also be reviewed.

Third, fabrication and process technologies in this discipline including several technologies for the surface acoustic wave atomizer, electrospray deposition of biomolecules, and handling of droplets using pneumatic, electrokinetic, ultrasonic, and centrifugal forces will be introduced. An overview will also be given about integrated microfluidic devices incorporating functional components such as heaters for reaction temperature control, micropumps for liquid transportation, air vent structures for pneumatic manipulation of small volume droplets, optical fibers with aspherical lense structures for fluorescence detection, and electrochemical sensors.

Finally, we will summarize the application of this new technology to medicals, sensors, and biochemical reaction systems. These are non-viral gene delivery systems based on a complex of nucleotides and cationic high-molecular weight compounds or cationic liposomes, label-free monitoring systems for biorecognition events using nanomaterials, such as metal nanoparticles and carbon nanotubes, and microchip-based bioreactor systems utilizing living mammalian cells and pressure driven flow.

We would like to mention lastly that the contributors of each chapter are the front-runners of their special field in the nano/microbiotechnology in the world. We also express our sincere thanks to the readers of this book if you would kindly give us your advices and comments on this book.

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