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Introduction

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The term “Nanotechnology” is nowadays commonplace not only in all relevant scientific and technical areas, but also to a considerable extent in the public domain, based on reports in newspapers, on television and, justified or not, in a series of commercially available products with “nano” as part of their names. On the one hand, this development could be considered in a positive sense, indicating nanotechnology as an accepted new technology. On the other hand, it contains some risks that should not be neglected. This is due to the rather complex definition of nanotechnology and nanoscience as a sectional science, involving natural and materials sciences, engineering and medicine. Especially it is the lack of a generally accepted definition of nanotechnology and nanoscience that is responsible for many misunderstandings. The relevant scientific communities have agreed that the term “nano” must always be linked with the appearance of a novel property. If “nano” is restricted just to a length scale, one would preferably speak of “technology on the nanoscale”, usually only based on scaling effects ranging from micrometer to nanometer dimensions, without being linked with the appearance of really novel physical or chemical properties. This imprecise view of nanotechnology is frequently misused for products that are linked with the term “nano”, but do not really offer a “nano-effect”.

The following chapters therefore deal with the principles and fundamentals of nanotechnology, explaining what nanoscience and nanotechnology really means and what it does not mean. Furthermore, this book contains philosophical and ethical aspects, since any new technology opens up questions concerning social consequences. Therefore, first of all, a scientifically unambiguous definition of nanotechnology and nanoscience is discussed in Chapter 2, followed by a series of examples elucidating this definition in various fields, reaching from size effects up to complex biosystems. Chapter 3 deals with the principles of how to generate effective nanosystems. Top-down techniques are completed by bottom-up procedures that are currently becoming increasingly important due to the use of ultimately small building blocks: atoms and molecules. Chapters 4 and 5 consider two kinds of fundamental objects of nanoscience: quantum dots, and wires, rods and tubes, respectively. Those species represent the world of size-determined properties of

manifold materials and so stand for one of the fundamental principles of nanotechnology, in agreement with the definition. Spherical or one-dimensional matter of appropriate size can no longer be described by classical physical laws, but by quantum mechanical rules, indicating the decisive change from the macroscopic or microscopic world to the nanoworld.

An extremely important field of nanoscience and also of nanotechnology is dealing with the intelligent combination of artificial nanoscopic building blocks with biomolecular systems, which can anyway be considered as the most powerful “nanotechnological” inventions that we know. Most building blocks of living cells represent perfect nanosystems, the interplay of which results in the microscopic and macroscopic world of cells. We have learned to learn from Nature and consequently try to develop technologically applicable devices reaching from novel sensor systems up to diagnostic and therapeutic innovations. Chapter 6 gives an insight into this fascinating part of the nanoworld.

Philosophical and ethical questions are discussed in Chapters 7 and 8. What kind of knowledge is produced and communicated by nanotechnology? What is its place in relation to other sciences? These and related problems are discussed in Chapter 7. Studying current and future developments in nanotechnology from the viewpoint of ethics is an essential requirement in order to elaborate rules and concerted actions on how to deal with them in society. Such reflections should accompany any novel technological development, especially nanotechnology, the power of which has already been compared with the beginning of a new genesis.

This is the first of a series of books dealing with the various fields of nanotechnology. In addition to the principles and fundamentals, treated in this volume, information technology, medicine, energy, tools and analytics as well as toxicity will be the subjects of subsequent other books. In all cases, developed fields of nanotechnology and future areas of nanotechnological applications will be described and discussed.