Preface

Nanotechnology can be regarded as the major technological challenge of this century that is stirring people's imagination about its potential use. But "Nano" should also be viewed as the major intellectual, social and moral challenge of this century — as an exquisite field for testing our ideas about how people generate knowledge, how they integrate new technologies into their practices and organize themselves around new kinds of artifacts, how they use emerging technologies to push the limits of human instrumentality. A new era has begun that is likely to change people's way of life, thinking and behaving in a very deep manner.

Thinking "small" is a revolutionary tool for making people's mind to be more focused on the "small" rather than on the "big", on the "inside" rather than on the "outside", on the details rather than on the showy aspects of the reality. Thinking "small" can influence people's ethical and social behaviour in terms of how they interact with each other, how they express their feelings, analyse and interpret physical, natural, social, historical, artistic phenomenon. Thinking "small" can represent the starting point for the reversal of the trend whose worse aspects lead some people to pursue ideals of greatness, to get the biggest house, car, fridge, television etc. in order to parade their own grandeur. Thinking "small" can stimulate minds to be more analytical, to look "behind" the appearances instead of at the surface, to swim deeply under water exploring a mervellous hidden world instead of floating superficially.

Nanoscientists manipulate objects and forces at a scale of one millionth of a hairs width. At that size, matter behaves differently. Light and electricity resolve into individual photons and electrons, particles pop in and out of existence, and other once-theoretical oddities of quantum mechanics are seen to be real. Nanoscale research encompasses communications, new materials, and the study of life, as well as weird quantum phenomena and incidental things that exist in the real world, like viruses, dust and diesel exhaust. Physics, mechanical and electrical engineering, materials science, chemistry, biology, and medicine converge here. This is the realm of the lowest common denominator.

Since nanotechnology was recognized as "the technology of the 21st century" billions of dollars of funding have been invested in the USA, Europe and Japan and a lot of investigations are being in progress about how this technology might affect our future. The National Science Foundation predicts that the market for nanotech products will reach $1 trillion by 2015. “We have learned that thinking very small may be even bigger than thinking big,” said Mark Tyler, president of a company, which had about $25 million in sales last year. But the vast majority of people still have little or no idea of what nanotechnology is or what the possible implications of this technology might be.

There is a high level of enthusiasm for the potential benefits of nanotechnology and little concern about its possible dangers. The general public perception of nanotechnology is still viewed in a favourable light, and public mentally connects it with other areas of science, such as the space program, nuclear power and cloning research, that are thought to be as well as a kind of science that is between science fiction and reality and that, for this reason, can only lead to positive and useful results for the human, animal and environmental well being in the next future. The public anticipates that nanotechnology will advance environmental protection, lower energy costs, and provide better food and nutrition products, according to a report from the Woodrow Wilson International Center for Scholars and the Pew Charitable Trusts.

Nano-supporters say that nature (or ‘biology’) has been doing nanotechnology for billions of years; every virus, bacterium, and cell is a nanomachine of enormous complexity. Nature’s nano-achievements show us that nanomachines are possible, and nature’s version of nano has completely restructured the earth and produced human life, culture, and consciousness. The progress of science, they say, means that it will inevitably be possible for us to understand and mimic nature’s nanomachines; once we have done so, our own nanomachines will develop in a way determined by biology, chemistry, and engineering design; and as they do develop, our inventions cannot help but revolutionize our world just as much as nature’s nanorobots did (Mody Cyrus C.M., 2004). Eric Drexler, a writer who can be regarded as the popularizer of the term ‘nanotechnology’ and one of the most influential visionaries of the field, by 1981 begun publishing his vision under the label of ‘nanotechnology’ — a vision in which very small ‘assemblers’, modelled on biological machines (cells, ribosomes, viruses, etc.), could reconstitute raw materials into almost any physically possible artefact. He tends to focus on the very ancient *biological* precursors of nanotechnology, since this helps to make the analogy between biological and artificial nanomachines (Drexler K.E., 1981). Others, outside the Drexler camp, are more likely to point out very old *craft* activities that would today count as ‘nanotechnology’: the process of nanofabrication, in particular the making of gold nanodots, is not new. Much of the color in the stained glass windows found in medieval and Victorian churches and some of the glazes found in ancient pottery, depend on the fact that nanoscale properties of materials are different from macroscale properties. In some senses, the first nanotechnologists were actually glass workers in medieval forges rather than the bunny-suited workers in a modern semiconductor plant. Clearly the glaziers did not understand why what they did to gold produced the colors it did, but we do understand now (Ratner M. & Ratner D., 2003). Nano, in this formulation, produces new *knowledge* that maps onto old *practice*. What makes nano new is that it brings *understanding* where before there was only *doing* (Mody Cyrus C.M., 2004) The nanoscale has become a place that tourists can visit, where everything is different, yet exactly the same — all the building blocks are atoms, at which we should wonder, but they are being used to make ordinary, familiar, everyday objects, whose use is something we intuit rather than theorize about. Nevertheless, this view could have positive as well as negative effects on people's minds. For instance, discoveries and developments within nanotechnology research and especially within carbon based nanotechnology (Carbon nanotubes and fullerenes) have led to some peculiar but also serious projects on various applications. Best known and widely referenced is a project called "the space elevator" from NASA, a 62,000-mile twine of carbon nanotubes that would transport cargo into orbit. This system is decades away from being feasible, nevertheless the public acceptance of this project is quite high as it is something that everybody can relate to in the sense that everybody knows an elevator and everybody knows that we are able to travel in space. Thus, it has the positive side that it can provide the general public with a gentle introduction to nanotechnology developments and allow them to learn more about carbon nanotechnology. On the other hand, the negative view is that this project is almost impossible to achieve and it gives the audience a wrong view of what to expect from nanotechnology in the near future.

The effects of future, yet unrealized technologies are in most cases subject to great uncertainty. Nanotechnology is an unusually clear example of this. As already mentioned, the technological feasibility of the nanoconstructions under ethical debate is in most cases uncertain. Furthermore, many of the possible future nanotechnologies are so different from previous technologies that historical experience provides very little guidance in judging how people will react to them. The development and use of new technologies is largely determined by human reactions to them, these have their influence via mechanisms including markets, politics and social conventions (Rosenberg N., 1995). It is not only the negative but also the positive effects of nanotechnology and other future technologies that are subject to great uncertainty. The most fervent proponents of nanotechnology have argued that it can solve many of humanity's most pressing problems: Nanotechnology can make cheap solar energy available, thus solving the energy problem. Nanoscale devices injected into the bloodstream can be used to attack cancer cells or arterial plaques, thus eradicating major diseases. Synthetic human organs can be constructed that replace defective ones.

Much of the public discussion about nanotechnology concerns possible risks associated with the future development of that technology. But analyzing technological risks, namely risk analysis, for guidance about nanotechnology is quite difficult. The reason for this is that the tools of risk analysis have been tailored to deal with other types of issues than those presently encountered in connection with nanotechnology. Risk analysis was developed as a means to evaluate well-defined dangers associated with well-known technologies. But nobody knows today whether or not any of these types of nanodevices will ever be technologically feasible. Neither do we know what these hypothetical technologies will look like in case they will be realized. Therefore, discussions on such dangers differ radically from how risk analysis is conducted. The tools developed in that discipline cannot be used when so little is known about that kind of nano-objects.

Carbon-nanotubes based nanostructures (C-nanotubes) in particular are viewed as a class of nanomaterials with high potential for biological applications due to their unique mechanical, physical and chemical properties. Among numerous potential applications, including DNA and protein sensors, *in vitro* cell markers, diagnostic imaging contrast agents, their use as multifunctional biological transporters, agents for selective cancer destruction and drug and gene delivery systems has been explored. Moreover, various cell types have been shown to grow extremely well on C-nanotubes, giving a potential for applications such as scaffolds and structures/coatings for tissue regeneration/repair. Furthermore C-nanotubes reinforced composites demonstrated a substantial promise for orthopaedic and dental devices as well as vascular stents.

Before medical applications can be developed it is necessary to explore the behaviour and fate of engineered C-nanostructures in mammals and environment. However, actually little is known in this area and results are often contradictory and not conclusive yet, in part because of the challenge of detecting and tracking these nanoparticles in complex biological environments, in part due to the different factors influencing their toxicity (length, degree of purity, presence of metal catalysts, degree of aggregation, functionalisation, etc.).

Not necessarily the real risks of these nanomaterials are high, but the uncertainty of their impact on health, safety and environment are a serious threat to further progress in nanosciences and even more so in nanotechnologies.

The purpose of this book is to provide an overview on the expected benefits and the possible risks of carbon-based nanotechnology and to evaluate the potential health, safety and environmental implications of carbon-based nanostructures in order to make people aware of what is going to change their life in the next future.

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