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Adverse Effects of Engineered Nanomaterials Exposure, Toxicology, and Impact on Human Health

B. Fadeel, A. Pietroiusti, and A. Shvedova (eds), 722. New York, NY: Elsevier, Academic Press; 2012. ISBN: 978-0-12-386940-1

Nanotechnology applications have the potential to greatly improve many aspects of human life. Concerns have been raised, though, about the health risks of the applications of engineered nanomaterials (ENMs) to workers, consumers, and the environment. These concerns have led to growth spurt in the nanotechnology risk sciences. In 2004, the term *nanotoxicology* made its first appearance in an editorial proposing that "a new subcategory of toxicology—namely nanotoxicology—be defined to address gaps in knowledge and to specifically address the special problems likely to be caused by nanoparticles."[1] In 2006, an international nanotoxicology conference was held, bringing scientists from the United States, Europe, and Asia together for the first time. These conferences have provided a forum for an international community of scientists to share their research findings and to chart a strategic course to fill in the knowledge gaps about the risks of ENMs to human health. The seventh such international conference is now being planned for 2014.

A fortunate outcome of the many collaborations fostered by these international meetings is a new 347 page book—*Adverse Effects of Engineered Nanomaterials—Exposure, Toxicology, and Impact on Human Health*. The three editors of and the 46-chapter contributors to the book are from eleven countries of Europe, the United States, China, and Australia. Despite the large number of contributing authors, the editors have done a good job in smoothing any rough stylistic edges that the reader might encounter in reading material written by so many different researchers from so many different nations.

The editors hoped their book would serve "as a useful guide for students and researchers in the field and for clinicians, policymakers, and regulators with an interest in nanosafety and human health." To appeal to such a wide audience, the editors choose to present a general overview of nanomaterials and human health risk rather than concentrating chapters on the risks of each of many classes of nanomaterials such as carbon nanotubules, metal oxides, quantum dots, graphene, and others or to produce a densely written technical volume just that only their fellow researchers could comprehend. For *Journal* readers, the book will indeed serve as a concise and readable guide about the human health risks associated with exposure to nanomaterials.

The book is divided into three major parts. Part 1—*Hazard, Exposure and Safety Assessment*—contains four chapters on the general health implications of ENMs, exposure assessment, biomonitoring, and toxicity testing. These four chapters provide the reader with an understanding of how the human health effects of nanomaterials are being researched using traditional scientific tools.

Chapter 5 on Computational Modeling—written by authors from Australia and Scotland—presents an exciting glimpse into the progress being made using computational modeling to research the biological effects of nanomaterials. The critical importance of computational modeling in understanding the potential health effects of nanomaterials was recognized by the US National Nanotechnology Initiative in its 2011 Environmental Health and Safety Strategy[2] and in its 2012 Signature Initiative on Nanotechnology Knowledge Infrastructure.[3]

Chapter 6 on Regulation and Legislation—written by an author from the US Environmental Protection Agency and an author from the European Commission's Institute for Health and Consumer Protection—is a valuable addition to a book whose focus is biomedical research. Understanding the legal and regulatory framework for risk control is an important perspective for any reader hoping to have a comprehensive understanding of nanotechnology. While Chapter 6 thoroughly describes current American and European laws and regulations applicable to environmental and consumer risks, we hope that a future edition of the book would expand on the slim treatment of worker protections in the current edition and also discuss quasi-regulatory and voluntary consensus standard approaches by national and international organizations.

Part 2—Impact on Human Health—contains eight chapters and is the heart of the book. The health implications chapters are rich in details about the fate and transport of nanomaterials arising from inhalational, dermal, gastrointestinal, and parenteral exposures, as well as how various types of nanomaterials can potentially adversely affect the respiratory, cardiovascular, neurological, and immune systems, in addition to the skin and gastrointestinal tract. Current research in in vitro cell models and in vivo animal studies indicates that a range of potential toxicities to biological systems are possible from nanomaterial exposure in cell and animal models, but chapter authors are quick to caution that significant questions remain and that more research is needed. Two chapters—one on reproductive toxicity and the other on genotoxicity and cancer—indicate that there is increasing evidence supporting the ability of nanomaterials to induce DNA damage through the promotion of oxidative stress, but also warn that further investigation is needed.

Part 3—Biological Applications of Engineered Nanomaterials—presents the beneficial aspects of nanomaterials, which also has direct relevance to the assessment of the adverse effects of nanomaterials. This is so because the steps in regulatory clearance of the biomedical applications of nanomaterials generates safety data that can be useful in assessing potential adverse effects resulting from intentional and unintentional exposure to nanomaterials. Part 3 contains two chapters on the diagnostic and therapeutic applications of nanotechnology.

Chapter 15—Diagnostic Applications—describes in detail the advances that the use of nanoparticle-based molecular probes will bring to diagnostic imaging, specially for cancer. Current or planned research on the use of nanoparticle-based magnetic resonance imaging contrast agents like iron nanoparticles, nanoparticle-based computerized tomography agents that show greater resolution capability than iodine contrast, nanoparticle-based positron emission tomography imaging, single-photon positron emission tomography imaging, and optical imaging enhanced by near-infrared fluorescent nanoprobes by means of dye-loaded nanoparticles are described by authors from the Molecular Imaging Program at the Stanford University School of Medicine. After reading their excellently written chapter, the reader begins to realize how truly revolutionary nanotechnology will be to the field of medical diagnosis.

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Chapter 16—Therapeutic Applications—only enhances the reader's view that medicine is on the verge of a true revolution. Authors from nanomedicine centers in the United Kingdom, Germany, the United States, and Sweden describe the exciting applications of nanotechnology in cancer therapeutics. Targeted drug delivery via types of nanomaterials—nanoparticles, polymer nanoparticles, dendrimers, and carbon nanotubes—is described clearly for the reader, and in detail. The illustrations and photographs in Chapter 16 are particularly helpful to aid the reader's comprehension of how ENMs are currently used as nanovectors in cancer interventions. The reader—like the reviewers—have generally heard about how one of the promising aspects of targeted drug delivery using nanomaterials is the ability to target diseased cells only, sparing exposure of toxic chemotherapeutics to healthy cells, but Chapter 16 presents the "how" of targeted drug delivery using nanomaterials in an understandable and comprehensive way.

At the end of each chapter, the editors have included a section called "Take-Home Messages," which provides an effective way to summarize the main points of the chapter. For busy readers who may not have time to read an entire chapter, these sections are very helpful. Each chapter also contains an extensive list of references, which will satisfy the reader who wants to examine the primary sources in greater depth.

An added feature after chapter 16 is a short Annex on the chemical production of the three commonly used nanomaterials in biomedical applications—carbon nanotubes, quantum dots, and metal nanoparticles. Manufacturing processes can affect the chemical composition and structure of the resulting nanomaterials, which, in turn, can influence their biological activity. This important connection is highlighted in the Annex. For that reason, the Annex may be of primary interest to materials specialists and chemical engineers. The Annex provides valuable information to the general reader who wants to understand how nanomaterials are made and enhances the overall comprehensiveness of the book.

The 16 chapters in the book are well-written and convey complex scientific research issues in a clear and concise manner. As the editors state in their Preface, "we hope that this volume will serve as a useful guide for students and researchers in the field and for clinicians, policymakers, and regulators with an interest in nanosafety and human health." We think that readers who do buy the book will indeed find it a useful guide to obtaining a broad understanding of both the potential risks of ENMs to human health, as well as a good understanding of their potentially remarkable benefits for mankind.

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