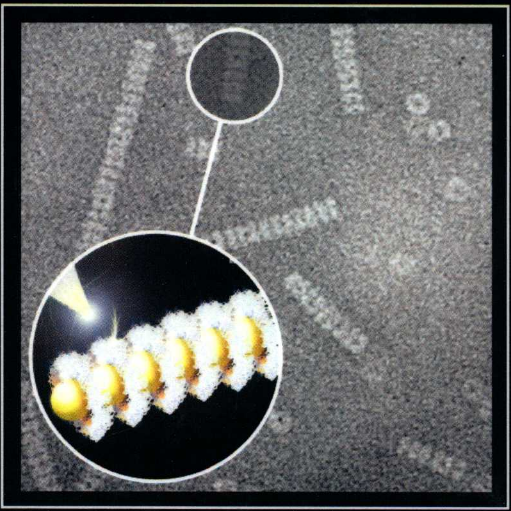

Bionanotechnology II

Global Prospects

Edited by
David E. Reisner

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Preface

Much has happened in the world in the past 36 months since the publication of my previous work, *Bionanotechnology: Global Prospects*. Let's take a look. Within a few weeks of publication, the 2008 global financial crisis bottomed out with the collapse of three of the biggest financial institutions over the so-called Lehman-AIG-Merrill weekend, a bitter testimonial to technology run amok in the form of "financial engineering" allowed to flounder in an era of deregulation. Complex financial derivative instruments such as the credit default obligation (CDO) and the credit default swap (CDS) are all captured in the 2011 Academy Award-winning documentary *Inside Job*. It is ironic and relevant to this book that the financial services sector in the United States continues to drain the best and brightest brains from Ivy League schools, gifted thinkers that otherwise could populate science and engineering jobs in the United States.

More benign (usually) social networking technologies now pervade our lives in ways unimaginable in 2008, even when Tim Berners-Lee declares in *Wired* magazine last September that "the Web is dead," referring to fragmentation caused by the exponential rise in "apps." Although Twitter reached a tipping point at the South by Southwest Festival (SXSW) in 2007, it has now reached upwards of 100 million tweets per day, dwarfing its mainstream impact of just a few years ago. Are we too connected? Maybe, but immediate Twitter pictures from the 2010 Haitian earthquake alerted the world to the extent of the tragedy, as did tweets from protesters in the Middle East that went viral across the region. A debate rages between the Malcolm Gladwell/Evgeny Morozov and Clay Shirky/Jared Cohen camps as to the true impact of Twitter, but the subsequent overthrow of authoritarian leaders in Tunisia and Egypt leaves little doubt of the power of social media.

For its part, WikiLeaks has grown to become a de facto purveyor of its own rogue Freedom of Information Act (FOIA) rules for whomever, empowering every human being with an Internet connection. Indeed, a Tunisian version (Tunileaks), played a crucial role in the Arab Spring. Futhermore, a cottage industry is blooming in the area of censorship circumvention software/hardware in response to Government shutdown of the Internet. Mobile Ad-hoc Networks or Wireless Mesh Networks (WMNs) can function phone-to-phone without cell tower infrastructures and are enabling "Internet-in-a suitcase" dreams to become reality.

And empowerment is a key to understanding the nature of technology development and deployment in the world today. The Internet is the great equalizer, enabling all countries to produce world-class intellectual property (IP). This is particularly evident in the oil-rich countries, where crystal balls are revealing peak oil milestones as soon to arrive or already passed. These countries understand that in the future, they will need to build economies on IP, not oil. In the preface to my first edition, I emphasized the "flat world" of Tom Friedman. Amy Chua's *World on Fire* challenged that notion, examining the disproportionate economic and political influence of "market-dominant minorities" and how less affluent majorities harbor resentment against them, a problem exacerbated by flat-world dynamics. As testimonial, we see such seemingly benign social networks as Facebook capable of fomenting popular revolts.

The hottest venture capital investment opportunities are now energy related and cleantech (nanotechnology thinly disguised). Bionanotechnology is also positioning itself as a front-runner. Its implications in more efficient health care delivery are compelling. Bionanotech-based products are already in the market place, including drug-releasing nanocoated vascular stents and numerous FDA-approved drug delivery nanotherapeutics. Various other bionanotech-based products are undergoing clinical trials. Examples range from perfluorocarbon nanoparticles (for angiogenesis in atherosclerosis diagnosis) to dendrimer-based topical gel (for HIV and HPV) to nanoliposomes (for various cancers).

This follow-up volume to *Bionanotechnology: Global Prospects* echoes the format of my previous effort. It is in no way meant to be comprehensive; in fact, it is a random walk of sorts, a result of having engaged authors in my professional travels. As in the first volume, I make no claims as to editing of any technical contents—the field is just too expansive and interdisciplinary. I am relying on reputation and credibility of authorship. I have sought out chapters from the traditional geographic "hotspots" of nanotechnology, though this distinction is somewhat fading. However, I have also actively pursued authors in parts of the world that seemed to be under the radar, for example, Thailand, Turkey, and Jordan. In fact, nearly a dozen countries are represented and include cities as far ranging as Ankara, Tehran, Randburg, Cairo, Singapore, Irbid, Chiang Mai, Bangkok, Exeter, and Buenos Aires.

Chapter title pages contain only the principal affiliation, with a few exceptions, in the event the work was evenly distributed across separate institutions. Author's given names are spelled out for the book format. This is purely a formatting consideration. I hope I have not offended any of my authors. Detailed affiliations are to be found in the list of contributors. By the same token, the publisher has kindly provided a color insert section. Note the color images also appear as grayscale images in the text. I made efforts to pick those color images that appeared to benefit most from a color display.

This collection includes a strong showing from the Middle East. I believe the region is witnessing the onset of a paradigm shift, in which IP starts to take hold in lands that are now known primarily for oil. Bahrain and Dubai are heavily focused on becoming world-class financial service centers. All the oil-rich countries realize that they need to search for the next big thing and create the infrastructure to do so. A good example is the new international university KAUST in the Kingdom of Saudi Arabia, focusing heavily on research. I am especially pleased to highlight in the opening chapter and on the book cover a collaboration between the Hebrew University in Jerusalem and Al Quds University in East Jerusalem, to form one-dimensional nanostructures. This work has been funded by the Israeli-Palestinian Science Organization (IPSO) and the Deutsche Forschungsgemeinschaft.

Topic areas span a wide range of subject areas that fall under the bionanotechnology banner, either squarely or tangentially. In the final accounting, this volume has a strong emphasis on nanomedicine, both drug delivery and tissue engineering. Other areas include water treatment, energy conversion (solar), nanoelectronics, photonics, and agriculture. It is my sincere hope that this book inspires readers to get involved in the burgeoning area of bionanotechnology, as much good innovation occurs at the crossroads of disparate disciplines. This book can only be described as a labor of love, what Shirky would categorize as a classic case of "intrinsic motivation."

David E. Reisner
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All the, small things
True care, truth brings
I'll take, one lift
Your ride, best trip

—"All the Small Things," lyrics by Blink-182

The Editor

David E. Reisner, Ph.D., is a well known early pioneer and entrepreneur in the burgeoning field of nanotechnology, who, in 1996, cofounded two nanotech companies in Connecticut, Inframat® and US Nanocorp®. Since founding, for nearly 15 years, he was CEO of both companies, which were recognized in Y2002 - Y2005 for their fast revenue growth as Deloitte & Touche *Connecticut Technology Fast50 Award* recipients. In 2004, The Nano Group, Inc. was formed as a parent holding company for investment. Reisner and cofounders were featured in *Forbes* magazine in 2004.

Reisner has over 175 publications and is an inventor on 10 issued patents. He is the editor for the Bionanotechnology section of the third edition of *The Biomedical Engineering Handbook* and is editor of the first edition of *Bionanotechnology: Global Prospects.* He has written articles on the business of nanotechnology in *Nanotechnology Law & Business* as well as in the Chinese publication *Science & Culture Review.*

Reisner served a three-year term as a Technology Pioneer for the World Economic Forum and was a panelist at the 2004 Annual Meeting in Davos. He is on the board of the Connecticut Venture Group and was chairman of the board of the Connecticut Technology Council from 2005-2009. Reisner was a NASA *NanoTech Briefs* Nano50 awardee in 2006. For his efforts in the field of medical implantable devices, Reisner won the 1st annual BEACON award for Medical Technology in 2004. He is a member of the Connecticut Academy of Science and Engineering.

Reisner is a 1978 University Honors graduate from Wesleyan University and received his Ph.D. at MIT in 1983 in the field of chemical physics. An avid hiker, he summitted Kilimanjaro in 1973. Reisner was recognized for his historic preservation efforts in 1994 when he received the Volunteer Recognition Award from the Connecticut Historical Commission and the Connecticut Trust for Historic Preservation. He is known nationally for his expertise in vintage Corvette restoration and documentation. Reisner did volunteer work in Haiti, soon after the 2010 earthquake, in Jérémie.

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1

SP1 Protein-Gold Nanoparticle Hybrids as Building Blocks for Nanofabrication of One-Dimensional Systems

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1.1 Introduction

One of the main challenges within the realm of nanoscience and nanotechnology is to fabricate wires where the internal structure along the wires can be well controlled and manipulated.[1–5] These structures hold the potential of miniaturizing current devices by embedding the computational unit within the wire.[6] Examples of other one-dimensional (1D) structures are DNA molecules and 1D crystals like nanotubes made of carbon or silicon.[7–9] These structures have several drawbacks; DNA was proven to conduct only over short segments,[10,11] while the 1D crystals usually have homogeneous structure and therefore lack recognition and structural manipulation capabilities.[12] Self-assembly of wires made of suitable building blocks that enable structuring and well-defined formation can be an attractive alternative route to overcome these limitations. The building blocks can be used to connect short DNA segments or form by themselves conductive wires. Candidates to serve as building blocks must demonstrate durability and a well-controlled structure.

Proteins can serve as useful building blocks for nanoelectronic implementations, among other reasons because of the ability to modify their structure using genetic engineering.[13] Such manipulations enable optimization of the desired building block properties, such as self-assembly and selective attachment of various nanoparticles.[14,15] One of the drawbacks