A Quiet Revolution

Recent estimates peg the worldwide total government investment in nanoscience research thus far at $40 billion; in 2009 alone, global government support will reach ~$9.75 billion.[1] More than 60 countries have adopted programs and various endeavors in the area.[2] Roco and co-workers suggest that nanotechnology is a "critical indicator of a country's technological competence",[2] and N. Katherine Hayles, a postmodern literary critic, believes nanotechnology to be a "potent cultural signifier".[3] An engine for ecomonic growth is how Swiss Re sees nanotechnology in the global marketplace,[4] and Lux Research attributed $50 billion to sales in 2006 of manufactured goods containing some form of emerging nanotechnology.[5] That sounds great, but I wonder where these manufactured goods are because, even though I live and breathe nanoscience day in and day out, it simply does not seem obvious to me what they might be. Does the iPod Nano in my pocket count? And even if it does, can the technology that has enabled the production and commercialization of this nifty device rise to the level of revolutionary (to borrow language from the patent literature)? Probably not, most would say, although it makes running on the treadmill a little nicer. Where is the "killer app(lication)" as a "disruptive technology" (to borrow more overused terms), and going a step further, is nanoscience really going to bring about societal change equal to that of a new Industrial Revolution, as some have predicted?[6] Or, could it be simply that as an academic in the thick of nanoscience-based research, I'm not seeing the forest for the trees, or that I am overlooking the applications for the molecules and quantum dots?

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It is through pondering these questions that I found the Project on Emerging Nanotechnologies (PEN), a partnership between the Woodrow Wilson Center for Scholars and the Pew Charitable Trusts (www.nanotechprojects.org). The web site contains several inventories and databases, including 1015 consumer products that are on the market at present, current medical applications and their timelines, environmental health and safety research related to nanoscience, and several others. The inventory of consumer products using nanoscience in some form has increased 379% since March 2006, with Health and Fitness being the largest category by far, and Home and Garden a very distant second. Health and Fitness, and Home and Garden products are the major fruits of our work? These are certainly not the motivating forces for doing the research we tend to do in academic nanoscience, nor are they the goals we state in manuscripts or grant proposals. I felt a little reassured looking through the Current Medical Applications inventory and found applications ranging from cancer therapy (*e.g.*, Doxil, manufactured by ALZA Corporation using lipid nanoparticles for drug delivery) to biological imaging (*e.g.*, quantum dot nanocrystals manufactured by Invitrogen), all applications that sounded more like cutting-edge published nanoscience literature.

Still, I found it unsatisfying to reduce the research we do in nanoscience to common consumer products. Initial thoughts in my mind suggested that consumer products do not portray an accurate representation of the broad area of nanoscience, or are, at very best, an extremely premature snapshot of the real potential of nanoscience. Nanoscience is certainly in its early stages, but the excitement continually generated by this area of research, and its constant growth, suggests an alternative explanation. I will wait for the big "killer app" and other "disruptive technologies" to come, but I believe that there is a quiet revolution ongoing right now and that, while rarely voiced or defined as such, is the reason for the excitement in the scientific community whose evanescent wave is felt far outside the traditional silos of science. Nanoscience is drawing diverse researchers together to work on problems of huge societal and fundamental significance that could not be tackled by individual groups, working independently in their own traditional corners of science. I would argue that scientific research has never had such a unifying catalytic upswell, driven by excitement such as is happening now, thanks to nanoscience. As reflected in this issue of

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ACS Nano, a full one-third of the papers involve researchers collaborating from different institutions, most of which are intercontinental: Hamburg and Santiago, Paris and Liverpool and Atlanta, Kyoto and Nagoya and Atlanta, and so on. Another third show collaborations between different departments within the same institution, meaning that almost two-thirds of the science published in this issue is collaborative. Here is the evidence for the quiet revolution: the ability of nanoscientists to see, to build, and to understand at this length scale, which is critical for basic materials science, cellular workings, and fundamental physical insights into materials. Researchers from all areas of science are looking to us as the means to understand many of the basic questions that have been dogging them for decades. These insights translate into discoveries in nanomedicine, alternative energies, new materials, and all the good things for which we continue to strive as researchers.

Thus, I am not so concerned that the "killer app" has not yet appeared from the whirlwind of research in nanoscience. What has happened is the following: science and research, I would argue, have become enabled to tackle the biggest problems facing society, and within basic science itself. Nanoscience is an enabler and is revolutionizing scientific research in its quiet way by allowing us to solve difficult problems from the ground up. Nanoscience is making science better, more productive, and ultimately, more exciting.

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REFERENCES AND NOTES

1. *Nanotechnology Takes a Deep Breath. . . and Prepares to Save the World!: Global Nanotechnology Funding in 2009*; Technical Report for Cientifica Ltd.: London, April 2009.
2. Li, X.; Hu, D.; Dang, Y.; Chen, H.; Roco, M. C.; Larson, C. A.; Chan, J. *J. Nanopart. Res.* **2009**, *11*, 529–552.
3. Berube, D. M. *Nano-Hype: The Truth Behind the Nanotechnology Buzz*; Prometheus Books: Amherst, 2005; p 29.
4. Nanotechnology - Spotlights on Swiss Re's perspective; http://www.swissre.com/pws/research%20publications/risk%20and%20expertise/risk%20perception/nanotechnology_spotlights_on_swiss_re_perspective.html (accessed October 2009).
5. Lux Research; http://www.luxresearchinc.com (accessed October 2009).
6. Roco, M. C. Government Nanotechnology Funding: An International Outlook. *J. Miner. Met. Mater. Soc.* **2002**, *54*, 22–23.
7. National Nanotechnology Initiative: Leading to the Next Industrial Revolution - January 21, 2000 press release; http://clinton4.nara.gov/WH/New/html/20000121_4.html (accessed October 2009).