Emerging Exposure Risks and Ethics of the Nanotechnology Workplace

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ABSTRACT

As the applications of nanotechnology continue to span various industries, the number of workers who may be in regular contact with nanomaterials correspondingly expand. The excitement associated with the promise of opportunities to create revolutionary advances in product development using nanotechnology must be moderated with the fact that there is a paucity of empirical data about the potential health effects of exposure to nanoparticles. This lack of exposure data hinders the development of nanotechnology health and safety guidelines (Murashov, 2009). Nanotechnology is science at the size of individual atoms and molecules. At that size scale, materials have different chemical and physical properties than those of the same materials in bulk. With the current state of knowledge in this field, there are unanswered questions about the impacts of nanomaterials and nanoproducts on human health and the environment. This paper reviews the state-of the-science, exposure assessment and mitigation, and potential macro ethical issues that must be considered to mitigate risk implications this emerging technology, nanotechnology.

Keywords: *Ethics, Health Effects, Nanoparticles Exposure, Nanoproducts, Nanotechnology Workplace*

INTRODUCTION

Nanotechnology is the science of manipulating extremely small particles in materials. It involves the manipulation of matter at the atomic and molecular level, and has the potential to make groundbreaking advances in technology, medicine, and green environmental initiatives (Balbus, et al., 2005). 'The novel properties that emerge as materials reach the nanoscale (changes in surface chemistry, reactivity, electrical conductivity, and other properties) open the door to innovations in cleaner energy production, energy efficiency, water treatment, environmental remediation, and "lightweighting" of materials, among other applications, that provide direct environmental improvements"(Baum, Drexler, and Smalley, 2003, p.65).

Although numerous studies have documented that nanotechnology can provide astounding benefits to humankind, there are

DOI: 10.4018/ijnmc.2013100103

others that suggest we must be aptly cautious before allowing nanotechnology based products to become part of our environment. There is concern that the novel properties that make nanotechnology so attractive may pose yet undiscovered risks to consumers of nanotechnology based products, occupational safety and health of the nanotechnology workplace, and the environment. This chapter seeks to highlight a variety of ethical concerns that arises from and must be adequately addressed to ensure that ensure that exposure of humans and our environment to nanotechnology is rigorously assessed and mitigated.

Effective discussion of any potential ethical issues relating to Nanotechnology must be preceded by definition and understanding of this phenomenon. There are several versions of definitions as well as claims on what nanotechnology can do and cannot do. This paper examines some select definitions and uses the identified characteristics to examine the potential ethical issues.

BACKGROUND

Overview of Nanotechnology

Frequently used in science and electronics, the prefix nano means one-billionth of a measure, such as a second or a meter. Nanoscience and nanotechnology generally refer to the world as it works on the nanometer scale, ranging from approximately one to one hundred nanometers (Bell, 2007, p. 1). Nanotechnology is science at the size of individual atoms and molecules, with objects and devices measuring in billionths of a meter. At that size scale, materials have different chemical and physical properties than those of the same materials in bulk. Nanotechnology has potential applications across various sectors of the global economy, including consumer products, health care, transportation, energy and agriculture. The technology also promises new opportunities to improve how we measure, monitor, manage, and minimize contaminants in the environment (Bello, et al., 2009, p. 1).

One of the first to articulate a future with possibilities of nanotechnology was Richard Feynman, a Nobel laureate who died in 1988. He presented a lecture entitled "There is Plenty of Room at the Bottom," in December 29, 1959 at the California Institute of Technology. In this lecture, he was talking about nanotechnology before the word existed. Feynman discussed the problem of manipulating and controlling things on a small scale, a staggeringly small world, a technological vision of extreme miniaturization (IWGN, 1999, p. 4). Extrapolating from known physical laws, Feynman argued it was possible to write all 24 volumes 1959 edition of the Encyclopedia Britannica in an area the size of a pin head. He calculated that a million such pinheads would amount to an area of about a 35 page pamphlet. According to Feynman: "All of the information which mankind has ever recorded in books can be carried in a pamphlet in your hand, not written in code, but a simple reproduction of the original pictures, engravings and everything else on a small scale without loss of resolution." (Feynman, 1960, p. 3).

Feynman talked about "A biological system can be exceedingly small. Many of the cells are very tiny, but they are active; they manufacture substances; they walk around; they wiggle; and they do all kind of marvelous things–all on a very small scale. Also, they store information. Consider the possibility that we too can make a thing very small which does what we want—that we can manufacture an object that maneuvers at that level!" (Feynman, 1960, p. 6).

Nanotechnology holds exciting promise in medical applications, with possibilities such as targeted cancer therapies where cancer can be eradicated without making the rest of the body sick (Bell, 2007). A great example of such therapy is described in the work of Samuel Wickline, M.D., principal investigator of The Siteman Center of Cancer Nanotechnology Excellence (SCCNE) at Washington University, and his colleagues who developed nanobees to deliver toxic peptides such as melittin specifically to cancer cells while sparing healthy cells from the otherwise nonselective havoc these molecules cause. "The nanobees fly in, land on the surface of cells, and deposit their cargo of melittin, which rapidly merges with the target cells," said Dr. Wickline. "We've shown that the