The Ethical, Legal and Societal Implications of Nanotechnology

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Abstract:

Globally, billions of dollars [1] are being invested nanotechnology, which is expected to contribute to society in significant ways through advances in the fields of medicine [2], environment [3], and even world hunger [4]. The study presented in this report compared how the United States, the Netherlands and China are approaching the research and development (R&D) of nanotechnology, as well as the legislation, workplace safety and public education related to nanotechnology. These international comparisons are meant to increase understanding of the ethical, legal and societal implications (ELSI) of nanotechnology in the increasingly globalized society of today.

Introduction:

Since Richard Feynman first posited the concept of molecular manipulation in 1959 [5], interest in nanotechnology has exploded. In 1994, the National Science Foundation (NSF) established the National Nanofabrication User Network (NNUN) [6], the precursor of the National Nanotechnology Infrastructure Network (NNIN).

The National Nanotechnology Initiative [6] (NNI) was established in 2000 to coordinate the research efforts of 25 federal U.S. agencies, and in 2003, the NSF created NNIN [7] as part of NNI. Following the precedence of the Human Genomes project, the 21st Century Nanotechnology Act [8] (2003) was passed to ensure that "ethical, legal… and appropriate societal concerns" were addressed during federally funded projects.

In 2005, the Netherlands was already conducting advanced microtechnology research [4] and existing collaborations between research groups and industry easily transitioned to nanotechnology with the creation of NanoNed [9]. This government-funded consortium between universities and industry separated research projects into different flagships and included a mandatory risk analysis component. NanoNed and two microtechnology programs were combined in 2009 to create NanoNextNL [10], which encompasses over 100 research institutions and companies.

China became one of the only developing countries with aggressive nanotechnology R&D with the establishment of the National Center for Nanoscience and Technology [11] (NCNST) in 2001. ELSI components are not compulsory for individual projects, but in 2006, NCNST established the Nanosafety Lab [12] to exclusively study the economic, environmental and social aspects of nanotechnology.

Methodology:

The addressing of the ELSI of nanotechnology in the United States, the Netherlands, and China were compared across three categories: occupational safety, community outreach efforts, and historical context. Peer-reviewed scientific literature as well as published reports by federal agencies in each country were reviewed. As an initial step, this study looked at regulations for consumer and occupational safety. The next comparison reviewed community outreach and education efforts. This study also examined how technology adoption has been historically addressed by each nation using the regulation of the electronic industry's waste as an example.

Results and Discussion:

Occupational Safety. Nanoparticle regulation in all three countries was found to be similarly limited. Significant insufficiencies exist within the Toxic Substances Control Act (TSCA) in the U.S. as well as in the similar Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) acts of the Netherlands and China. Under these acts, new nanoparticles are exempt from registration if the bulk (material) equivalents have already been approved.

Officials from the Nanotechnology Task Force [13], created by the US Food and Drug Administration, and from the Netherlands delegation to the European Commission [14] have released documents expressing concern over treating nanoparticles and bulk chemicals equally.

Each country has additional information for ensuring worker safety. The US National Research Council, for example, updated "Prudent Practices in the Lab" in 2011 [15] to include safe nanoparticle handling practices. The Netherlands released a similar document in 2008 [16]. In China, the National Nanotechnology Standardization Technical Committee [11] has been charged with establishing nanotechnology standards and research methodologies.

Community Outreach. Various educational programs have been launched and reflect the importance each country attributes to nanotechnology. NNIN alone reached over 20,000 people in 2010 through events like summer camps and lab tours [6]. In the Netherlands, where public dialogues are popular, the Committee for Societal Dialogue on Nanotechnology launched Nanopodium [17] in 2009 to act as a platform for citizens to share ideas and opinions about nanotechnology. In China, the Ministry of Science and Technology holds an annual "Science Week" with lectures introducing the basics of nanotechnology [13].

Historical Context. A good parallel to nanotechnology regulation can be found in the electronics industry. The role the Precautionary Principle played in regulating the waste produced was a reflection of cultural differences, as only the Netherlands seemed to promote it. This principle states that a "lack of full scientific certainty" is not an excuse to neglect taking preventative safety measures [18]. This initial comparison may indicate the direction nanotechnology regulation will take.

In 1980, it was discovered that leaking industrial waste tanks owned by electronic manufacturers had heavily contaminated the groundwater in Silicon Valley, CA [19]. Because the chemicals had been grandfathered into the TSCA, the lack of regulation and information lead to the creation of 25 Superfund Sites in the immediate area. The Netherlands also had a vibrant electronics industry, including Royal Philips Electronics, but managed to avoid similar disasters through carefully planned pollution taxes and incentives for processing end-of-life products. The Restriction of Hazardous Substances (ROHs) directive was adopted in 2003 to restrict six toxic chemicals used in the industry [20], something the United States has yet to do. China modeled its own ROHs [20] after the Netherlands', but weak local implementation created serious consequences. For example, the city of Guiyu is home to one of the largest electronic-waste dumpsites in the world and its residents are exposed to lethal levels of chemicals like cadmium [21].

Conclusions:

This study compared regulation of nanotechnology in the United States, the Netherlands, and China. Each country has predominantly approached nanotechnology according to their unique cultures, as exemplified by the educational programs and the credence given to the Precautionary Principle. Some actions, such as existing regulations and the push for nano-specific legislation, have been internationally influenced. With the advent of this globalized technology, understanding of policies in place must also be viewed from an international standpoint.

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