Benefits and Dangers of Nanotechnology: Health and Terrorism

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Abstract The first goal in this paper is to discuss the fundamental principles, applications, advantages, and disadvantages of nanotechnology with a view of promoting the importance and validity of nanotechnology in the developed countries as well as the emerging developing countries in Africa and elsewhere. The second goal is intended to provoke critical thinking, analysis, medical applications, environmental and economic issues or implications involving nanotechnology. The third goal is to discuss the potential security threat that would pose world peace, should nanotechnology, nanodevices, nanomaterials fall into the wrong hands.

Keywords Nanotechnology · quantum dots · nanites · United Nations · cancer

1 Introduction

The discoveries in the field of nanotechnology of its existence and applications over the past four decades are staggering. If the dream of a nanoage is within two decades according to nanotechnology prognosticators, then life as its known today will be changed forever. The science of manipulating matter at its most fundamental level, atoms and molecules, would be the discovery of the millennium. The National Science Foundation (NSF) of the United States of America is massively funding research in nanotechnology. Neal Lane, Director of NSF, said: ‘If I were asked for an area of science and engineering that will most likely produce the breakthroughs of tomorrow, I would point to nanoscale science and engineering, often called simply *nanotechnology*.’ Nano is a one billionth unit of measurement and derives from the Greek word for dwarf. The

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focus of nanotechnology ranges from developing nano-sized chips for supercomputers to engineering molecular robots (nanorobots) that perform specific functions.

More specifically, nanotechnology deals with the creation of functional materials, devices and systems through the control of matter and exploitation of novel phenomena and properties on nanometer scale (Merkle 1992). For an example, if atoms are re-arranged in coal, that structure converts itself into a diamond. Also, if the atoms that are found in sand are re-arranged and added a few other elements, that structure becomes computer chips or solar panels. Of particular significance is the emerging field of nanotechnology-based biomedical techniques.

2 Medical Applications of Nanotechnology

For many different reasons, there has been great effort to improve and discover new manufacturing processes, products, and systems, which will aid physicians to treat and prevent asthma, cancer and other chronic diseases. As far fetched, as this may seem, this is what has been discussed in this paper: the application of nanotechnology for the treatment and prevention of chronic diseases, such as asthma and cancer. Two main applications are presented.

2.1 Application of Gold Nanoparticles (GNPs) Used as Biomarkers for Detecting Metastasis of Cancer Tumor

Due to their biocompatibility and excellent optical properties, gold nanoparticles are finding increasing application in a variety of areas including DNA detection and cancer diagnostics. The gold nanoparticles can be conjugated to an antibody for epidermal growth factor receptor (EGFR) proteins. These EGFR cells which are found on the surface of most cancer cells respond to the presence of gold due to the ability of the gold nanoparticles to absorb light. Figure 1 shows the optical effect of gold nanoparticles on cancer cells due their high affinity for cancer cells. In addition to these developments, colloidal gold nanoparticle platforms have been designed and used as a tumor targeting ligand and a cancer therapy (Paciotti et al. 2005). A new synthesis has been developed for the tumor-associated, cell-surface carbohydrate moiety, known as the Thomsen-Friedenrich antigen (T-antigen) (Svarovsky et al. 2005).

2.2 Use of Nanoparticles (I.E.: Quantum Dots) to Aid in Imaging of Cancer Cells for Site-Specific Drug Delivery

A variety of nanomaterials are finding viable applications including drug delivery as well as targeting and imaging of the onset of malignant tumor formation in tissues (Owusu and Owusu 2000). It is estimated that the global market for drug

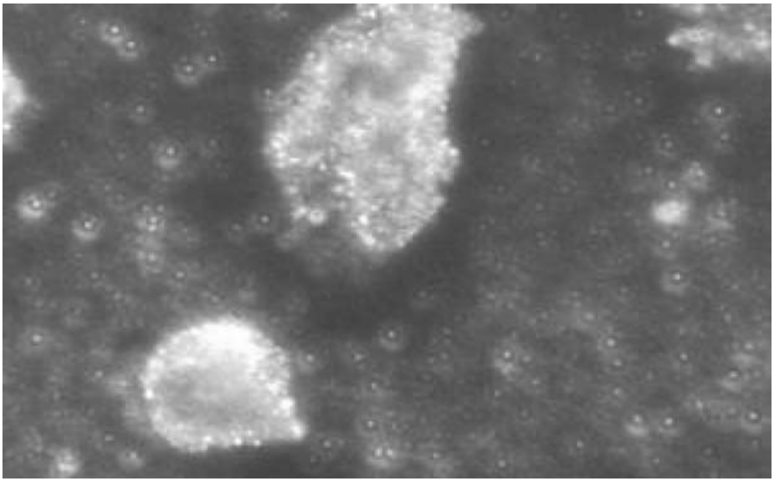

Fig. 1 SEM image showing the high affinity of gold nanoparticles for cancer cells. The gold nanoparticles stick to cancer cells and make them shine (El Sayed 2005)

delivery products is $33 billion per year and growing at a rate of 15% per year (Hill 2005). Recent studies have suggested that nanoparticle drug delivery might improve the therapeutic efficacy of anticancer drugs and allow the simultaneous monitoring of drug uptake by tumors (Kukowska-Latallo et al. 2005). Research in the design and applications of semiconductor nanocrystals, known as Quantum Dots (QDs) is gaining prominence. Quantum dots are the nanoparticles that are recently emerging as an alternative to organic fluorescence probes in cell biology and biomedicine. QDs are monodispersed semiconductor nanocrystals (size range: 2–10 nm) covered with a stabilizing monolayer. QDs have several predictive advantages such as ability to absorb light within a broad band of wavelength but emit at much narrower bands. QDs have high stability, and possess superior imaging capabilities. These unique properties allow simultaneous excitation of different sizes of quantum dots with a single excitation light source with simultaneous resolution and visualization as different colors (Fig. 2). In the area of biomedical applications, water-soluble and biodegradable QDs that have been encapsulated with glycopeptides in the form of receptors and ligands have been shown to bind to living cells (Loo et al. 2004). Recently, highly luminescent encapsulated quantum dots with cadmium tellurium (CdTe) core structure (Fig. 3) have been synthesized in a one-pot aqueous synthetic method (Svarovsky et al. 2005).

The goal of this current research work is to exploit the luminescence properties of QDs to aid in imaging for identifying cancer cells for site specific drug delivery. T-antigen bearing quantum dots are used to locate small metastasis in the midst of normal tissue. In addition, QDs can significantly improve clinical diagnostic tests for the early detection of malignant tumors. Encapsulated QDs

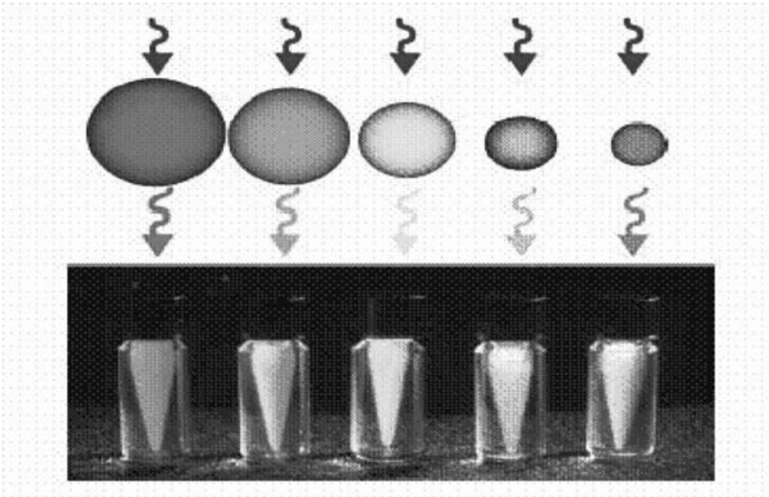

Fig. 2 Schematic representation of the effect of size on the color of QD particles (Five different QD solutions can be excited with a single wavelength)

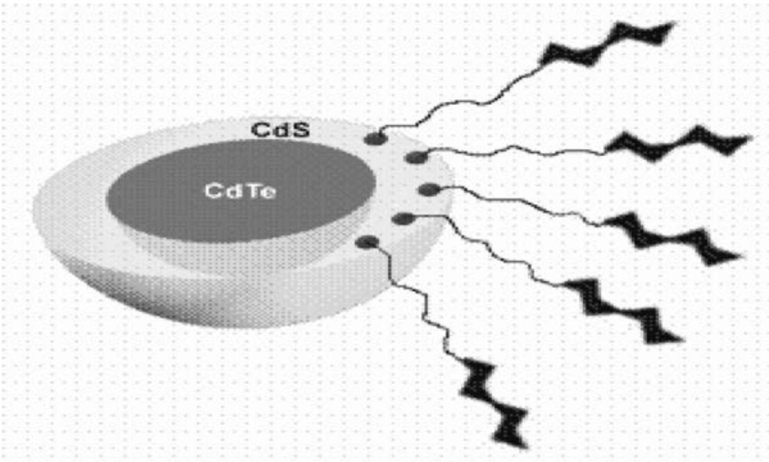

Fig. 3 Quantum Dot structure showing CdTe core and cds shell formation. The linkers are the ligand attachments (Svarovsky et al. 2005)

can be used to identify disease markers similar to currently widely used Magnetic Resonance Imaging (MRI).

Of particular significance is the emerging field of nanotechnology-based biomedical techniques. Nanoparticle-based techniques are promising novel tools that present the ability for earlier, faster and more selective diagnosis of cancer at much lower costs and reduced side-effects than traditional methods.

2.3 *Nanoparticles for Malignant Tumor Diagnostics and Drug Delivery*

A variety of nanomaterials are finding viable applications in the area of targeting and imaging of the onset of malignant tumor formation in tissues. The targeting capability of nanoparticles is influenced by particle size, surface charge, surface modification, and hydrophobicity whilst their general performance in vivo is influenced by morphological characteristics, surface chemistry, and molecular weight. Nanoparticles can be designed for site-specific delivery of drugs since they act as potential carriers for several classes of drugs such as anticancer agents and antihypertensive agents.

2.4 *Design and Synthesis of Gold Nanoparticles*

Due to their biocompatibility and excellent optical properties, gold nanoparticles are finding increasing application in a variety of areas including DNA detection and cancer diagnostics. They are also useful for identification of protein-protein interactions (Salata 2004). Gold nanoparticles functionalized with oligonucleotides have been used as probes in DNA detection (Daniel and Astruc 2004). The gold nanoparticles can be conjugated to an antibody for epidermal growth factor receptor (EGFR) proteins. These EGFR cells which are found on the surface of most cancer cells respond to the presence of gold due to the ability of the gold nanoparticles to absorb light. The gold nanoparticles display a much higher efficacy. QDs acting as multivalent fluorescent tags (Fig. 4) can be used to seek out specific lectins and antibodies in a multiplex fashion to detect various disease states or harmful pathogens simultaneously in high throughput for medical diagnostics. Small spherical particles of average diameters between 5 and 20 nm have been prepared by UV radiation of gold ions. Larger particles (20–110 nm) have been formed by irradiation coupled by reduction with absorbic acid (Sau et al. 2001). Figure 5 shows schematic representation of protein complexes formation in relation to cell genomics. Figure 6 shows the effect of gold nanoparticles (GNPs) on lung specimens compared with treatment with phosphate buffered saline (PBS) solution. Those treated with GDPs look better than those treated with PBS (as shown in Fig. 6).

2.5 *Expected Outcome, Intellectual Merit, and Broader Impact of Current Research*

It is envisioned that quantum dots and gold nanoparticles sensors outlined in this paper would:

- Improve sensitivity and selectivity of nanosensors in targeting of Epidermal Growth Factor Receptor (EFGR) proteins commonly present at the surface of most cancer cells (since EFGR proteins are at the same molecular level as the cancerous cells)

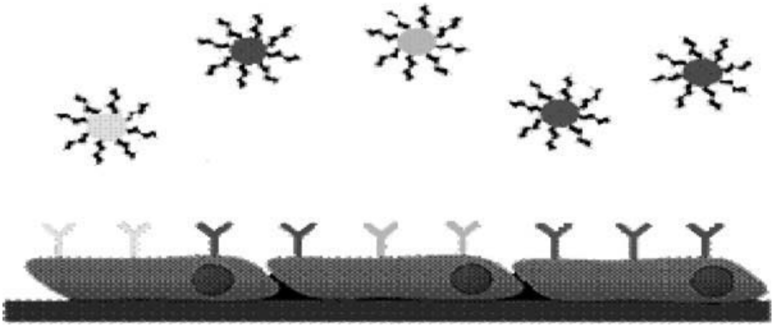

Fig. 4 The multivalent fluorescent tagging property of quantum dots (QDs)

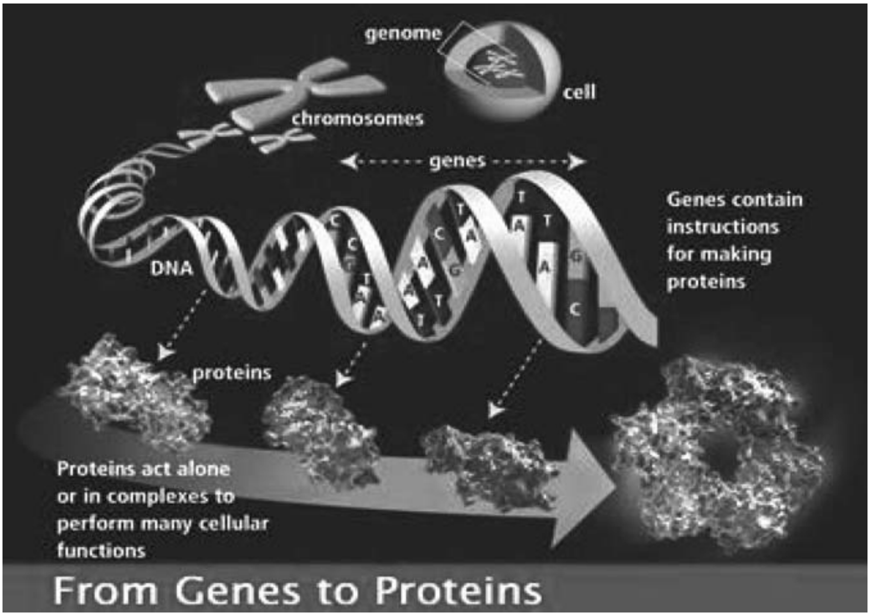

Fig. 5 Schematic representation of protein complex formation in relation to cell genomics (U.S. Department of Energy Human Genome Program, Available at: http://www.ornl.gov/hgnis, 2008)

- Lead to a more effective screening and detection of cancerous tumors
- Improve selectivity of drug injection into individual cells

It is likely that this advanced technology will soon result in rapid and widespread introduction of manufactured nanomaterials and devices into commerce.

The progress in this research endeavor is expected to uniquely and substantially enhance our capability in our efforts toward the development of nanorobotic devices (Owusu et al. 2006) that will be programmed to mitigate against the growth

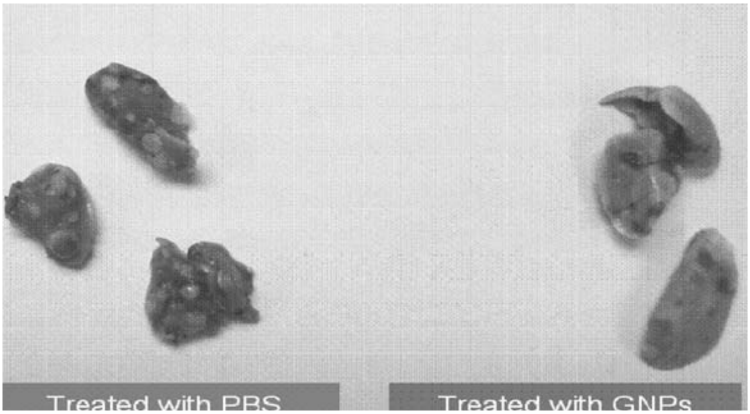

Fig. 6 Comparison of lungs treated with phosphate buffered saline (PBS) solution (left) and gold nanoparticles, GNPs (right)

of malignant cells in the human body that are responsible for diseases like cancer, asthma, etc. The expected outcomes outlined above coincide with the research goals of Research Center for Cutting Edge Technologies (RECCET) aimed at providing positive implications to the human interface between incurable diseases and nanotechnology (Owusu and Owusu 2000). The set-up in Fig. 7 is to aid in generating ultra-violet radiation for fabrication of nanosensor particles by the authors of this paper at the Research Center for Cutting Edge Technologies (RECCET) in Tallahassee, Florida, USA. This is a small portion of an elaborate experimental set up and sophisticated equipment servicing the Research Center.

2.6 Real World Applications of Nanotechnology in Medical Field

This is a proposed structure of a simple nano robot and diamondiod sphere for selective transport method as envisioned for controlled release of oxygen by Drexler (1992) in Figs. 8 and 9, respectively (1992). The concept in Figs. 10 and 11 will help to mitigate heart attacks and strokes by pumping oxygen to where it is needed during an attack or stroke.

2.7 Simulation of Selective Oxygen Nanotransport Device (SOND)

Nanodevices can be of great use in the medical field just for the purpose of preserving human life. Nanodevices are on the scale in which all things are created, there by, have the ability of accomplishing feats that no drug itself can do. This is due to

Fig. 7 Solar simulator and its controls along with the electrometer at Research Center for Cutting Edge Technologies (RECCET)

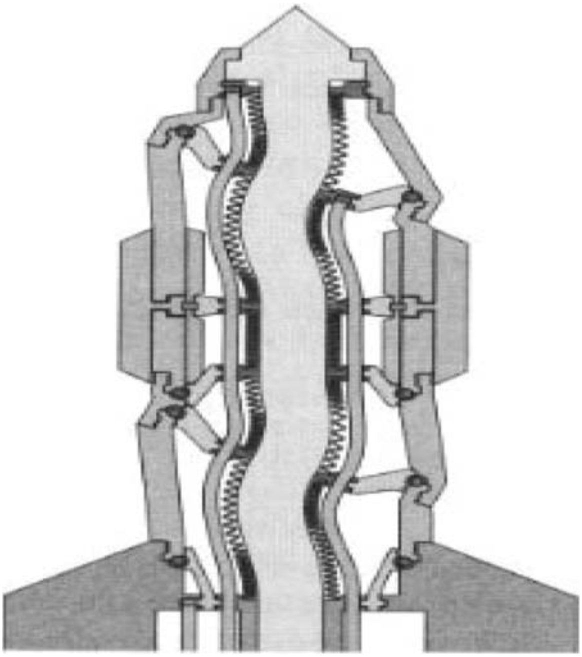

Fig. 8 Robotic device (Drexler 1992)

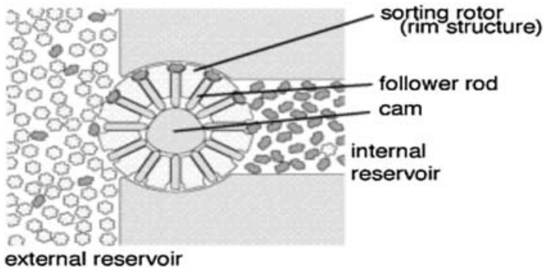

Fig. 9 Selective transport method (Drexler 1992)

the fact that nanodevices are extremely precise. In fact, nanodevices have the ability to form a structure whether living or nonliving, atom by atom. With this level of precision, nanodevices will not only be able to cure, but will also be able to prevent diseases. Specifically, a nanodevice such as Oxygen Nanotransport Device being developed at the Research Center (RECCET) by the authors of this paper can be used to prevent horrible medical ailments such as heart attacks, aneurism, and strokes. Heart attacks, aneurism and strokes are caused by the lack of oxygen going to the heart and/or the brain. Schematic views of the Selective Oxygen Nanotransport Device (SOND) combined with the artificial holding reservoir are shown in Figs. 10 and 11. The device can collect and redistribute oxygen in the blood stream in order to prevent abnormally low levels of oxygen or shortage of oxygen in the blood stream to the brain and/or the heart.

3 Terrorism Issues of Nanotechnology

The purpose of the following sections is to discuss the potential dangers and security threats that may be posed to world peace should nanotechnology materials and devices fall into the wrong hands for the purpose of terrorism and domination of world power. The role of the United Nations Regulatory Committee, as a watchdog for monitoring the use of nanotechnology, is also discussed.

3.1 The Right Tools in the Wrong Hands

Like computers, nanotechnology and programmable assemblers could become ordinary household objects. It is not too likely that the average person will get hold of and launch a nuclear weapon, but imagine a deranged person or a terrorist launching an army of nanorobots programmed to kill anyone with brown eyes and curly hair or people with blue eyes and straight hair. Even if nanotechnology remains in the hands of governments, think what a Stalin or a Hitler could do or few

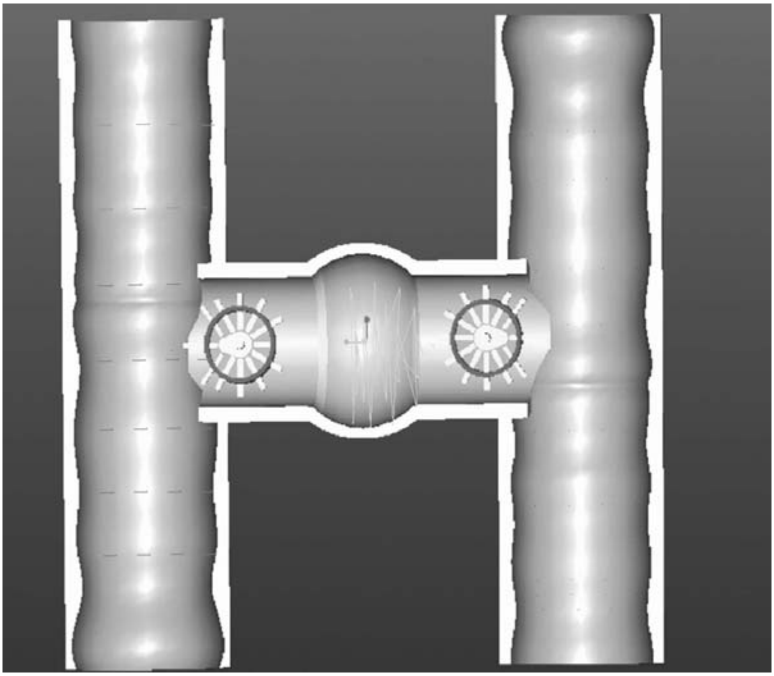

Fig. 10 The oxygen nanotransport system (SOND) and arteries in human body

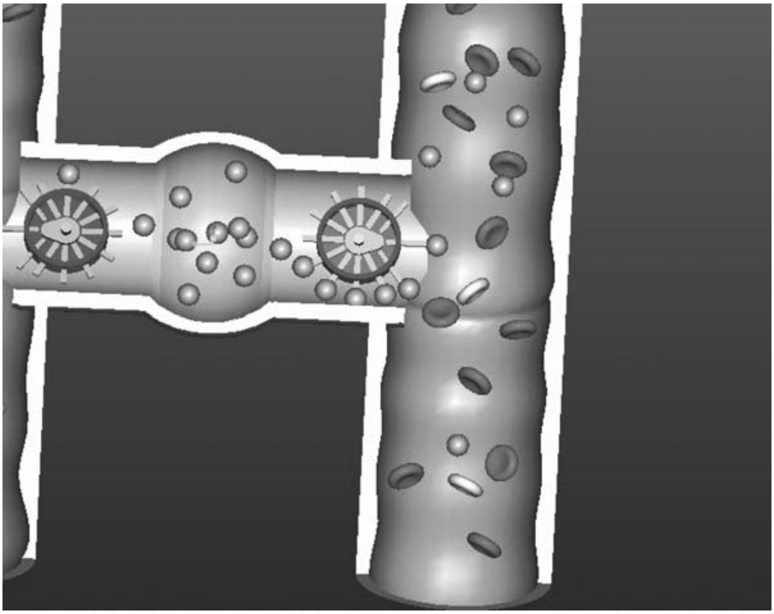

Fig. 11 Lack of oxygen in the right artery shows the SOND on the right releasing oxygen molecules (ball shaped particles)

countries will lord over other countries (as it is currently with nuclear weapons). Vast armies of tiny specialized nano killing machines could be built and dispatched in a day. Nano-sized surveillance devices or probes could be implanted in the brains of people without their knowledge.

3.2 Potential Threat of Bio-terrorism

The most serious aspect of the down side of nanotechnology, yet, is the potential threat of bio-terrorism. Matter is being manipulated at its most fundamental level, and this is the level at which diseases could be manufactured. Trillions of deadly, poisonous, and infectious nanites (nanorobots) could be manufactured in a nano-laboratory and be released on a sector of humanity wiping out whole populations, should this technology fall into the hands of terrorist organizations or some power seeking countries.

3.3 Role of United Nations for Nanotechnology Security Around the World

It is with this in mind that the authors of this paper feel strongly that the need for a world governing body or regulatory organization on nanotechnology is imperative. This proposed body, formed, constituted and run by the United Nations will focus its energies on the down side of nanotechnology. Figure 12 shows a proposed organizational chart of what such a body will look like. It is in this vain that the proposal to establish this International Steering Committee on Nanotechnology (ISCON) as a governing body to regulate the development, deployment, and the use of nanotechnology is of utmost importance. The governing body should take the form of a Committee of the United Nations and will comprise members from developed as well as developing countries. Lawyers, Doctors, Scientists, the Clergy as well as Government appointed officials will form the core of such a committee with 12 members; and each being also an active member of a sub-committee responsible for different aspects of the regulatory function. The chairperson of this committee will be appointed every 4 years by the United Nations Security Council and will report directly to the office of the United Nations (UN) Secretary General.

It is not the purpose of the authors of this paper to dampen the natural initiatives, innovations, and discoveries in this field; but one cannot over emphasize the need to keep this potentially deadly form of technology from falling into the wrong hands. Nanotechnology must be seen as one of the tools of science, engineering, and technology to foster a sense of brotherhood, goodwill, and peace among nations while forging greater ties among peoples, rather than for destructive means.

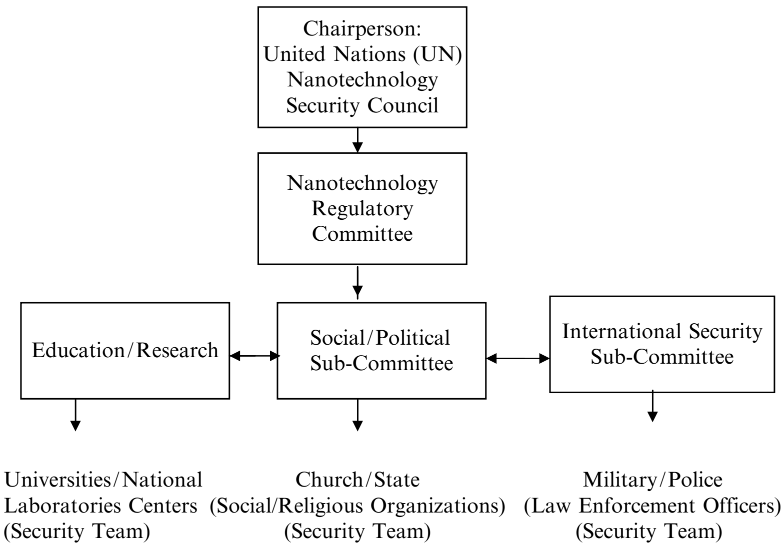

Fig. 12 Proposed organizational chart of United Nations Regulatory Committee on nanotechnology and its applications

4 Concluding Remarks

It is not a matter of if, but when nanotechnology becomes a household application. The nanoage is here and it will revolutionize the status quo on planet earth, including its International Security Profile. Had Albert Einstein foreseen the use to which his relativity theory would have been put in 1945, in Hiroshima, Japan, he probably would have had second thoughts about the way he disseminated his discoveries.

As General Douglas Macarthur said in his farewell speech before a joint sitting of the US Congress after the end of World War II on April 19, 1951:

> Men since the beginning of time have sought peace. Various methods through the ages have been attempted to devise an international process to prevent or settle disputes between nations. …. We have had our last chance. If we will not devise some greater and more equitable system, our Armageddon will be at our door. The problem basically is theological and involves a spiritual recrudescence, an improvement of human character that will synchronize with our almost matchless advances in science, art, literature, and all material and cultural developments of the past two thousand years. It must be of the spirit if we are to save the flesh.

We need to heed General Macarthur's warning and learn from the lessons of history and use nanotechnology solely for peaceful means.

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