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RESEARCH ARTICLE

ETHIC IN NANOTECHNOLOGY

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ABSTRACT

Emerging and Readily Available Technologies and Security is a study on the ethical, legal, and society issues relating to research, development, and used of rapidly changing technologies with low barriers of entry that have potential applications, such as information management, synthetic biology, and nanotechnology. The nanotechnology sector, which generated about $11.5 billion in product sales in 2009, is predicted to expand rapidly over the next decade. The increasing production and use of engineered nanomaterials may lead to greater exposures of workers, consumers, and the environment, and the unique scale-specific and novel properties of the materials raise questions about their potential effects on human health and the environment. For this reason government agencies, academic institutions, industry, and others have conducted many assessments of the environmental, health, and safety aspects of nanotechnology.

Nanotechnology has many prospects for improving the quality of life of humans and solving problems related to poverty, health, and the environment. However, it can also have a negative impact if it is not used in accordance with ethical principles. It is not a panacea for our ills.

INTRODUCTION

Today Nanoscience and Nanotechnology are seen as transformative movements, which have a big potential to stimulate and improve innovation in all areas of life. They could greatly benefit our society, but this new science includes many concerns about possible risks to human health and environment.

Nanotechnology has been established as a priority research and policy focus, cutting across several R&D fields from pharmaceutics, food and electronics. The raise of nanotechnologies has been accompanied by an enduring uncertainty characterizing the developments of the scientific knowledge related to this field, as well as the social trajectories of technological applications. Such a condition inevitably affects regulatory responses to such technologies, their development and their uses (Arnaldi and Muratorio, 2013).

One of the main concerns about human health risk is the possibility of the nanoparticles to pass through the cell membrane and interact with biomolecule components, but this property is used precisely to target infect cells, deliver drug agents on this cells and kill then. The behavior of nanomaterials at the nano level is curiously unpredictable from behavior at the macro or even micro level. We have thus found new and wonderful uses for some old standbys, but we have been surprised and, predictably, will continue to be surprised by the effects of nanoparticles. Nanoparticles are so small; they can go through cell membranes. That is part of the point of nanotechnology, of course, some nano - artifacts are to deliver lethal drugs precisely to wayward cells, for example, killing only them. The concern is that such tiny particles may migrate into cells where they could do great damage in the brain, for instance (Robinson, 2011)

The environment concern is related to a possible eco-toxicity, when the nanomaterials reach landfills, water or air because the nanomaterials could harm the eco-systems also it could be a potential exposure, because they can coming into our body by breath, drinking or eating, be deposited in the lungs or on the skin, or other organs. However, agglomerates of nanoparticles may have the potential to express toxicity.

NPs (nanoparticles) may enter the human body via the lungs and the intestines (if ingested); penetration via the skin is less evident but it is possible that some NPs can penetrate deep into the dermis. NP internalization depends on the particle size,

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surface properties, and functionalization. After internalization, the NP distribution in the body is a strong function of the NP's surface characteristics (Brayner, 2008).

The potential human and ecological toxicity associate with nanomaterials is a growing area of investigation, a few nanotoxicology studies have addressed the effects of nanomaterials in a variety of organisms and environments, this situation made difficult for the risk assessment and it is worse because each type of nanomaterial has different properties that also have its own unique biological or ecological responses, as a result, different types of nanomaterials must be categorized, characterized, and studied separately.

People are all routinely exposed to a broad range of pollutants that are present within the environment, including pollutants within the air we breathe, the food we eat, and the water we drink. Some trace pollutants and heavy metals are seriously harmful to human health and some of them are nanoparticles. Therefore, in situ trace detecting and accurately, rapidly and quantitatively measuring these toxic substances in air, water and soil are very important. Up to now, although large size and modernization expensive equipments in labs can be used to analyze pollutants and heavy metals, on this area the nanomaterials offer a tremendous potential due to their large surface area for a given volume, high surface activity, and strong adsorption ability. Nanomaterials are the nucleus for the design of the detection devices and they are of great aid to improve the detection limit. This is difficult to be realized by using traditional materials. Based on detection techniques of surface plasmon resonance, surface-enhanced Raman effect, fluorescent emission and absorption of quantum dots, and electrochemical measurements, etc., development of detection nanosensors will become an important research field. The nano-detection sensors and devices will be the main instruments for trace heavy metals and pollutants detection. In recent years, as the nanosensors and nanodevices occur frequently, most people recommend them for application in pollutants and heavy metals detection [33]. Nanomaterials have the potential to improve the environment through the development of new solutions to environmental problems, by direct application of nanomaterials to detect, prevent and remove pollutants or by using nanotechnology to design cleaner industrial process and create environmentally friendly products. Nanoparticles can be used to convert pollutants to less harmful chemicals in the environment using the properties of surface area, high reactivity and enhanced transport of nanoparticles (Baalousha and Lead, 2009).

Nowdays with all huge scientific and technological developments, it is difficult to create methodologies or philosophies that can guide the engineers and scientists who perform this development. They must follow the right path in search of the truth, and this truth must be to solve the problems of humanity either regionally or globally, focusing on the humanization of both the scientific and technological sectors.

Basic research in all theoretical and practical branches of nanotechnology and nanoscience provide quick access to study elements, processes, and applications of nanoscale structures. The inorganic and organic synthesis and processing of nanoscale materials by physical, chemical and biological methods to modeling and simulation methods of interaction and assembly now constitutes an unexplored field. This entails a development of innovative nanostructures and devices affecting our society. Nanotechnology has variously been described as a transformative technology, an enabling technology, and the next technological revolution. Even accounting for a certain level of hype, a heady combination of high-level investment, rapid scientific progress, and exponentially increasing commercialization point toward nanotechnology, having a significant impact on society over the coming decades (Maynard, 2006). The current and expected spread of nanoproducts in the market makes this broad and diverse technological field a considerable force shaping the future of modern societies and widely characterizing our present (Ruggiu, 2013).

Nanoscience and Nanotechnology have an enormous potential, and a bright future with multiple applications in many areas like engineering, optics, energy, consumer products, nanomedicine (superior diagnostic, therapeutic and preventive measures); hence, they should not be abused or corrupted with different interests than development of our societies, environmental and human health protection. It is important to establish regulatory guidelines for the control of manufacturing products which may threaten human security and the environment. But most important is to train researchers with ethical principles, so that they self-regulate scientific work.

Ethics in Nanotechnology

Nanotechnology is a new field of scientific and technological research that provides the ability to create a variety of new materials based on an original class of atomic and molecular configurations. Currently significant advances are presented, and are seen in a few years a fast growth occurs with a wide range of possible products and applications that contribute significantly to human progress. As example of this development nanomaterials that enable major medical treatments are proposed, the research related to agriculture, food production, environmental remediation procedures, energy applications to enable the manufacture of solar cell coatings, cosmetics, protective skin creams, dirt-repellent textiles. However, despite this significant development potential, one must also consider the urgent need to track not only the many benefits but also the potential negative effects of nanoparticles getting in to the atmosphere. The product toxicity, along with the risks to people and the environment, are the most pressing problems posed by nanotechnology in the short term, thus the need to establish measures and relevant control parameters.

Nanotechnology offers great promise, but much of this lies in the future. This future orientation has made nanotechnology vulnerable to the current trend of over-claiming in science, either the potential benefit or harm. There is a need to be careful about placing premature weight on speculative hopes or concerns about nanotechnologies raised ahead of evidence. Fore-sighting of breakthrough technologies is notoriously difficult, and carries the risk that early public engagement may promote either public assurance or concern over (Boisseau and Loubaton, 2011). Today nanotechnology is an established area of cross disciplinary research, as well as a billion dollar industry. How much nanotechnology contributes to the global economy is a controversial issue in itself. A recent report research claims that total global sales revenues for nanotechnology were US$11.6 billion in 2009, and are expected to reach more than US$26 billion by 2015. Much of nanotechnology literature emphasizes nanotechnology as the engines of the next industrial revolution and extols the incredible benefits that nanotechnological innovation is predicted to bring. While research and policy decisions emphasizing risk are, of course, not absent, it is relatively rare that the risk issues are discussed comprehensively under one framework. A particular framework might address one or the other aspect of nanotechnology associated risk, but none of them include risk issues ranging from the narrow eco-toxicological concerns to the broad societal/cultural impacts (Senjen and Hansen, 2011).

Considering the great amount of interest in scientific, economic and commercial aspects of nanotechnology, it is important to reflect on the need to establish worldwide guidelines to control or prevent any manufacturing process or product that could undermine human and environmental safety. Participants in nanotechnology development actors, including Governments, industries, investors, research centers, must agree to ethical monitoring, so that the social and environmental good is not sacrificed by an unreasonable and irresponsible search for benefits. In this process it is essential for society to be kept informed and be a participant in the decision making. A process is required to avoid any irresponsible act by establishing regulatory and preventive permanent constraints. Given the growing reach of nanotechnology, how should we reconcile the interests of nanotechnologists and environment? I now consider traditional environmental ethics with which nanoethics can be practically extended to include environmental considerations. One reason for emphasizing a practical approach is that the probability of nanotechnologists, including consumers, rejecting nanotechnology on environmental grounds is close to zero. The theoretical framework that we choose should be based on its ability to be used by those in a decision making capacity (government officials, business executives, and researchers) to reasonably balance the promise of nanotechnology with potential environmental harm, given the overwhelming likelihood that nanotechnologies will continue to find their way into the marketplace (Attia, 2013).

While products based on nanotechnology are actually reaching the market, sufficient knowledge on the associated toxicological risks is still lacking. The literature on toxicological risks of the application of nanotechnology in medical technology is scarce (Logothetidis, 2006). To date, our understanding of the interactions of nanomaterials with biological systems is limited and thus it is unclear whether intentional (medical) or unintentional exposure of humans to engineered nanomaterials could produce harmful biological responses. This does not mean that all nano-sized materials a priori should be considered to be dangerous. However, in view of the fact that a scientific paradigm for the possible adverse effects of nanoparticles is still lacking, each novel nanoparticle formulation should be tested on a case by case basis. In this regard, efforts are needed to improve the standardization of assays used for in vitro and in vivo testing of nanomaterials (Fadeel and Bennett, 2010).

It is clear that achieving compliance with this regulatory process is not a simple or short-term activity. Because of the large variety of phenomena that are involved with potential nanotechnology development, it is really a complex task to combine all possible procedures in order to achieve regulatory criteria. Moreover, even today there is no unanimous agreement as to the possible effects that could result from the introduction of nanoparticles into a variety of existing ecosystems. The environmental impacts of nanotechnology can be extremely difficult to assess. Due to the complex nature of ecological cycles, as well as the impossibility of direct experiments with the environment, little knowledge exists about the dangers and risks of contamination that nanoparticles may pose to the environment. With the nanotechnology and nanomedecine grows another complementary discipline, the nanotoxicology that must will be provide for the necessary safety assessment of nanoproducts, until now the results of nanotoxicological researchs and data are not too much and some of these research still considerable debates for a contradictions, because these reports neglect important factors such as the sedimentation of NPs, absorption of proteins, biomolecules onto the surface, etc. Ascertaining the ecotoxicity of nanomaterials and how they are distributed in the environment, as well the effect they may have on organisms, is currently not only challenging but also beset with limitations due to a lack of suitable monitoring equipment and extensive knowledge gaps. There is a currently no environmental monitoring of nanomaterials in the field, but this may change in the near future (Senjen *et al*., 2013). Due to their small size and physical resemblance to physiological molecules such as proteins, NPs possess the capacity to revolutionized medical imaging, diagnostics, therapeutics as well as carry out functional biological processes. But these features may underlie their toxicity. Also, depending on the mode of administration and sites of deposition, toxicity may vary in severity. Therefore, to maintain clinical relevance, information on toxicity is presented using a system-based approach focusing on experimental lung, dermal, liver and brain targets. NPs have certain unique characteristics which can be and have been exploited in many biomedical applications. However, these unique features are postulated to be the grounds for NP-induced biotoxicity which arises from the complex interplay between particle characteristics (e.g. size, shape, surface chemistry and charge), administered dose and host immunological integrity. Recently, more emphasis has been placed onto understanding the role of the route of particle administration as a potential source for toxicity (Yildirimer *et al*., 2011). A critical step in nanotoxicology is to characterize the nanomaterial under examination and this is much more difficult than is the case in classical toxicology because of the multitude of variables in the parameter space. These include: particle size, roughness, shape, charge, composition and surface coating. The latter can change depending upon the matrix into which it is introduced (Elsaesser and Howard, 2012).

Many groups advocate a moratorium on any future nanotechnology development, including those that could cause irreversible damage in the long run, but especially those for which the potential risks to humans and the environment are more immediate. However, it is clear that achieving compliance with this request is really difficult. First, consider that many of the bases of nanotechnology are public knowledge and interest. On the other hand, private companies and scientific communities have a considerable investment in this. Clearly a balance between scientific and technological progress in this field and the prevention of threats to health and the environment is required**.**

The precautionary principle used as an ethical rule says: If some action has possibility of causing harm, then the action should not be undertaken unless some measure is put in place to minimize or eliminate the potential harms.

To accomplish this precautionary principle, an evolutionary progress is required, in which a dialogue must be carried out with all stake holders, with the overriding goal of encouraging a socially responsible global perspective for nanoscience and nanotechnology development**.**

Weckert and Moor believe the precautionary principle includes three different categories of harm needing to be analyzed: direct harm, harm by misuse and harm by mistake or accident. Each kind of risk involved in each type of harm must have different analyses. They also expressed concerns about the negative impacts that moratoriums can have for the advance of certain technologies, especially those that may be needed and may be appropriately safe (Decker and Gutmann, 2012).

Ethics may help identify limits on how the goal ought to be pursued. Some means are not ethically acceptable, even if their ends are worthwhile. This is why medical research involving human subjects must be regulated, for example. Good intentions and a laudable goal are not sufficient to ensure ethically acceptable practice (Sandler, 2009).

Strategic Approach to International Chemicals Management (SAICM) and Recommendations

SAICM is the "approach to the management of chemicals worldwide," approved in Dubai in February, 2006, by the International Conference on Chemicals Management. This agreement constitutes a high-level political declaration, a planned global action of a regulatory framework to ensure that chemicals are produced and used so as to significantly reduce impacts on the environment and health.

SAICM is a voluntary agreement that countries have agreed to be the global framework to discuss cooperative measures and specific actions that can be taken in relation to nanoscience and nanotechnology products (Faladori and Invernizzi, 2011).

The SAICM is managed by the United Nations Environment Programme (UNEP) with the World Health Organization (WHO). It is the only forum where voluntary measures on the management of chemicals throughout their life cycle are discussed and agreed by consensus, including aspects of occupational health, public health and environment. The second International Conference in Geneva in 2009 adopted resolution II-4-E where nanotechnology and nanomaterials were included. Between 2010 and 2011, workshops developed a number of recommendations, which stand approved. These recommendations apply the precautionary principle throughout the life cycles of nanomaterials and products containing them and extend producer responsibility even when the product becomes waste.
At the First Open Meeting of the Working Group of SAICM in Belgrade, Serbia, November 15-18, 2011, Swiss proposals specifically to be included in the Global Plan of Action of SAICM were discussed and consensus was reached in some activities. However, the most progressive proposals, which would have implemented policies for extended product liability for manufacturers, product labeling, registration of nanomaterials, and the involvement of the health sector in developing future regulatory measures did not reach consensus because of opposition from industrialized countries like the United States, Canada, Japan, and Australia,

Initially, responses will necessarily consist primarily of soft law measures, such as codes of conduct, ethics, and self-regulation. These initiatives do not involve legislation or regulation of any one jurisdiction because the international response to such measures, based on growing information and experience, must produce the migration from ethic...to more formal action...and finally to a framework convention.

The European Environmental Bureau (EEB) was working on nanotechnology aspects, too, and included the needs for some developments, particularly regarding societal benefits. These subjects and the ethics were cached by the EEB Commission’s Strategic Nanotechnology Action Plan for 2010-2015.

EEB is also concerned by the wording of the questionnaire, which seems to consider a trade-off between risks and benefits, while leaving out wider societal costs or impacts. Technological innovation is assumed to have benefits (which remain largely unexamined) that are used to counter-balance unintended side-effects or risks (Duprez, 2010).

Following SAICM guidelines, the Organization for Economic Co-operation and Development (OECD) that is an international economic organization of 34 countries provides a platform that is a global resource (Database), which details EHS research projects and identifies research needs; provides opportunities to identify similar fields; and lead to create new collaboration and networks around nanoscience and nanotechnologies.

OECD Nanosafety Projects includes

- OECD database on Manufactured Nanomaterials to Inform and and Analyse EHS Research Activities
- Analyze EHS Research Activities
- Safety Testing of a Representative Set of Manufactured
- Nanomaterials
- Manufactured Nanomaterials and Test Guidelines
- Alternative Methods in Nano Toxicology
- Co-operation on Voluntary Schemes and Regulatory Programs.
- Risk Assessment approach

- Exposure Measurement and Exposure Mitigation
- Environmentally Sustainable Use of Nanotechnology (Kearns, 2011).

Nanotechnology and controversy

Modern science has an enormous quantity of reliable knowledge and comprehension of phenomena of the world and its processes, interactions, structures (and their components) and the underlying laws. Moreover, a good part of this knowledge and this understanding is being used to give rise to more efficient technology, better medicine and advancements in other areas. These advances, which enjoy a wide positive assessment, contribute to fundamentally transform the world in which we live, providing human with increased power to reconfigure materials and objects and to solve problems that were previously considered unsolvable.

The precautionary principle (PP) from SAICM identifies the risks to be investigated in the light of the ethical judgments involving (among others) universal human rights, accountability, sustainable development, equity, and participatory democracy. The standard critique of the precautionary principle highlights two kind of weakness. Whilst the first weakness, a problem to which we have just adverted, is that the key variables are open to many different interpretations, the second is that it takes a one sided approach to risk management (Brownsword, 2009).

Responsible development of nanotechnology entails research toward understanding the public health and safety and environmental implications of nanotechnology, as well as research toward promising, highly beneficial uses of the technology. Responsible development of nanotechnology also entails establishing channels of communication with relevant stakeholders, in terms of both providing information and seeking input (Harthorn, 2013). The potential of and the risk of nanotechnology and nanomedicine need to be openly researched, analyzed debated and regulated (Senjen, 2013).

Much of the debate on human enhancement technologies starts from the standpoint of traditional ethics. The usual ethical principles applied are familiar to medicine, such as the physician's injunction to do no harm. But emerging technologies blur the line between what is medicine and what is engineering. In such circumstances, such as in the human enhancement debate, it is appropriate to use conceptual tools from engineering ethics as well, such as risk-benefit analysis (Lin *et al*., 2013). Since a few years ago is debated with some truth about the existence and timing of nano-ethical reflection and discourse specific ethical for problems that entails (and brings in the future) the development of nanotechnology. There have been dozens of articles and several collective books (mostly in English) on the definition and scope of nano-ethics. There is even an international magazine called Nano-ethics (Escalante, 2010). The immense potential range of scientific, commercial, and medical applications marks nanotechnology as one of the most promising new forms of applied science. The future of nanotechnology, however, will depend not just on anticipation of its likely benefits but also on fear of its possible risks. Many members of the public, upon hearing of nanotechnology for the first time, often react with near-instantaneous concern about the hazards it may pose to the environment and to human health. Despite the nascent state of the nanotechnology industry, moreover, efforts to subject it to comprehensive regulation are already under way. Given the large number of activities that could damage the environment, what are needed are centralized rules on the technology itself (Kahan *et al*., 2007).

The ethical considerations of nanoscience and nanotechnology are controversies discussed in international forums like UNESCO, IFCS and SAICM. All of these discussions are around the implications of this new technology, the potentially beneficial or harmful relationships among science, technology and society. Principles of public accountability and transparency are needed to make good decisions and to choose the best way to implement new science and technology developments. These principles and guidelines from a code of conduct that involve all stakeholders and have been addressed directly by the European Union on the Commission's Strategic Nanotechnology, Action Plan for 2010-2015.

CONCLUSIONS

Nanotechnology is so amazing and its aims are so broad that it is expected to affect all areas of science. It is considered a key technology of the XXI Century and will cause a new revolution in the fields of thought, economy and society. It will require the efforts of scientists, technologists, policy economists, professors and teachers to lead to a harmonious and consistent new framework that will give us a better quality of life. Revolutionary or not, the transformative effects of nanotechnology will invariably shape our planet and its inhabitants. A holistic, consequentialist environmental ethic with a base of solely humans is useful in evaluating decisions involving nanotechnology.

Nanotechnology may lead to the production of new materials, equipment and systems with unique properties that cannot be obtained with current processing technologies in materials and workmanship. It is predicted that new developments in nanotechnology will play an important role in advancing knowledge and promoting many developments with great impacts on business and society.

It would be difficult to deny the potential benefits of nanotechnology and stop development of research related to it, since it has already begun to penetrate many different fields of research. However, nanotechnology can be developed using guidelines to insure that the technology does not become too potentially harmful. As with any new technology, it is impossible to stop every well-funded organization who may seek to develop the technology for harmful purposes. However, if the researchers in this field put together an ethical set of guidelines (e.g. Molecular Nanotechnology Guidelines) and follow them, then we should be able to develop nanotechnology safely while still reaping its promised benefits (Chen, 2014). Nanotechnology, nanomedicine and nanotoxicology are complementary disciplines aimed at the improvement of human life: nanotechnology has a bright future with multiple applications in many areas including engineering, optics, energy, consumer products. Nanomedicine will develop applications for novel and superior diagnostic, therapeutic and preventive measures. Nanotoxicity provides for the necessary safety assessment of nano-enabled products. Exciting achievements based on nanotechnology and nanomedicine await us in the future; yet there are as many challenges to get it right and recognize and avoid potential risks associated with these new developments where nanotoxicology will have a crucial role. Essential for the successful present and future developments is a multidisciplinary team approach involving material scientists, physicians and toxicologists who work closely together (Oberdörster, 2010).

New developments in technology usually entail some hazard as well as advantage to society. Hazard of a material translates into risk by exposure of humans and or their environment to the agent in question, and risk is reduced by control of exposure, usually guided by regulation based on understanding of the mechanisms of harm (Seaton *et al.*, 2009). Current nanotoxicological research aims to identify the physic-chemical characteristics of NPs responsible for the observed health effects. These results could be incorporated in the design of new engineered NPs. The challenge is to produce new nanomaterials that are without adverse characteristics and still fulfil the industrial requirements. This approach would have the advantage of initiating a sustainable and safe nanotechnology (Nath and Banerjee, 2013).

While all this activity around nanotechnology currently is not predictable for humans or for ecosystem risks, we need to introduce specific regulatory regimes for the protection of workers involved in the production and handling of nanoparticles and to include a risk analysis to human health and the environment. Clearly, this analysis won't generate a simple and straightforward answer to all questions related to human health and environment protection, but an ethical analysis based on a code of conduct can acknowledge the real value of nanoscience and nanotechnological progress, while balancing the private and self-interest with the ethical obligations that all stakeholders have with our communities, countries, society, and our world. Nanotechnology will have broad applications across all fields of engineering, so it will be an amplifier of the social effects of other technologies. There is an especially great potential based on the material unity of nature at the nanoscale and on technology integration from that scale. It will be important to integrate social and ethical studies into nanotechnology developments from their very beginning. Technically competent research on the societal implications of nanotechnology will help give policymakers and the general public a realistic picture free of unreasonable hopes or fears (Gebeshuber, 2007). Nanotechnology is a major player in the technological future, and there is an exciting opportunity to design the future. Nanotechnology presents an opportunity to redesign and to engineer technologies to specification. This offers the chance to minimize the risks and maximize the benefits of technological innovation. So if it seems as a material or technology may be more hazardous than we are willing to accept, this is an opportunity for innovation to engineer out the hazard. New materials can be (and increasingly are) designed to be safer (so called green manufacturing) and more environmentally friendly. Risk analysis is a tool to help achieve a sustainable future with nanotechnology (Shatkin, 2013).

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