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An Investigative Study of Societal Implications of Nanotechnology

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ABSTRACT

Codes of ethics signal the seriousness of a group of professionals to think about their impacts and goals. The emergence of professional organizations and professional codes of ethics are an important part in the development of a discipline or sub-discipline. They help provide a professional identity for a field of study. Nanotechnology, being so diverse and distinct because of its diversity, should be developed to address the aims of the many other disciplines it encompasses, but this coming together of disciplines also serves to make the formation or "professionalization" of this field more difficult and complex. How should this profession develop, and what values should it hold? What is its identity? What is the aim of this new field? In other words, what should its code of ethics be? Professionals working with the nano scale need to be aware of the public's perception when they make statements.

Keywords - Nano , Nano Particles, Ethics, Societal, Nanobots

I. INTRODUCTION

Nanoethics, or the study of nanotechnology's ethical and social implications, is an emerging but controversial field. Outside of the industry and academia, most people are first introduced to nanotechnology through fictional works that posit scenarios which scientists largely reject – of self-replicating "nanobots" running amok like a pandemic virus. In the mainstream media, we are beginning to hear more reports about the risks nanotechnology poses on the environment, health and safety, with conflicting reports from within the industry. But within the nanotechnology industry, there is a strange schizophrenia afoot. We have heard about the wonderful things that nanotechnology might enable not just today's mundane products, such as better sports equipment or cosmetics, but the truly fantastic applications. Our imagination seems to be our only limit, as scientists and other experts predict such innovations as: toxin-eating nanobots; exoskeletons that enable us to leap walls in a single bound; affordable space travel for everyone; nano- factories that can make anything we want; and even near immortality. Yet nearly in the same breath, many advocates continue to deny or to ignore that nanotechnology will cause any significant disruptions or raise any serious ethical questions that we have to worry about – dismissively labeling these as "hype". But how is this possible? How can such a brave new science, one that is so full of potential that it has been called the "Next Industrial Revolution" by governments and scientists, not also impact our relationships, society, environment, economy, or even global politics in profound ways?

Gunpowder, the printing press, the camera, the automobile, nuclear power, the computer, Prozac, the mobile phone, the Internet. Undoubtedly, these have brought us much good, but each has also changed society in important, fundamental ways and caused new problems, such as increased pollution, urban sprawl, cyber-crimes, privacy concerns, intellectual property concerns, drug dependencies, other unintended health problems, mutually-assured destruction and much more. The point here is not that we would have been better off without these inventions. Rather, we should come to terms that our creations can have unintended or unforeseen consequences. Many of the social problems associated with the aforementioned technologies might have been anticipated and mitigated with some forethought. This is a lesson not lost on policymakers and scientists today, for instance, in having spent millions of dollars to study the ethical implications of decoding the human genome, such as privacy and genetic discrimination concerns. The same lesson, however, apparently was lost on the commercial biotechnology industry, which recently discovered that by ignoring its ethical and social issues – specifically, the possible harm from genetically-modified foods on human health and the environment – they invited a public backlash that crippled progress and sent corporate stocks plummeting. To be sure, no one expects ethicists, scientists, policymakers and other experts to anticipate and address all possible scenarios. It is a plain fact of the human condition that we do not and cannot know everything. We do not fault Thomas Edison, for instance, for the copyright-violating devices that his phonograph would inspire, or Henry Ford for the agonizing commutes we endure daily, or Bill Gates for the email "spam" we receive. Clearly, it is easy to be too conservative or short-sighted in estimating the future impact of technology. The dangers associated with technology can likewise be underestimated, for instance, as was the case with asbestos, lead paint and the pesticide DDT. But this is not just a failing of our distant past. In 2006 alone, a study has suggested that mobile phones, after all our years of using them, can cause brain tumors and infertility. Another study showed that computer manufacturing workers, after decades on the job, are at a much greater risk of death from cancer and other illnesses . In the year2006, the U.S. Environmental Protection Agency concluded that a key chemical (PFOA) used to make Teflon-the ubiquitous material used for the last 50 years in non-stick cookware, carpeting, clothing, food packaging and thousands of other products, and traces of which can be found in the blood of nearly everyone in the US and other developed nations is a carcinogen . Discourse into the ethical and social dimensions of nanotechnology so called "nanoethics" is therefore critical to guide the development of nanotechnology. This anthology provides an introduction to many of the most urgent issues today in nanoethics, focusing on current and near-term debates. First, we need to be clear on what nanotechnology is before we can appreciate the ethical and social questions that arise therein. Nanotechnology is a new category of technology that involves the precise manipulation of materials at the molecular level or a scale of roughly 1 to 100 nanometers – with a nanometer equaling one-billionth of a meter – in ways that exploit novel properties that emerge at that scale. How small exactly is a billionth of a meter? As one journalist had put it, "If a nanometer were somehow magnified to appear as long as the nose on your face, then a red blood cell would appear the size of the Empire State Building, a human hair would be about two or three miles wide, one of your fingers would span the mcontinental United States, and a normal person would be about as tall as six or seven planet Earths piled atop one another".Working at the nanoscale, it turns out that ordinary materials can have extraordinary properties, about which we are still learning. At the nanoscale, quantum physics begins to play a key role in the behavior of materials, and the large surface to volume ratio of elements means that they are much more reactive.

II.CURRENT AND EMERGING WORRIES IN NANOETHICS

If nanoethics is a distinct discipline or even if it is not, but we still understand what the term describes then what are its issues? Again, controversy surrounds even this question. If we are conservative and only acknowledge those issues that will likely or possibly arise from current lines of research in nanotechnology which is primarily focused on the discovery and applications of new nanomaterials then nanoethics certainly covers some of the issues mentioned above: EHS impacts, privacy, human enhancement as well as global security (since the military is a major driver of nanotechnology research to such a degree that some fear a new arms race). Other relevant issues may include research ethics (if some research seems to dangerous to publish or pursue), intellectual property (if today's patent-grab and processes stifle innovation), and humanitarianism (why we are not doing more to solve poverty, hunger, energy, clean water and other problems through nanotechnology). But more imaginative people, such as Drexler, postulate a more advanced form of nanotechnology in our future – sometimes called "molecular manufacturing" by which we can position individual molecules with exact precision. The difference between how we create nanomaterials today (e.g., carbon nanotubes) with precisely positioned molecules, and molecular manufacturing is the difference between engineering and chemistry. Again, throughout history and even now, ideas that have been dismissed as unworkable somehow become reality, despite their technical challenges, so it is not irrational to treat molecular manufacturing, space settlements and so on as a real possibility absent compelling evidence to the contrary. Furthermore, no matter how speculative some of these scenarios seem to be, they provide a useful platform to test our moral principles as at least "thought experiments", which is a commonly-accepted practice in ethics. For instance, no one thinks that anyone would plausibly be kidnapped and surgically connected to a famous violinist – the premature detachment of whom would lead to the violinist's death – but this hypothetical example isolates and tests out intuitions in Judith Jarvis Thomson's discussion about the moral permissibility of abortion. Also, few actually question the wisdom of sending spiders into outer space on the grounds that spiders do not exist and may never exist in space (unless we introduce them into space); yet this sort of experiment is useful to study the relationship between gravity and a spider's ability to orient itself and spin webs by isolating gravity as a variable. Like any other natural or industrial particles that present toxicity risks for living organisms, engineered nanoparticles (which are created voluntarily) also carry risks associated with their manipulation or their deliberate or accidental release into the air, soil, and water. These risks must be taken into consideration in order to protect workers, the public, and biodiversity as a whole:

● Risks tied to the manufacture, handling, transportation, storage, or elimination of potentially toxic or dangerous products

● Risks that laboratory or industrial workers, or any populations who come into contact with toxic powders or products after their release into the air, water, or soil, will inhale or ingest these products or absorb them through the skin

● Risks that products released into the air, water, or soil will contaminate flora or fauna

● Environmental and health risks tied to the reactivity of certain substances. A number of existing statutes and regulations already address such risks withrespect to products not derived from nanotechnology. But other risks, that research has not yet demonstrated, may specifically concern nanotechnology-derived products due to their particular characteristics

● The clustering tendency of engineered nanoparticles and its potential effects on the environment and living organisms

● The ratio of the specific surface of nanomatter compared to its mass, which modifies or intensifies the properties of the original material

● The reactivity of certain nanometric particles, particularly metallic nanopowders, which can lead to explosion, flammability, or toxicity

● The ability of nanomatter to cross the cutaneous, pulmonary, intestinal, placental, and blood-brain barriers that protect human and animal organisms. While there is still very little environmental and epidemiological data to support a process for assessing and managing the risk associated with nanotechnology-derived products, IRSST (a Québec research institute on occupational health and safety)believes it has been clearly demonstrated that the degree of toxicity of nanoparticles is tied to their specific surface and resulting new properties, not their mass .

Lastly, the Commission takes into consideration that the effects of nanoparticles on health and the environment have been studied very little in the laboratory to date, particularly on humans, and the few research results obtained are sometimes contradictory and difficult to reproduce. Some believe that current equipment for measuring exposure to free nanoparticles is inadequate, as are assessment methods for determining the environmental fate of nanoparticles.

In any case, the Commission considers the following issues crucial to assessing the risks associated with engineered nanoparticles, as proposed following a consultation by leading US organizations:

● Assessment of degree of exposure

● Toxicity

● The ability to extrapolate nanoparticle toxicity using non-nanometric particle and fiber toxicity databases

● The environmental and biological fate, transportation, persistence, and transformation of nanoparticles and the recyclability and overall sustainability of nanoparticles.

The Commission believes that the emergence of nanotechnology and the marketing of nanotechnology-derived products clearly pave the way for new health and environmental risk assessment methods.

III. DEVELOPING A CODE OF ETHICS FOR NANOTECHNOLOGY

Codes of ethics signal the seriousness of a group of professionals to think about their impacts and goals. The emergence of professional organizations and professional codes of ethics are an important part in the development of a discipline or sub-discipline. They help provide a professional identity for a field of study. Nanotechnology, being so diverse and distinct because of its diversity, should be developed to address the aims of the many other disciplines it encompasses, but this coming together of disciplines also serves to make the formation or "professionalization" of this field more difficult and complex. How should this profession develop, and what values should it hold? What is its identity? What is the aim of this new field? In other words, what should its code of ethics be? Professionals working with the nanoscale need to be aware of the public's perception when they make statements. The NBIC report, Drexler's Engines of Creation, the NNI reports, and other documents that outline plans for the nanoscale have promised much. The NBIC Report, "Converging Technologies for Improving Human Performance," tries to lay out the possibilities for human improvement with the advancing technologies associated with the convergence of nanotechnology, biotechnology, information technology, and cognitive science. This reports talks about altering the "fabric" of society, initiating a "new renaissance," and converging technologies being "a turning point in the evolution of human society" . However, there are some things that we think a code for nanotechnology should include, despite possible debates in the future. A code of ethics for nanotechnology needs to include a focus on honesty in the representation of data and results both in the public arena and within the community. Right now, the public is being to believe that nanotechnologists are working to create tiny robots, but this perception may lead to disappointment and disaster for nanotechnology as a field. Nanotechnologists need to know what the professional expectations are for their field, and they can work to have these defined by communicating with each other and the public. In nanotechnology, the public arena and engagement with the public are particularly important because of the newness and the hype of the field of nanotechnology. Scientists usually have to answer to other scientists, but, in this case, it might be beneficial to both the field and the public for a broader and more public dialogue on the nature of the field and on the duties of someone working in nanotechnology.Before any mention of honesty is proper in the code, nanotechnologists should first address public safety because of the fear factor associated with popular representations of nanotechnology in the media. Because of the aims toward application that we find in all the funding and founding documents of nanotechnology, the public will be receiving the outcomes.

IV. MORAL REASONS FOR DATA-PROTECTION

4.1 Information-based Harm:

The first type of moral reason for data-protection is concerned with the prevention of harm, more specifically harm that is done to persons by making use of personal information about them. Criminals are known to have used databases and the Internet to get information on their victims in order to prepare and stage their crimes. The most important moral problem with "identity theft" for example is the risk of financial and physical damages. One's bank account may get plundered and one's credit reports may be irreversible tainted so as to exclude one from future financial benefits and services. Stalkers and rapists have used the Internet and on-line databases to track down their victims. They could not have done what they did without tapping into these resources. In an information society there is a new vulnerability to information-based harm. The prevention of information-based harm provides government with the strongest possible justification for limiting the freedom of individual citizens. RFID information could be sniffed, people could be monitored, accurate pictures could be made of what they carry with them and their identity could be stolen. We would also like to prevent that people deceive others by manipulating the information about the nature of objects and present goods as new, when they are old, as edible when they are in fact poisonous, as legitimate when they are stolen, as having cleared customs, when they were in fact smuggled. No other moral principle than John Stuart Mill's Harm Principle" 20 is needed to justify limitations of the freedom of persons who cause, threaten to cause, or are likely to cause, information-based harms to people. Protecting personal information, instead of leaving it in the open, diminishes the likelihood that people will come to harm, analogous to the way in which restricting the access to fire arms diminishes the likelihood that people will get shot in the street. We know that if we do not establish a legal regime that somehow constrains citizens' access to weapons, the likelihood that innocent people will get shot increases.

4.2 Informational Equality

The second type of moral reason to justify data-protection is concerned with equality and fairness. More and more people are keenly aware of the benefits that a market for personal data can provide. If a consumer buys coffee at the shopping mall, information about that transaction can be generated and stored. Many consumers have come to realize that every time they come to the counter to buy something, they can also sell something, namely, information about their purchase or transaction (transactional data). Likewise, sharing information about ourselves on the Internet with web sites, or through sensor technology may pay off in terms of more and more adequate information (or discounts and convenience) later. Many privacy concerns have been and will be resolved in quid pro quo practices and private contracts about the use and secondary use of personal data. RFID sensor, tracking and tracing would turns our environment into a transaction space, where information is generated constantly and systematically. But although a market mechanism for trading personal data seems to be kicking in on a global scale, not all individual consumers are aware of this economic opportunity, and if they do, they are not always trading their data in a transparent and fair market environment. Moreover they do not always know what the implications are of what they are consenting to when they sign a contract or agree to be monitored. We simply cannot assume that the conditions of the developing market for personal data guarantee fair transactions by independent standards. Data protection laws can help to guarantee equality and a fair market for personal data. Data-protection laws in these types of cases protect individual citizens by requiring openness, transparency, participation and notification on the part of business firms and direct marketers to secure fair contracts. Amazon was already accused of price targeting. In general, if a retailer knows that I like product X and bought lots of it, irrespective of its price, then they may charge me more for X than someone who does not know the product and needs to be enticed by means of low prices and discounts.

4.3 Informational Injustice

A third and important moral reason to justify the protection of personal data is concerned with justice in a sense which is associated with the work of the political philosopher Michael Walzer. Michael Walzer has objected to the simplicity of John Rawls' conception of primary goods and universal rules of distributive justice by pointing out that "there is no set of basic goods across all moral and material worlds, or they would have to be so abstract that they would be of little use in thinking about particular distributions". Goods have no natural meaning, their meaning is the result of socio-cultural construction and interpretation. In order to determine what is a just distribution of the good we have to determine what it means to those for whom it is a good. In the medical, the political, the commercial sphere, there are different goods (medical treatment, political office, money) which are allocated by means of different allocation or distributive practices: medical treatment on the basis of need, political office on the basis of desert and money on the basis of free exchange. What ought to be prevented, and often is prevented as a matter of fact, is dominance of particular goods. Walzer calls a good dominant if the individuals that have it, because they have it, can command a wide range of other goods. A monopoly is a way of controlling certain social goods in order to exploit their dominance. In that case advantages in one sphere can be converted as a matter of course to advantages in other spheres. This happens when money (commercial sphere) could buy you a vote (political sphere) and would give you preferential treatment in healthcare (medical), would get you a university degree (educational), etc. We resist the dominance of money—and other social goods for that matter (e.g., property, physical strength)—and think that political arrangements allowing for it are unjust. No social good X should be distributed to men and women who possess some other good Y merely because they possess Y and without regard to the meaning of X. What is especially offensive to our sense of justice. The meaning and value of information is local, and allocation schemes and local practices that distribute access to information should accommodate local meaning and should therefore be associated with specific spheres. Many people do not object to the use of their personal medical data for medical purposes, whether these are directly related to their own personal health affairs, to those of their family, perhaps even to their community or the world population at large, as long as they can be absolutely certain that the only use that is made of it is to cure people from diseases. They do object, however, to their medical data being used to disadvantage them socio economically, to discriminate against them in the workplace, refuse them commercial services, deny them social benefits, or turn them down for mortgages or political office on the basis of their medical records. They do not mind if their library search data are used to provide them or others with better library services, but they do mind if these data are used to criticize their tastes, and character. They would also object to these informational cross-contaminations when they would benefit from them, as when the librarian would advise them a book on low-fat meals on the basis of knowledge of their medical record and cholesterol values, or a doctor poses questions, on the basis of the information that one has borrowed a book from the public library about AIDS. We may thus distinguish another form of informational wrongdoing: "informational injustice", that is, disrespect for the boundaries of what we may refer to, following Michael Walzer, as "spheres of justice" or "spheres of access". I think that what is often seen as a violation of privacy is often more adequately construed as the morally inappropriate transfer of data across the boundaries of what we intuitively think of as separate "spheres of justice" or "spheres of access." RFIDs, and tagging and surveillance technology more generally, allow for a wide range of cross-domain profiling and information processing practices, which do not respect the boundaries of these spheres of access unless they are explicitly designed to do so. What was taken out of the public library is carried into a shop, what was taken from the pharmacist mat travel with you to the workplace. What was collected at the post office may accompany you to school, etc. We would certainly like border controls for RFID tagged objects and in some cases blocked exchanges between certain areas of our lives.

V. FUNDAMENTAL PRIVACY PROBLEMS WITH NANO-ELECTRONICS

Invisibility:

Privacy was construed above in terms of moral reasons for protecting personal Information i.e., moral reasons for putting constraints on the acquisition, processing and dissemination of personal information. The central constraint was informed consent; personal information can only be processed if the data-subject has provided informed consent. The moral reasons for making informed consent a necessary condition were discussed. This indicates that the core problem concerning privacy with nano-electronics is epistemic in nature. It is the fact that we do not know that we are monitored, tracked and traced. Stanley Benn already clearly stated what the problem with this epistemic condition is. We need to distinguish between two cases. First, if the information processing is covert, it is clear that this interferes with our autonomy, because our thinking and choices are tainted by our false assumption—i.e. that we assume we are unobserved. Many of our assumptions and reasoning can be defeated just by adding the information that we are observed. If the information processing is overt, we can adjust to being observed, but we no longer have the prior choice to be unobserved. In both ways our autonomy is compromised. A related but slightly different aspect of invisibility and lack of relevant knowledge was articulated by Jeffrey Reiman in his essay on Automated Vehicle Registration Systems. If unbeknownst to me, my passage from A to B is registered, something strange happens. If asked what I did, I will respond that I drove from A to B. But this is only part of the story. My action could be more adequately described as "I drove from A to B and thereby created a record in the database of the system". In the same way people will have to become aware of the fact that when they buy clothing they could be buying invisible transponders and memory sticks as well. It changes the conditions under which people consent to and intend things. Actions like trying on a coat, carrying a gift out of a shop, or driving from A to B, are no longer what they appear to be. What actually happens is that one buys a gift and one lets the store know which route one followed through the shop. A socio-technological system which obfuscates these mechanisms, robs individuals of chances to describe their actions more adequately. Moreover it seems to violate a requirement of publicity or transparency, articulated by Rawls and Williams among others. The functioning of social institutions should not depend on a wrong understanding of how they work by those who are subject to them. Suppose that ubiquitous and covert surveillance arrangements work well and to the satisfaction of a majority, then they seem to work because those affected by them have a false understanding of why and how they work. This seems to violate a reasonable requirement of transparency. A further fundamental problem needs to be discussed which is relevant to nanotechnology and ubiquitous surveillance by means of RFID and functionally equivalent technology. Is the information concerned personal information and does the data protection laws by implication apply? The answer is affirmative. Although an RFID tag may not contain personal information, although they sometimes do, if it is likely and not excessively expensive or cumbersome, that information can be linked in a back-end database so as to establish a match and add the data to a file which does contain data which can be linked to a natural person, it counts as personal data.

VI. CONCLUSION

It would be unfortunate if government agencies, in the US, China, and elsewhere, squandered this unique opportunity to help direct nanotechnology along a responsible path, improve public confidence in the private and public sectors, and increase the capacity of public institutions to deal with the risks and challenges posed by cutting-edge innovation. The thrust of the arguments presented above is clear: nanotechnology is here and that we, as a global society, are not yet fully prepared to deal with it. The encouraging point is that a collective response—with the US and China as central players—to the aforementioned challenges can still be formulated. Much remains to be done, however, and it cannot be assumed that addressing such transnational nanotechnology governance questions will be easy. In fact, the opposite is true, since nanotechnology's development is expected to test the notion that innovation progresses in a linear and continuous fashion. Due to the rapid pace of R&D, discoveries in nanotechnology could come in great, discontinuous leaps and, in turn, revolutionize society's knowledge and understanding of the physical world in rather short amounts of time. In turn, these technological leaps could come to strain the ability of public institutions and public infrastructure—especially in China, which will likely face an additional host of resource, population, and energy challenges in the coming decades—to respond in an effective and timely manner. While specific analyses of nanotechnology's interface with these larger areas of concern is beginning to occur, it is clear that the expected innovative jumps increasingly associated with nanotechnology's future could make today's issues related to product risk management and internationally coordinated over- sight strategies appear trivial by comparison. Such would be the case in the wake of a high-profile mishap or perceived accident, as occurred with respect to other areas of technological development, such as chemicals (e.g., Bhopal) and nuclear power (e.g., Three Mile Island).In the meantime, in order to make certain that nanotechnology does not "fall through the cracks" of the oversight system, a dual risk management approach must be adopted, one that supports research into nanotechnology's greatest near-term risks and benefits while, simultaneously, looks prospectively to any transformations or shifts in the technology's development that that may occur in the future. Though nanotechnology R&D is currently an effort based largely upon chemistry and materials science, many anticipate that the applications and innovations developed to date are only the tip of the iceberg. Instead, the high priority placed on it in both the US and China will quickly lead nanotechnology to interact with other fields of study—such as biotechnology, information technology, and cognitive science—that could further quicken the pace of both basic research and product development. This convergence of technologies could cause an even greater set of governance challenges than nanotechnology alone, further impacting institutions tasked with the responsibility of managing new technological advances. Since developments in nanotechnology are at the forefront of these potentially radical innovations, the US and China have the chance to think and operate proactively, and work collectively, toward ensuring that the future potential of nanotechnology is realized through sound governance, thoughtful decision-making, and public participation.

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