# Applications and Issues in the Fields of Nanotechnology, Information Technology, Neurotechnology, and Biotechnology

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## Abstract

*Applications and issues in the fields of nanotechnology, information technology, neurotechnology, and biotechnology were discussed. Nanotechnology has been developed fairly recently and regulation is limited, according to some scholars; nonetheless, the scientific community foresees tremendous possibilities with this technology. Advances in information technology are not as recent as nano and neuro technologies; but the field remains transforming the ways in which people communicate and work. Some scholars show concerns in the fashion of regulation and cybercrime; the economic meltdown of 2008 was blamed on the lack of information governance of the banking system. Neurotechnology is highly criticized by some scholars, because of the heavy use of medications to control human behavior; particularly among children. For the purposes of this paper, the focus is on agricultural biotechnology, which has been practiced for decades in the United States. Nevertheless, many other countries still avoid and criticize the use of genetically modified organisms (GMOs).*

**Keywords:** nanotechnology, neurotechnology, information technology, biotechnology, agricultural biotechnology

Technologies such as nanotechnology, information technology, neurotechnology and biotechnology are considered futuristic because these technologies were not employed at its fullest yet and most scholars agree such technologies will keep altering the manner humans live (Cornish, 2004; Kurzweil, 2005; Naisbitt, 2006; Rose, 2005). Nanotechnology is the engineering of products at the molecular or atomic scale; it improves products by shrinking its physical properties (Frankel & Whitesides, 2009). This technology is currently being used in a large array of products such as cosmetics, clothing, sporting goods, personal care, and sunscreen. Information technology utilizes computers and software to manage information, such technology is vital to the survival of operations and logistics of large and medium size businesses (Komkov, Lugovtsev, & Yakunina, 2012). It is responsible for storing, processing, protecting, transmitting and retrieving information.

The developments in neurotechnology can improve the lives of the handicapped and also of individuals with mental illness; however, there are questions about the establishment of what constitutes a mental illness and this issue is further discussed later in this paper. Some examples of already developed neurotechnologies are the CAT scanner, MRI (Magnetic Resonance Imaging) and psychopharmaceuticals. Biotechnology involves the use of living organisms to modify or produce needed products for specific purposes (Singh, Singh, & Ward, 2012). Biotechnology has become important in the fields of agriculture, food, pharmaceuticals, and environmental studies (Singh, Singh, & Ward, 2012). For the purpose of this paper, agriculture is focused since it is one of the most debated topics involving the use of the biotechnology. Genetically engineered crops are more resistant to parasites and its growth can be accelerated with the use of biotechnology. Although the outcomes provided by biotechnology proved to be positive for businesses, some scholars believe it is not under proper governmental regulation, jeopardizing the socio-economic welfare of small farmers (Kinchy, Kleinman, & Autry, 2008). In contrast, alterations in the rate of growth of foods provide a solution for the demands of an increasing world population.

Although these technologies promise to bring an efficient solution to daily life issues and make the demands of the workplace easily resolved; there are serious considerations to be analyzed from such changes in paradigm. Naisbitt (2006) makes a remark on the fact that people rather send text messages or e-mails instead of writing letters with poetry to each other. Although the diminished interest in poetry seems to be evident; a diminished need for the postal service personnel seems to be more troublesome.

Furthermore, Lenzer and Zhao (2012) state that governmental regulations were not enough to keep up with financial innovations and therefore, some financial institutions were able to use information asymmetries to their advantage. Because of such unethical business practices and the governmental inability to oversee lending procedures over the internet, the worldwide financial crisis emerged (Lenzer & Zhao, 2012). The complexity of data sharing through information technology appears to be generating a certain degree of chaos in the financial industry; as information and regulations can be used and interpreted in different ways dependent upon geography (Lenzer & Zhao, 2012). Moreover, the advances in information technology seem to bring questions regarding the need for people in certain lines of work and the possible dislocation of the workforce.

Since the advent of agricultural biotechnology in the early 1970s, the use of genetically modified organisms (GMOs), particularly plants; have become widely accepted (Juma, 2005). In the process of producing genetically modified foods and observing its effects on the environment; researchers have accepted the beneficial outcomes of such technology (Anderson & Nielsen, 2004; Aneja, Chawla, Yadav & Yadav, 2012; Hansson & Joelson, 2012; Juma, 2005; Rawat, Rawat, Mishra, & Mishra, 2012; Vassilev, Eichler-Lobermann & Vassileva, 2012). Although arguments against GMOs have diminished considerably, there is a contrasting view that agricultural biotechnology is actually under little scrutiny from the political arena; as a way to enable big corporations (Kinchy, Kleinman, & Autry, 2008). In other words, the lack of effort in regulating agricultural biotechnology benefits larger companies and harms small farmers (Kinchy, Kleinman, & Autry, 2008).

Unlike agricultural biotechnology, nanotechnology is still under high scrutiny for it's a) insufficient regulation; b) low public awareness, and a c) comparison to asbestos in a possible link to cancer (Andreev, Minashkin, Nevskii, & Putilov, 2009; Austin & Lim, 2008; Brandi, Nobili, Girolamo, Grazi, Fiorentino, Golfieri, & Biasco, 2009; Dyehouse, Diefes-Dux, Bennett, & Imbrie, 2008; Hansen, 2010; Nash, 2012; Schmidt, 2009; Schulte & Salamanca-Buentello, 2007). Nonetheless, several scholars rather abide for the benefits of nanotechnology on the account that a) it has improved drug delivery and solubility, particularly to the brain, due to the existence of blood brain barriers; b) it can reduce chemical waste, and decrease environmental impact; c) it has the capability to be applied to the creation of nanosensors which may improve analysis of gases, liquids, biochemicals, and biological objects; d) biomaterials produced with nanotechnology can be low weight, tough, stiff, and possibly, self-healing; and e) the economic implications for this field are immense, since the Federal research funding for nanotechnology for the 2012 fiscal year was $2.1 billion in the United States (Barthelat, 2007; Bennewitz & Saltzman, 2009; Horton, Khan, & Maddison, 2006; Kaya-Celiker & Mallikarjunan, 2012; Lin, Liu, Song, Liu, & Sha, 2010; Ravichandran, 2009; Shin, An, & Jeong, 2012; Shtykov & Rusanova, 2008).

Neurotechnology is under the same predicament as nanotechnology, possibly because both technologies are fairly new; compared to information technology (IT) and biotechnology. In this respect, there are some researchers who present positive aspects of neuroscience. For instance, Shenoy and Nurmikko (2012) discuss the use of optogenetics to encourage brain recovery from reversible injury. Optogenetics is a neurotechnology which utilizes light to excite, or inhibit neural circuits in the brain (Shenoy & Nurmikko, 2012). This technology may eventually help patients with damage of the nervous system, since it produces a well-defined control of neuronal events with a time resolution of the millisecond (Shenoy & Nurmikko, 2012). There are scholars however, who promote the use of neurotechnology as a non-invasive procedure (Steinerman, 2010).

In this case, scholars rely on the neuroplasticity of the brain to promote cognitive training for the elderly; therefore, coaching interventions are based on cognitive exercises (e.g. classes, workshops, book clubs, mnemonic strategic thinking, brain fitness programs, and so forth). Mathan et al. (2006) suggest that neurotechnology could be used to improve human efficiency in sorting large sets of critical information through the caption of neurophysiological signals associated with early perceptual process. Contrastingly, there are authors who clearly question this new science. At stake, are concerns related to a) a trend in placing neurotechnology as a leading tool for research and diagnosis; b) a decreasing interest in human psychology; c) limitations of this technology; d) alteration in brain activity over time, due to deep brain stimulation; e) the need to further development, and so on (Borgelt, Buchman, & Illes, 2011; Bosl, 2012; Giordano, Abramson, & Boswell, 2010; Walter, Berger, & Schnell, 2009). All of the aforementioned scenarios are further analyzed in this paper. In order to make an educated evaluation of these life-altering scientific advances, it is necessary to scrutinize its pros and cons. The importance of this study lies on the aforementioned premises.

## *Applications and Perspectives in Nanotechnology*

### *Introduction to Nanotechnology*

"Nanoscience, or nanotechnology, is science or technology that creates functional materials from atomic particles" (Dawson, 2008, p. 690). In other words, the science of nanotechnology makes possible for humans to create functioning systems at the molecular scale. Nanotechnology is yet to be fully explored and its effects concerning health and the environment are not entirely known. Nonetheless, this fairly new technology is being widely used. Dawson (2008) stated, "Estimates are that by 2014, more than 15% of all products on the global market will have some kind of nanotechnology incorporated into their manufacturing process" (p. 690). This trend implies that the manipulation of nanotechnology is just beginning.

Even though this new scientific advance has been extensively used, health and environmental concerns are emerging among scientists and scholars. Apprehension is mounting regarding human health and the effects associated to the new technology. Because of its small size, nanomaterials have unique properties and could penetrate into human cells, causing inflammatory responses and oxidative stress (Schmidt, 2009). Some scholars imply that nanoparticles could have similar influence or toxicity in the human body as asbestos (Austin & Lim, 2008). There is not sufficient information to precisely understand the environmental effects of nanotechnology. According to Dawson (2008), "Scientists at the University of Florida have identified potential pathways for engineered nanoparticles that carry mercury into natural systems, and a recent review of potential environmental risks associated with emerging nanotechnologies" (p. 690).

### *Nanotechnology and its Applications*

There are numerous beneficial aspects involving the development of nanotechnology. Scientists predict that nanomedicine could provide replacement organs; nanoengineered artificial red blood cells could hold oxygen longer, allowing people to remain under water for hours, and nano-designed processors might be implanted to allow high brain functioning (Dawson, 2008). Furthermore, this technology applies to IT and communications in the development of sensors, quantum computing, photonics, novel communications, and memory. In terms of environmental applications, energy sources such as solar cells and fuel cells are considered high-efficiency and low-cost (Horton, Khan, & Maddison, 2006). Nanotechnology can be a catalyst for economic and scientific growth; generating new jobs and business opportunities.

Nanoparticles are effective at carrying drugs into the body for, several drug molecules can be encapsulated into a single nanoparticle; henceforth, optimizing the dissolution and solubilization of a drug. According to researchers, the delivery of drugs to the brain will benefit greatly with the advances in nanotechnology; because blood-brain barriers operate as a constrictor of molecular transport. In other words, the capillaries' structural characteristics allow for rather tight regulation of transport of molecules (Bennewitz & Saltzman, 2009; Lin et al., 2010). According to Ravichandran (2009), the emergence of nanotechnology will have positive effects on drug production because of its low toxicity, improved bioavailability, and reduced treatment costs. Shtykov and Rusanova (2008) state that the decrease in costs of instruments for the implementation of nanotechnologies has made nanosensors' research practical; thus, improving the capability to analyze gases and liquids. Shin et al. (2012) discuss nanotechnology in chemical mechanical polishing; used on the fabrication of semiconductors. Such process takes more than 35% of the fabrication of semiconductors and it is important for the reliability of devices and products yielded (Shin et al., 2012). According to the authors, the use of nanotechnology in polishing the semiconductors, has reduced chemical waste; hence diminishing environmental impact (Shin et al., 2012).

Barthelat (2007) and Horton et al. (2006), offer considerations about the future use of nanotechnology. Barthelat (2007) argues that biomimetics are the future of the next generation materials. According to Barthelat (2007), biomimetics represents the science of imitating nature, leading to the production of novel materials with exceptional mechanical properties. In this perspective, the author states that it may enable the production of bio-inspired synthetic materials. Furthermore, he states that the use of biomineralization and self-assembly; in the nanoscale, can revolutionize biomimetics because it enables tight control of the structures. In sum, products made in the nanoscale with the use of synthetic structures may be able to heal or self-assemble without external intervention (Barthelat, 2007). Horton et al. (2006) make predictions related to drug delivery which can be targeted to a specific region of the body, henceforth reducing toxicity to other organs.

The authors state that applications of nanoparticles used for image contrast agents and drug delivery have been clinically approved. Moreover, nanotechnology may be used on the fabrication of sensors capable of testing several chemical reactions at real time, enabling the monitoring of cell or organism function (Horton et al., 2006). Although the use of nanotechnology by the food sector can be dubious for obvious reasons; some scholars make positive remarks. Kaya-Celiker and Mallikarjunan (2012) offer a positive view related to the use of nanotechnology to foods because this technology can improve the receptivity of nutrients by the cells; as well as improved taste, texture, and storage. The authors state that consumers are increasingly interested in foods with added values and enriched with nutrients and because of that, there is a considerable market for nanotechnology in the food industry. Contrastingly, some authors take a conservative view on the matter and refrain from such positive conclusion (Chaudhry et al., 2008). In this perspective, there is a certainty that such foods are to bring beneficial outcomes to the food industry but not necessarily to consumers. Mainly because there is doubt about the toxic nature of these products, as well as a lack of research and regulatory framework (Chaudhry et al., 2008)

### *Contrasting Approach*

The use of nanotechnology by the pharmaceutical or food industry is not yet approved and therefore, all of the aforementioned advances related to nano by-products entering the human body are being tested in laboratories. One of the main concerns regarding the manipulation and consumption of nano by-products is the lack of sufficient toxicity assessments. In sum, studies suggest that nano by-products can decrease toxicity whereas other studies imply that nano by-products can do the opposite. In this perspective, the concern reflects on the size of the nano-particle and the fact that it can enter the cell with ease. In terms of toxicity, many authors compare nano-particle exposure to asbestos exposure; as the particles of such materials can be inhaled and lodged in the lungs, thereby causing cancer (Andreev, et al., 2009; Austin & Lim, 2008; Brandi et al., 2009; Dyehouse et al., 2008; Hansen, 2010; Nash, 2012; Schmidt, 2009; Schulte & Salamanca-Buentello, 2007; Schulte et al., 2008; ).

According to Schmidt (2009), there were approximately $147 million dollars worth of nano by-products sold in 2007 and the figure might go up to $3 trillion by 2015. The author states that risk management institutions such as the National Research Council and the National Nanotechnology Initiative are investigating potential risks for human health and the environment (Schmidt, 2009). Furthermore, until 2009 there were no cases of human toxicity linked to nano materials; as researchers have found the development of tumors in mice were detected when nano particles were injected at extremely high doses (Schmidt, 2009). Nonetheless, it is unknown how the toxicity could manifest in real life human exposure.

## *Applications and Perspectives in Information Technology*

### *Introduction to Information Technology*

Canton (2006) defines information technology (IT) as the "impact of computing, microchips, and the Internet on careers, communications, work, creativity, and entertainment" (p. 73). According to Canton's definition, information technology currently affects the lives of all humans, even if indirectly. The expeditious exchange of information through technology has greatly changed the human condition. The workplace does not necessarily need an address since it can be virtual; henceforth, the integration of conference phone calls, cell phones, fax machines, computers and telephone modems, implies that the office can be anywhere (Willis, 1995). Nanotechnologies have helped IT through the process of shrinking phones, computers, and other electronics; as well as merging them together, facilitating its portability. Information Technology does not connect people only through work. The advances in information technology also facilitate family interactions, since parents can run their business from a home office and care for the children (Willis, 1995). Another positive aspect of information technology involves population shifts, since communication is so easy, people do not need to live in highly inhabited cities (Willis, 1995).

Nonetheless, although advances in IT support human activity in many ways, there are also disadvantageous perspectives. Governments as well as private enterprises spend tremendous amounts of money to keep up with its systems interoperability, security and privacy. Furthermore, information technology made communication amongst terrorists and extremist groups easier as these groups have access to information regarding the production and acquisition of armaments and biological weapons.

### *Information Technology and its Applications*

Unlike nano, bio, and neuro technologies, studies focused on IT have demonstrated more positive than detrimental findings. Clearly, the aforementioned technologies could threat human health whereas IT does not pose such a threat. Furthermore, children from developed countries would not know what it means to (a) never have seen a computer; (b) be in oblivion about the Internet; or (c) have never seen a smart phone. Following this rationale, it is possible to conclude that IT has become a necessary and familiar tool for individuals in developed countries. Although not all people have direct access to computers, it is estimated that by 2015 there will be about 3 billion people connected to the Internet (Canton, 2006). Moreover, developing and underdeveloped countries have expanded and improved in terms of mobile phone usage.

In fact, scholars from developing economies argue about the importance of innovation and its relationship with competitive advantage. Komkov, Lugovstev, and Yakunina (2012) state that although companies in the United States and Germany have intensified its investments in innovation after the financial crisis; Russian companies experienced budget cuts in terms of research and development. The authors imply that Russia's difficulties in overcoming the financial crisis are largely due to its lack of innovation (Komkov, Lugovstev, & Yakunina, 2012). In addition, Arutyunov (2012) proposes that Russian universities should include special IT and information protection courses, to reflect the reality of modern information society. The author also states that Russia is the second country in the world most afflicted by cyber attacks, after the United States (Arutyunov, 2012).

According to Jorgenson and Vu (2005) and Isik (2011), the investments in IT have benefitted developed countries in a greater extent than developing countries. Isik (2011) found that investments in IT have had a positive impact on Turkey's economy in the short run, but negative impact in the long run. The author implies that an explanation for such disparity is based on the fact that economic growth in terms of innovation can only be supported by great investments on information infrastructure on national level (Isik, 2011). Although IT is the most important source of growth for the United States, most of the developing world does not follow suit.

Even with high costs in terms of implementation and maintenance; investments in IT have demonstrated to improve supply-chain operations, consumer knowledge, organizational knowledge, and overall competitive advantage (Clemons, Dewan, & Kauffman, 2006; Ketteni, 2009; Kim & Lee, 2006; Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). Clemons, Dewan, and Kauffman (2006) state that once IT processes are incorporated, there is higher flexibility in supply-chain operations; thereby facilitating outsourcing. The authors imply that outsourcing could, in fact, benefit an industry since organizations can focus on the product it is developing. Such process can cut costs and elevate the quality of products and services; however, the authors state that there is no evidence that companies outsource only for the purpose of cutting expenses (Clemons, Dewan, & Kauffman, 2006).

Some scholars suggest that it is no longer possible to study organizations without taking into consideration the developments in IT. This is mainly because IT affects the dynamics of human interactions (Zammuto et al., 2007). According to Kim and Lee (2006), organizations with effective knowledge-sharing channels are more productive. In this perspective, the authors also discuss public administrators' interest in enabling the integration and sharing of information amongst governmental agencies and networks (Kim & Lee, 2006). Clearly, such an arrangement would facilitate the work of law enforcement agents in tracking criminals.

The use of IT by health care practitioners is often reason for discussion. Although IT is being used by health practitioners, there is a niche for further use. For instance, the Department of Veterans Affairs (VA) has been a leader in the use of IT to organize and manage patient health records (Jackson et al., 2011). The VA actually facilitates for the patient to electronically organize his or her personal health information; the VA website also allows for prescription refill requests (Jackson et al., 2011). It is an ongoing discussion by leaders in the medical field, if practitioners could not only prescribe medications electronically but also assess a patient's health electronically. A study by King et al. (2012) found that all patients surveyed favored face-to-face interaction with health practitioners; however, the majority of the participants demonstrated interest in using technology as a tool to support daily diabetes self-management and to receive customized health information. All surveyed participants opted for the choice to have access to technology, learn how to access personal information; and to communicate with the healthcare team (King et al., 2012).

Furthermore, patients 65 and older emphasized the need for technical assistance to access personal records; whereas all patients emphasized the need for real-time assistance with day-to-day behavioral decision-making (King et al., 2012). An analogy to the banking system can be made. Consider the advents in banking, related to the fact that people are able to make almost all transactions electronically; it is conceivable that the medical field can eventually follow suit. This trend can lower the number of patients' visits to doctors' offices and increase the number of health practitioners consulting via Internet.

### *Contrasting Approach*

As previously mentioned, IT has been widely accepted and the positive aspects of this technology are discussed more often than the detrimental factors. This is true because IT does not pose a direct threat to individuals; furthermore, this technology has been in use for many decades. There are, however, scholars who point out questions which mainly focus on the misuse of IT, as the technology itself will only cause harm if improperly used. As proposed by Nakata, Zhu, and Kraimer (2008), the impact of IT can be demonstrated through social contingency. That is, the organizational effectiveness of IT is only as productive as a favorable organizational climate. Heroux and Fortin (2011) question IT governance and the control of website contents by business executives. According to the authors, there is a general lack of interest and participation from board of directors and senior executives in IT governance (Heroux and Fortin, 2011). IT governance is based on the overall control of the contents posted on an organization's website (Heroux and Fortin, 2011). The authors suggest that executives should learn about IT governance, even though it is not part of the job description. The lack of attention to details related to website contents can be detrimental to many industries, but one of the riskiest misuses of IT relates to banking. Lenzer and Zhao (2012) state that regulation, whether local or international, is not able to keep pace with financial innovation since unethical business practices were observed during the financial crisis initiated in 2008. In short, the process of cutting the middle man through mortgage lending practices; facilitated the misuse of IT in banking. Without an individual to be blamed for handling an incorrect set of data, tainted information can easily and rapidly move from one country to another without being noticed. The efficiency in which information moves in terms of geography can magnify the outcome of an event; whether if it is good or bad.

## *Applications and Perspectives in Neurotechnology*

### *Introduction to Neurotechnology*

According to Canton (2006), neurotechnology is defined by "The use of devices, drugs, and materials to heal, manage, and enhance mental performance and functioning" (p.73). Such technology is already being utilized in the treatment of depression, attention deficit disorder, and restoration of lost motor functions. Motor impairment troubles a great number of individuals and mobility, communication and independence can be profoundly limited by a paralyzing disorder. Scientists are currently working on neuromotor prostheses, which work as a brain-computer interface (BCI); that guides movement by controlling the existing neural substrate, for actions related to neuronal activity patterns in motor areas. People suffering from tetraparesis caused by spinal cord injury, brainstem stroke, muscular dystrophy, or amyotrophic lateral sclerosis, can benefit from neuromotor prostheses.

In contrast, advances within pharmacology are currently causing ethical debate. University students are known to be using methylphenidate (Ritalin), which is a drug used for attention deficit hyperactivity disorder, in order to have greater focus and study (Butcher, 2003). This drug is also known for being overly used to control unruly children within poor urban school districts, hence bringing neurotechnology to ethical concerns.

There are tremendous business opportunities related to the field of neurotechnology. Numerous psychological and motor related illnesses can be treated; and sectors such as neurodiagnostics, neurodevices and neuropharmaceuticals, are estimated to generate billions of dollars in profits. The antagonistic effect of this trend lies on the possibility of scientific manipulation of the human brain towards social injustice. Some scholars are concerned about what would happen if the level of normal cognitive performance is increased, as it is possible, that only the wealthy might have the means of obtaining the new level of normal (Butcher, 2003).

### *Neurotechnology and its' Applications*

Neuromotor prostheses along with brain-computer interfaces (BCIs) have been used to facilitate movement for individuals with paralysis for about a decade (Hochberg et al., 2006; Santhanam et al., 2006). Although such technology helps individuals impaired by restricted mobility, researchers are developing higher performance neurotechnologies. One of the latest advances in neurotechnology is the use of electrical current to stimulate neurons and facilitate the recovery related to brain injury (Shenoy & Nurmikko, 2012). Researchers have found that light-induced modulation through optogenetics facilitates neural cell excitation and inhibition, capable of managing neuronal events by the millisecond time resolution (Shenoy & Nurmikko, 2012). Optogenetics is the process of enabling light to reach the neural cell; henceforth, producing such rapid response. The importance of this technology relates not only to enabling disabled individuals to move but, it also facilitates the possibility of real time movement. There are, however, scholars who reject such neurotechnology as discussed later in this paper.

Goldberg (2009) and Steinerman (2010), agree with the idea of brain plasticity; meaning that the brain can change based on environmental factors. Goldberg (2009) states that individuals who pursue advanced education are less likely to suffer from dementia, including Alzheimer's disease. Furthermore, the author suggests that the nature of the work of highly educated people forces vigorous mental activities that prevent dementia, as the brain has additional neural connections and blood vessels (Goldberg, 2009). Steinerman (2010) focuses his work on coaching interventions to brain enhancement for the elderly and for patients with brain trauma. This perspective agrees with Goldberg's (2009) idea that brain plasticity can minimize the occurrence of dementia.

### *Contrasting Approach*

Because neurotechnology is in its early stages, there are many contrasting approaches. The analogy is similar to the field of biotechnology, when genetically modified foods started to be consumed by the general population. Interestingly, in the field of neurotechnology, two groups seem to have reached the status of opponents. There are scholars who follow the black-box approach and scholars who follow reductionism. The black-box approach, or purely functional approach, is mainly perceived by the studies of psychologists, focused on relationships amongst people and groups. In this perspective, group environment and interactions have a great effect on human behavior. Rose (2005) suggests that businesses and governments have interests in neurotechnology; mainly because it leads to financial gain and population control. According to the author there is an out of control use of psychotropic drugs such as Prozac; he claims that there is no interest in finding the reason as to why there are so many people with depression (Rose, 2005). Henceforth, it is much easier to prescribe Prozac to a person claiming to be depressed, than it is to try to find out why the person is depressed. The same is true for the diagnosis of Attention Deficit Hyperactive Disorder (ADHD), primarily in children (Rose, 2005).

Furthermore, the author calls for an epidemic in the prescription of Ritalin; which is used to treat individuals with ADHD. He believes that people are being brainwashed to believe that there are issues with the functionality of each one's brains; instead of focusing on a broader social problem (Rose, 2005). This context could infer a possible paradox of the modern society. Instead of analyzing how schools and parents deal with the children's needs, the focus becomes on the children's defective brains. Furthermore, Walter, Berger, and Schnell (2009), extensively criticize the use of neurotechnologies to understand human pain. The authors suggest that functional Magnetic Resonance Imaging (fMRI), cranial computer tomography (CCT), and transcranial magnetic stimulation, are being overly used to understand what causes pain in humans (Walter, Berger, & Schnell, 2009).

Ramachandran (2011) is, contrastingly, an advocate of reductionism. He criticizes psychology because it predicts phenomena in a superficial way. In other words, it does not explain phenomena in depth; but just the superficial part, without ramifications (Ramachandran, 2011). According to Ramachandran (2011), the key to understand the brain is to map function unto structure; which reflects the reductionist way of thinking. He has concluded that the great conflict between neurology and psychology is that research in neurology receives much greater financial support than research in psychology (Ramachandran, 2011). Furthermore, he discredits some of Freud's work by revealing that brain injury has caused some of his patients to behave in ways that appear erratic (Ramachandran, 2011). Aside of the battle between purely-functional approach scholars and reductionist scholars; there are yet, authors who criticize the use of brain-computer interfaces, as it may cause alteration in brain activity over time, due to deep brain stimulation (Giordano, Abramson, & Boswell, 2010).

This perspective conflicts with Shenoy and Nurmikko (2012), as previously discussed. Borgelt, Buchman, and Illes (2011), demonstrate concern about neurotechnology becoming the leading tool in neuroscience research, as most providers demonstrate great commitment to brain scans when diagnosing mental illness. The authors indirectly question the future of psychology and psychiatry, somewhat like Ramachandran.

## *Applications and Perspectives in Biotechnology*

### *Introduction to Biotechnology*

Biotechnology is defined as the impact of genomics on health care, life extension and medicine, as well as the deciphering of DNA and life sciences (Canton, 2006). The use of biotechnology is currently applied to genetically modified crops and animals, longevity medicine, biological engineering, bioremediation and biodegradation. The advances in biotechnology could benefit the health care system tremendously. Tucker (2008) states that it is possible that researchers might find cures for diabetes and certain cancers, parents might be able to screen their children for autism even before they are born. Furthermore, antiaging activist Aubrey de Grey has identified "several types of accumulating human tissue damage that cause the symptoms of old age and rejuvenation therapies that might undo each" (Docksai, 2008, p.61). Aubrey de Grey believes it is possible to reverse the human aging process with the use of biotechnology.

In contrast, biotechnology could bring to life an artificial world, were babies are custom made. People could develop different kinds of cancer or even experience genetic mutations for eating genetically modified foods. Kinchy et al. (2008) states that "One of the main objections to ag-biotech is that it has the potential to negatively impact national agricultural economics by accelerating consolidation and small farm loss, creating farmer dependence on multinational corporations, and driving prices down by stimulating over production" (p.147).

For the purposes of this paper, however, the discussion is focused on agricultural biotechnology. The United States has been producing genetically modified foods for over 30 years. The main applications of biotechnologies within agriculture are bovine growth hormone, which ensures bovines grow faster and produce more milk; and genetically engineered crops that produce their own pesticide (Kinchy et al., 2008). Although a large number of people have consumed genetically modified food for many years, and such foods are approved by the Food and Drug Administration; there is still debate whereas certain illnesses are yet to arise because of modified foods.

### *Agricultural Biotechnology and its' Applications*

Because agricultural biotechnology has been used for so many years; openly in America and in other countries, the focus of the debate has become more political and less scientific. The scientific community has demonstrated interest in this field as it has been proved to solve environmental problems, grow crops faster, and enhance the soil. Hansson and Joelsson (2012) state that agricultural biotechnology can help minimize the use of pesticides irrigation, tillage, and fertilizers. It can decrease the size of the land used to grow crops; reducing hence, the $CO^2$ originated from agriculture and improving biodiversity (Hansson & Joelsson, 2012). Furthermore, the authors suggest that human health can be improved when pesticides are not necessary and the nutritional value of food can be increased (Hansson & Joelsson, 2012).

Aneja et al. (2012) discuss the use of marker-assisted breeding, as it has gained momentum, for it does not need biosafety regulations. The authors claim that the marker is tightly linked to the trait of interest; such as resistance to pathogens, tolerance to abiotic stresses, resistance to insects, and so forth (Aneja et al., 2012). The authors cited the following crops in which this process applies: broccoli, tomato, tartary buckwheat, durum wheat, mulberry, okra, ganoderma, pea, cucurbits, apricot, and buffalo grass (Aneja et al., 2012). Another study stresses the need for the use of agricultural biotechnology because of the growing population and increase in food prices (Vassilev, Eichler-Lobermann, & Vassileva, 2012). In this perspective, the authors argue for soil enhancement by the use of P-solubilizing microorganisms (Vassilev, Eichler-Lobermann, & Vassileva, 2012). These microorganisms can facilitate crop production even in areas where there are abiotic adverse factors; such as drought, high or low temperature, and salinity (Vassilev, Eichler-Lobermann, & Vassileva, 2012).

### *Contrasting Approach*

Since its advent in the 1970s, biotechnology has been openly used in the United States, Canada, Japan, and Western Europe (Anderson & Nielsen, 2004; Juma, 2005; Niosi, Hanel, & Reid, 2012).

Because the United States has its economic roots in capitalism and Canada follows a somewhat socialist agenda; the United States has a more permissive regulatory agenda in terms of biotechnology policies (Montpetit, 2005). This scenario appears to be true regarding the present debate about agricultural biotechnology; a paradigm that is mostly focused on political than scientific debate. Kinchy, Kleinman, and Autry (2008), highly criticize the government of the United States for accepting the use of agricultural biotechnology as a tool of wealth. The authors state that the elites control the market and that there is not enough regulation related to agricultural biotechnology (Kinchy, Kleinman, & Autry, 2008).

In the political paradigm, researches' findings have reached similar endings; in this view, scholars found that (a) the more people know about agricultural biotechnology, the less likely people are to accept it; (b) governmental regulations are influenced by the market or by the populace; (c) people favor ideas that are transmitted by a trusted institution rather than technical knowledge; hence, government approval means populace approval; (d) the level of awareness of GMOs amongst Americans is about 50%; (e) the media has a significant impact on people's opinions about GMOs; (f) Americans' opinions about GMOs change according to the media (Brossard & Shanahan, 2007; Fink & Rodemeyer, 2007; Kolodinsky, 2007).

Interestingly, the acceptance or dismissal of agricultural biotechnology appears to follow a nation's, or regions', political and cultural orientations. Germans are highly critical of this technology, according to scholars, this tendency relates to governmental lack of trust and controllability; possibly related to the rise of the Nazi (Peters & Sawicka, 2007). Eastern European countries are more likely to accept GMOs; whereas Western European countries are less likely to use such technologies. Brazilian authorities have disapproved the use of GMOs, however, it is known that GMOs are being used without public awareness through corrupted sources (Massarani & Moreira, 2007). Furthermore, the cultural paradigm against the GMOs reflects partially, on the aversion to the American imperialism (Peters & Sawicka, 2007).

## *Conclusion*

Jasanoff (2005) wisely points out the inherent and axiomatic distaste humans have for change, by stating that the public has distrust and antipathy for issues raised by rapid advances. Clearly, it is possible to notice how new technologies are more scrutinized than technologies that have been used for decades. The criticism regarding information technology and agricultural biotechnology are less harsh than the criticism around nano and neuro technologies. A simple explanation to this behavior is the fact that people have learned to adapt and accept these technologies. There are, however, issues related to regulation as opposed to a fear of immediate danger. In this perspective, some scholars point out that information technology lacks enough governmental surveillance in terms of medical privacy, cybercrime, and the manipulation of the banking system. The manipulation of the banking system is blamed as the cause of the 2008 economic crisis that affected most of the world's economy.

Agricultural biotechnology has been practiced in the United States for approximately four decades. Considering the fact that no scientific data has linked the manipulation of foods to human diseases; the public and the government have accepted the technology. Nonetheless, some countries, mainly Western European, still resist the implementation. Furthermore, the acceptance or dismissal of agricultural biotechnology seems to have roots in a nation's culture and political ideology. In other terms, it is possible that the refusal to accept GMOs is based on the refusal to accept the American imperialism; or yet, to accept market intervention in such great scale. Nevertheless, it is important to point out the significance of the media in bending populace judgment. Recently, Americans have been avoiding products with high fructose corn syrup and transgenic organisms on its' product label. Even more interesting, organic foods have become the food of the elite, since it is more expensive than the modified foods. The status quo of fifty years ago has become a luxury today, since the foods sold fifty years ago were mainly produced as today's organic. In this fashion, a niche has opened in the United States, for markets that only sell non-GMO foods.

Conversely, neuro and nano technologies are highly scrutinized, as these technologies are not yet exhaustively tested. Neurotechnology scholars are in a current battle between the psyche and brain physiology. This could be exemplified by Freud in one side, trying to explain human behavior through a person's conscious and unconscious feelings. On the other side, there is Ramachandran (2011), explaining that the physiology of the brain makes a person more or less gifted; or more or less inclined to be a psychopath, and so on.

Although such interaction appears highly interesting for the educated mind, there is also a tremendous downfall related to the abuse of prescribed medications, pointed out by Rose (2005). Furthermore, it appears that there is absolutely no governmental intervention to the amount of medication, particularly Ritalin, being prescribed to children. Nanotechnology becomes part of neurotechnology on the account that many medications used for brain related illnesses benefit from nano particles to penetrate brain barriers. Such discovery is clearly beneficial to individuals suffering from seizures, for instance. Furthermore, some scholars appear to be very enthusiastic about this technology; as many products can be modified to fit one's needs. Conversely, some scholars scrutinize the fast approach towards nanotechnology, since nano particles could potentially penetrate human skin tissue and possibly cause cancer. There is no doubt that this scientific field needs many more years of testing and governmental regulation.

In terms of limitations, it is impossible to cover every single aspect of these life-altering technologies. Biotechnology, for instance, could be directly related to nano, neuro, and information technologies. Information related to stem cell research, animal cloning, and life extension, was not covered in this paper. Furthermore, the applications and issues related to each technology could be much further investigated in separate studies. Nonetheless, technology must be observed from a macro perspective as well. Technologies are in fact, connected and the consequences of the developments of one technology can easily affect the next. For instance, nanotechnology furthers the development of neurotechnology by making better medications, and so forth.

Finally, the following questions arise: what is the extent of control that the media, the markets, and the governments have on consumer behavior? What type of regulation controls the use, or abuse, of Ritalin and the like, for children? How does the government study or observe the high use of mood elevators among the population? Why is there a governmental program in place to combat obesity, but not the excessive use of Ritalin? How can governments avoid the misuse of IT by the banking system? Can the organic food paradox become a trend worldwide? As neurotechnology receives increased funding from private patrons and research institutions, what is the future of psychology as a scientific field?

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