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Nanotechnology and its Application

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Abstract

Nanotechnology is new frontiers of this century.The world is facing great challenges in meeting rising demands for basic commodities (e.g.,food, water and energy), finished goods (e.g., cellphones, cars and airplanes) and services (e.g., shelter,healthcare and employment) while reducing and minimizing the impact of human activities on Earth's global environment and climate. Nanotechnology has emerged as a versatile platform that could provide efficient, cost-effective and environmentally acceptable solutions to the global sustainability challenges facing society. In recent years there has been a rapid increase in nanotechnology in the fields of medicine and more specifically in targeted drug delivery.opportunities of utilizing nanotechnology to address global challenges in (1) water purification, (2) clean energy technologies, (3) greenhouse gases management, (4) materials supply and utilization, and (5) green manufacturing and chemistry. Smart delivery of nutrients,bio-separation of proteins, rapid sampling of biological and chemical contaminants, and nanoencapsulation of nutraceuticals are some of the emerging topics of nanotechnology for food and agriculture.

Keywords: Nanotechnology, Nanomaterial, drug delivery.

1. Introduction

Nanotechnology, introduced almost half century ago, is one of the most active research areas with both novel science and useful applications that has gradually established itself in the past two decades.Not surprisingly, it is observed that expenditure on nanotechnology research is significant. The U.S. National Nanotechnology Initiative (NNI) expenditures exceed $1 billion each year, with the President's 2008 budget for

NNI at $1.5 billion. However, the research is mainly moving forward motivated by immediate profitable return generated by high value commercial products [1].According to a study by the Canadian Program on Genomics and Global Health (CPGGH), nanotechnology in construction ranked 8 of 10 applications that most likely have impact in the developing world [2].

2. Nanotechnology Basics

Nanotechnology is the creation of materials and devices by controlling of matter at the levels of atoms, molecules, and supramolecular (nanoscale) structures [3]. It is the use of very small particles of materials to create new large scale materials [4].To better understand the difference among various scales, Table 1 shows the categories of scales and its related topics[5].

Table 1: Scales vs. Topic Areas.

Scales	Relates Topics (not inclusive)
	10-2 Quantum Mechanics Molecular Dynamics
10-3	Nanomechanics Molecular Biology Biophysics Elasticity
10-6	Plasticity Dislocation
10-9	Mechanics of Materials
10-0	Structural Analysis

Nanotechnology is not a new science or technology. It was believed first introduced by Richard P. Feynman in his lecture at the California Institute of Technology in 1959. However, the research on this has been very active only in recent two decades. This is because the development and application of nanotechnology are relying on the development of other related science and technology such as physics and chemistry that are commonly new to break through at that time.Most promising developments of nanotechnology are fullerene (a new form of carbon, C60) and carbon nanotubes[6]. In Figure 1, are “a grapheme sheet rolled into a cylinder with specific alignment of hexagonal rings.”[6].

3. Applications of Nanotechnology

At nanoscale, materials have novel properties like increased strength, resiliency, electrical conductivity[7,8]. One of the most common example of nanodevice is the iPod Nano which uses microscopic memory chips for increasing the storage capacity. Life sciences combined with nanotechnology has given rise to nanobiotechnology that has been given insights in to disease processes, hence identifying more efficient biomarkers and understanding the mechanism of drug action[9]. Abraxane® a chemotherapic agent created by Abraxis is another lively example. Bioscience is used to destroy the tumor cells. The chemotherapy is delivered directly into tumour cells because tiny particles penetrate cell membrane easily[10]. Nanomaterials are used in treating glaucoma patients also. Many vaccines like hepatitis and malaria are also utilizing nanotechnology[11]. Nanomaterial vaccines are used to produce greater immunity to pathogens by delivering medications directly to specialized dendritic cells in the immune system[12]. Glucose level are being monitored with the help of patient monitoring devices. Miniature biochips detect increase in glucose level[13].

3.1 Drug Delivery System

At present, 95% of all new therapeutic system have poor pharmokinetics and less developed biopharmaceutical properties[14]. There is no such medicinal system that delivers drug and distribute therapeutically active drug molecules to the site of action or inflammation without any side effects[15]. This problems are overcome by nanotechnology drug delivery system which possess multiple desirable attributes. Nanomedicine has a size such that it can be injected without occluding needles and capillaries which enables targeted drug delivery and medical imaging[16]. Thus nanosized liposomes, micelles, nanoemulsions, nanogels are used for this purpose.

3.2 Implications of nanotechnology

Implantations of nanotransmitters and nanosensors within individuals have opened gates for monitoring and treating them at the microscopic level with the use of nanodevices.But this crosses traditional bounderies of care in the hospitals as persons can get the treatment done while siting in their homes[17].Pateients at home could have access to date transmitted from biochips which will moniter the diseases like hypercholesterolemia, alerting them when critical levels are obtained. Patients and clinicians would need to have throughout knowledge of device interfaces as all body metabolism will be regulated by these devices. The day may not be far than insurance deny us as money due to monitoring our health at cellular level in early stages[18]. Nanotechnology will make us over dependent on devices. Inaccurate and errors with monitoring devices will be very challenging to detect. Advocates will be needed by everyone for safe and ethical use of nanomaterials[19]. Monitoring methods would be needed to assure that devices are checked and caliberated within safety limits. Hence if these implications can be managed nanotechnology is the biggest boon to mankind.

3.3 Targeted drug therapies for treatment of cancer

If scientists can load their cancer-detecting gold nanoparticles with anticancer drugs, they could attack the cancer exactly where it lives. Such a treatment means fewer side effects and less medication used. Nanoparticles also carry the potential for targeted and time-release drugs. A potent dose of drugs could be delivered to a specific area but engineered to release over a planned period to ensure maximum effectiveness and the patient's safety[20].These treatments aim to take advantage of the power of nanotechnology and the voracious tendencies of cancer cells, which feast on everything in sight, including drug-laden nanoparticles. One experiment of this type used modified bacteria cells that were 20 percent the size of normal cells. These cells were equipped with antibodies that latched onto cancer cells before releasing the anticancer drugs they contained.

From manufacturing to medicine to many types of scientific research, nanoparticles are now rather common, but some scientists have voiced concerns about their negative health effects. Nanoparticles' small size allows them to infiltrate almost anywhere[21]. That's great for cancer treatment but potentially harmful to healthy cells and DNA. There are also questions about how to dispose of nanoparticles used in manufacturing or other processes. Special disposal techniques are needed to prevent harmful particles from ending up in the water supply or in the general environment, where they'd be impossible to track.

3.4 Gene-Silencing Nanoparticles

The researchers attach a protein (transferrin) that normally delivers iron to cells so that it delivers short interfering RNA (siRNA) molecules to cancer cells. The main function of RNA is protein synthesis within a cell. siRNA molecules are a class of RNA molecules that interfere with the expression of particular genes[22]. The researchers encased the siRNA payload with sugar-containing polymers to create nanosized particles. Attaching transferrin molecules to the outer surface of a nanoparticle is one of the methods used to target nanoparticles to cancer cells. The nanoparticles will seek out cancer cells that overexpress the transferrin receptor.The gene-silencing siRNA nanoparticles are injected into the bloodstream and pass through blood vessels into the surrounding tissue. When the siRNA nanoparticles enter the tumor cells, acidic substances cause the nanoparticles to release the siRNA. The siRNA shuts down (silences) particular genes by leading to the degradation of the RNA transcripts of these genes throwing a monkey wrench into the cellular machinery and halting the multiplication of cancerous cells.To test their approach they tried it on laboratory mice with Ewing's sarcoma tumors. They designed the siRNA to target a specific growth-promoting gene that is only active in Ewing's sarcoma tumors, the EWS-FLI1 gene[23]. Their siRNA inhibits expression of EWS-FLI1, this shuts down part of the cellular machinery in the cancerous Ewing's sarcoma cells so they should stop multiplying. This treatment technique should have fewer side-effects than traditionally administered chemotherapy (which affects all dividing cells in the body, both healthy and cancerous) since the nanoparticles are doubly targeted to the cells that overexpress the transferrin receptor and have the EWS-FLI1 gene—i.e., the tumor cells. The ingested siRNA nanoparticles only exert their effect in cells that contain the EWS-FLI1 gene—i.e., they have no effect when taken in by normal cells. After three consecutive days of treating 50 mice, they observed, "strong, but transient, inhibition of tumor growth. However, when used over longer durations (twice-weekly injections up to four weeks), the results were striking. Long-term treatments with this delivery system markedly inhibited tumor growth, with little or no tumor growth in many animals.[24]”

4. Conclusion

Nanotechnology has brought a revolution in manufacturing materials, creating a vast number of new devices, drug delivery systems and monitoring and diagnosing systems. but the implications if this technology are very diverse, impacting consumers, clinicians and the practice of informatics. A major area of concern for health care providers is the ethical use of nanomaterials. Nanotechnology has brought a new era in healthcare but the challenges is to develop it by overcoming various difficulties and implications. New opportunities have provide us with a powerful tool in the field of genomics, proteomics, molecular diagnostics and high throughout screening. Nanoparticles have the properties to become the most versatile materials for developing diagnostics. Advances in nanotechnology will provide a good inside view of our human systems. It has a bright future with the emergence of several promising approaches for delivery of therapeutics agent and imaging using the advantage of nanoscale carriers. Future studies will now be addressing a no. of challenges faced in nanomedicine application. Greater funds are being allocated for clinical and pre-clinical studies but still are studies are lacking in safety data that includes toxicity studies. Also the cost of nanomedicine should be in acceptable range so that it is successful in clinics. Nanotechnology is being applied at all stages of drug development, from formulations for optimal delivery to diagnostic applications in clinical trials. Actual utilization of nanotechnology novel drug delivery techniques lag behind because of perception that such technologies could delay products due to technical or regulatory reasons. So oral drug delivery remains a prefered option. Further the cost factor becomes a hinderance in its daily use.

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