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Nanotechnology and its Applications in Medicine

Anna Pratima Nikalje*

Department of Pharmaceutical chemistry, Y.B. Chavan College of Pharmacy, Dr. Rafiq Zakaria Campus, Rauza Bagh, Aurangabad- 431001, Maharashtra, India

Abstract

Nanotechnology is the study of extremely small structures, having size of 0.1 to 100 nm. Nano medicine is a relatively new field of science and technology. Brief explanation of various types of pharmaceutical nano systems is given. Classification of nano materials based on their dimensions is given. An application of Nanotechnology in various fields such as health and medicine, electronics, energy and environment, is discussed in detail. Applications of nano particles in drug delivery, protein and peptide delivery, cancer are explained. Applications of various nano systems in cancer therapy such as carbon nano tube, dendrimers, nano crystal, nano wire, nano shells etc. are given. The advancement in nano technology helps in the treatment of neuro degenerative disorders such as Parkinson's disease and Alzheimer's disease. Applications of nano technology in tuberculosis treatment, the clinical application of nanotechnology in operative dentistry, in ophthalmology, in surgery, visualization, tissue engineering, antibiotic resistance, immune response are discussed in this article. Nano pharmaceuticals can be used to detect diseases at much earlier stages.

Keywords: Nano devices; Nano material; Nano medicine; Nano pharmaceutics; Drug delivery

Introduction

Advancement in the field of nanotechnology and its applications to the field of medicines and pharmaceuticals has revolutionized the twentieth century. Nanotechnology [1] is the study of extremely small structures. The prefix "nano" is a Greek word which means "dwarf". The word "nano" means very small or miniature size. Nanotechnology is the treatment of individual atoms, molecules, or compounds into structures to produce materials and devices with special properties. Nanotechnology involve work from top down i.e. reducing the size of large structures to smallest structure e.g. photonics applications in nano electronics and nano engineering, top-down or the bottom up, which involves changing individual atoms and molecules into nanostructures and more closely resembles chemistry biology.

Nanotechnology deals with materials in the size of 0.1 to 100 nm; however it is also inherent that these materials should display different properties such as electrical conductance chemical reactivity, magnetism, optical effects and physical strength, from bulk materials as a result of their small size.

Nanotechnology works on matter at dimensions in the nanometer scale length (1-100 nm), and thus can be used for a broad range of applications and the creation of various types of nano materials and nano devices.

History of Nanotechnology

The development in the field of nanotechnology started in 1958 and the various stages of development have been summarized in Table 1.

Nano scale and Nanostructures

The nano scale is the place where the properties of most common things are determined just above the scale of an atom. Nano scale objects have at least one dimension (height, length, depth) that measures between 1 and 999 nanometers (1-999 nm) (Figure 1).

The brief explanation of pharmaceutical nano system is as follows: As shown in the schematic diagram (Figure 2), pharmaceutical nanotechnology is divided in two basic types of nano tools viz. nano materials and nano devices. These materials can be sub classified into nano crystalline and nano structured materials. Nano structure consists of nano particles, dendrimers, micelles, drug conjugates, metallic nano particles etc.

Carbon nano tubes: These are small macromolecules that are unique

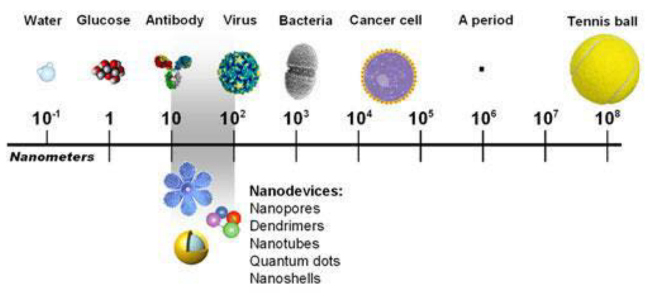

Figure 1: Nanoscale and nanostructures.

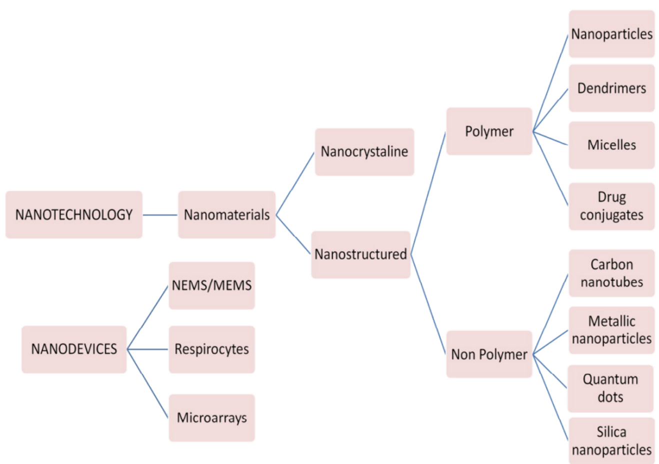

Figure 2: Schematic diagram of various types of pharmaceutical nano systems.

***Corresponding author:** Department of Pharmaceutical Chemistry, Y.B. Chavan College of Pharmacy, Dr. Rafiq Zakaria Campus, Rauza Bagh, Aurangabad- 431001, Maharashtra, India, Tel: +91 9823619992, E-mail: annapratimanikalje@gmail.com

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Year	Development in nanotechnology
1959	R. Feynman initiated thought process
1974	The term nanotechnology was used by Taniguchi for the first time.
1981	IBM Scanning Tunneling Microscope
1985	"Bucky Ball"
1986	First book on nanotechnology Engines of Creation published by K. Eric Drexler, Atomic Force Microscope
1989	IBM logo was made with individual atoms
1991	S. Iijima discovered Carbon Nano tube for the first time.
1999	1st nano medicine book by R. Freitas "Nano medicine" was published
2000	For the first time National Nanotechnology Initiative was launched
2001	For developing theory of nanometer-scale electronic devices and for synthesis and characterization of carbon nanotubes and nano wires, Feynman Prize in Nanotechnology was awarded
2002	Feynman Prize in Nanotechnology was awarded for using DNA to enable the self-assembly of new structures and for advancing our ability to model molecular machine systems.
2003	Feynman Prize in Nanotechnology was awarded for modeling the molecular and electronic structures of new materials and for integrating single molecule biological motors with nano-scale silicon devices.
2004	First policy conference on advanced nanotech was held. First center for nano mechanical systems was established, Feynman Prize in Nanotechnology was warded for designing stable protein structures and for constructing a novel enzyme with an altered function.
2005-2010	3D Nano systems like robotics, 3D networking and active nano products that change their state during use were prepared.
2011	Era of molecular nano technology started

Table 1: Periodical development in nanotechnology.

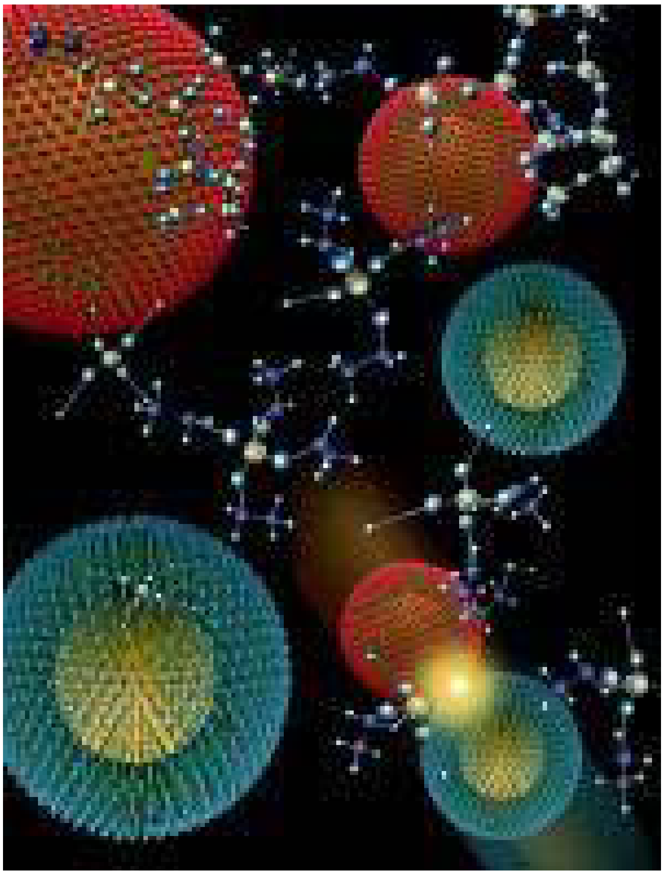

Figure 3: Surface functionalized gold nano particles.

for their size, shape, and have unique physical properties. Nano tubes have some special advantages over other drug delivery and diagnostic systems (Figure 3) due to their unique physical properties.

Metallic nano particles: Metallic nano particles have used in drug delivery, especially in treatment of cancer and also in biosensors. Amongst various metals, silver and gold nano particles are of prime importance for biomedical use (Figure 3).

Liposomes: These have been extensively explored and most developed nano carriers for novel and targeted drug delivery due to their small size, these are 50-200 nm in size. When dry phospholipids are hydrated, closed vesicles are formed (Figure 4). Liposomes are biocompatible, versatile and have good entrapment efficiency. It finds application as long circulatory and in passive and active delivery of gene, protein and peptide.

Dendrimers: Dendrimers are hyper branched, tree-like structures. It contains three different regions: core moiety, branching units, and closely packed surface (Figure 5). It has globular structure and encloses internal cavities. Its size is less than 10 nm. These are used for long

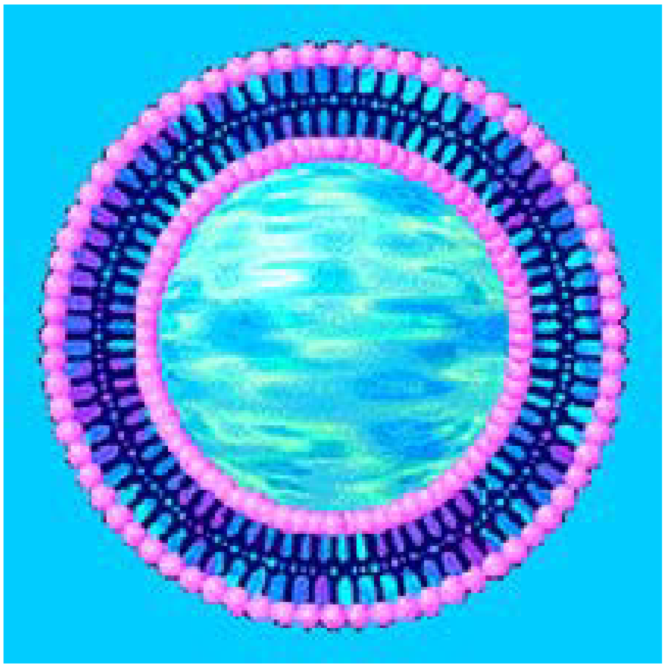

Figure 4: Structure of Liposomes.

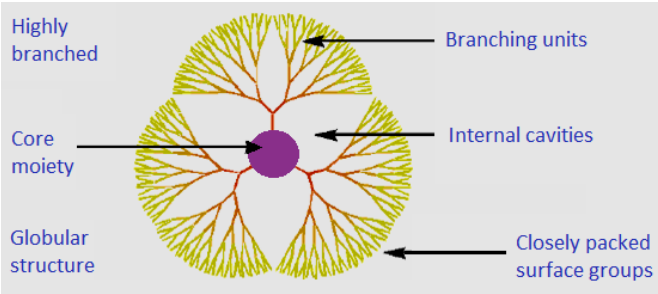

Figure 5: Schematic representation of a dendrimers showing core, branches, and surface.

circulatory, controlled delivery of bioactive material, targeted delivery of bioactive particles to macrophages and liver targeted delivery.

Classification of Nano Materials

Nano materials can be classified dimension wise into following categories:

Classification Examples

- Nano rods, nano wires have dimension less than 100 nm.
- Tubes, fibers, platelets have dimensions less than 100 nm.
- Particles, quantum dots, hollow spheres have 0 or 3 Dimensions < 100 nm.

On the basis of phase composition, nano materials in different phases can be classified as,

- The nano material is called single phase solids. Crystalline, amorphous particles and layers are included in this class.
- Matrix composites, coated particles are included in multi-phase solids.
- Multi-phase systems of nano material include colloids, aero gels, Ferro fluids, etc.

Manufacturing Approaches

The two major approaches [2] to get nano materials are -one is the bottom up and the other is top down approach. Bottom up produce components which are made of single molecules, and covalent forces hold them together that are far stronger than the forces that hold together macro-scale components. Enormous amount of information could be stored in devices build from the bottom up. For example, use of AFM, liquid phase techniques based on inverse micelles, sol-gel processing, and chemical vapor deposition (CVD), laser pyrolysis and molecular self-assembly use bottom up approach for nano scale material manufacturing.

Top manufacturing involves the construction of parts through methods such as cutting, carving and molding and due to our limitations in these processes highly advanced nano devices are yet to be manufactured. Laser ablation, milling, nano-lithography, hydrothermal technique, physical vapor deposition and electrochemical method (electroplating) uses top down approach for nano-scale material manufacturing.

Every element of periodic table can be utilized in nanotechnology depending upon the target material which someone is going to fabricate range from nano medicine and goes up to nano concrete via nano electronics. Nanotechnology provides us the chance to synthesize nano scale building blocks with control on size, composition etc. Materials manufacturing will be revolutionized by further assembling into larger structures with designed properties. Without machining, metals, polymers, ceramics etc. can be manufactured at exact shape.

Nanotechnology can benefit chemical catalysis due to the extremely large surface to volume ratio. The various applications of nanoparticles in catalysis range from fuel cell to catalytic converters and photocatalytic devices. It is also important for the production of chemicals. Modern revolution in catalysis is due to the availability of unlimited commercial quantities of zeolites.

Applications of Nanotechnology

The different fields that find potential applications of nanotechnology are as follows:

a. Health and Medicine

b. Electronics

c. Transportation

d. Energy and Environment

e. Space exploration

Nanotechnology in health and medicine

Even today various disease like diabetes, cancer, Parkinson's disease, Alzheimer's disease, cardiovascular diseases and multiple sclerosis as well as different kinds of serious inflammatory or infectious diseases (e.g. HIV) constitute a high number of serious and complex illnesses which are posing a major problem for the mankind. Nano-medicine is an application of nanotechnology which works in the field of health and medicine. Nano-medicine makes use of nano materials, and nano electronic biosensors. In the future, nano medicine will benefit molecular nanotechnology. The medical area of nano science application has many projected benefits and is potentially valuable for all human races.

With the help of nano medicine early detection and prevention, improved diagnosis, proper treatment and follow-up of diseases is possible. Certain nano scale particles are used as tags and labels, biological can be performed quickly, the testing has become more sensitive and more flexible. Gene sequencing has become more efficient with the invention of nano devices like gold nano particles, these gold particles when tagged with short segments of DNA can be used for detection of genetic sequence in a sample.

With the help of nanotechnology, damaged tissue can be reproduced or repaired. These so called artificially stimulated cells are used in tissue engineering, which might revolutionize the transplantation of organs or artificial implants.

Advanced biosensors with novel features can be developed with the help of Carbon nano tubes. These biosensors can be used for astrobiology and can throw light on study origins of life. This technology is also being used to develop sensors for cancer diagnostics. Though CNT is inert, it can be functionalized at the tip with a probe molecule. Their study uses AFM as an experimental platform.

i. Probe molecule to serve as signature of leukemia cells identified.

ii. Current flow due to hybridization will be through CNT electrode to an IC chip.

iii. Prototype biosensors catheter development.

Nanotechnology has made excellent contribution in the field

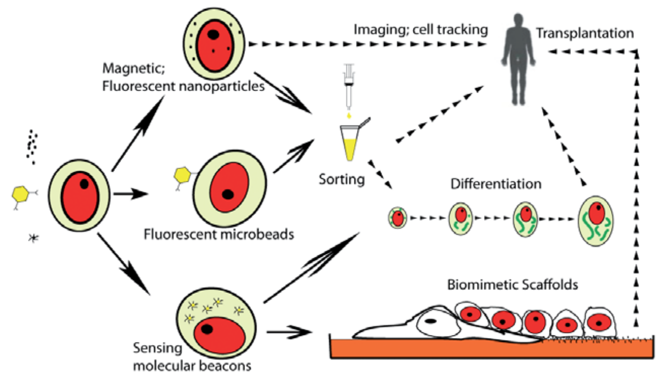

Figure 6: Nanotechnology applications in stem cell biology and medicine.

of stem cell research. For example, magnetic nanoparticles (MNPs) have been successfully used to isolate and group stem cells. Quantum dots have been used for molecular imaging and tracing of stem cells, for delivery of gene or drugs into stem cells, nano materials such as carbon nano tubes, fluorescent CNTs and fluorescent MNPs have been used. Unique nanostructures were designed for controllable regulation of proliferation and differentiation of stem cells is done by designed unique nano structures. All these advances speed up the development of stem cells toward the application in regenerative medicine [3]. The recent applications of nanotechnology in stem cell research promises to open new avenues in regenerative medicine. Nanotechnology can be a valuable tool to track and image stem cells, to drive their differentiation into specific cell lineage and ultimately to understand their biology. This will hopefully lead to stem cell-based therapeutics for the prevention, diagnosis and treatment of human diseases [4].

Nano devices can be used in stem cell research in tracking and imaging them. It has its applications for basic science as well as translational medicine. Stem cells can be modulated by mixing of nano carriers with biological molecules (Figure 6). Nano devices can be used for intracellular access and also for intelligent delivery and sensing of biomolecules. These technologies have a great impact in stem cell microenvironment and tissue engineering studies and have a great potential for biomedical applications [5].

Nanotechnology, energy and environment

Nanotechnology will play a critical role in coming 50 years by protecting the environment and providing sufficient energy for a growing world. The advanced techniques of nanotechnology can help storage of energy, its conversion into other forms, ecofriendly manufacturing of materials and by better enhanced renewable energy sources.

Nanotechnology can be used for less expensive energy production and for renewal energies, in solar technology, nano-catalysis, fuel cells and hydrogen technology. Carbon nano tube fuel cells are used for storage of hydrogen, thus finds application in power cars.

Nanotechnology is used on photovoltaic , for making them cheap, light weight and more efficient, which can reduce the combustion of engine pollutants by nano porous filters, and can clean the exhaust mechanically, with the help of catalytic converters made up of nano scale noble metal particles and by catalytic coatings on cylinder walls and catalytic nanoparticles as additive for fuels.

Nanotechnology can help in developing new ecofriendly and green technologies that can minimize undesirable pollution. Solid state lightening can reduce total electricity consumption. Nano technological approaches can lead to a strong reduction of energy consumption for illumination.

Medical use of Nano Materials

Nano medicine is a relatively new field of science and technology. By interacting with biological molecules at nano scale, nanotechnology broadens the field of research and application. Interactions of nano devices with bio molecules can be understood both in the extracellular medium and inside the human cells. Operation at nano scale allows exploitation of physical properties different from those observed at micro scale such as the volume/surface ratio.

Two forms of nano medicine that have already been tested in mice and are awaiting human trials; use of gold nano shells to help diagnose and cure cancer, and the use of liposome as vaccine adjuvants and as vehicles for drug transport [6,7]. Similarly, drug detoxification is also another application for nano medicine which has been used successfully in rats. Medical technologies can make use of smaller devices are less invasive and can possibly be implanted inside the body, and their biochemical reaction times are much shorter. As compared to typical drug delivery nano devices are faster and more sensitive [8].

Drug Delivery

In nanotechnology nano particles are used for site specific drug delivery. In this technique the required drug dose is used and side-effects are lowered significantly as the active agent is deposited in the morbid region only. This highly selective approach can reduce costs and pain to the patients. Thus variety of nano particles such as dendrimers, and nano porous materials find application. Micelles obtained from block co-polymers, are used for drug encapsulation. They transport small drug molecules to the desired location. Similarly, nano electromechanical systems are utilized for the active release of drugs. Iron nano particles or gold shells are finding important application in the cancer treatment. A targeted medicine reduces the drug consumption and treatment expenses, making the treatment of patients cost effective.

Nano medicines used for drug delivery, are made up of nano scale particles or molecules which can improve drug bioavailability. For maximizing bioavailability both at specific places in the body and over a period of time, molecular targeting is done by nano engineered devices such as nano robots [9]. The molecules are targeted and delivering of drugs is done with cell precision. *In vivo* imaging is another area where Nano tools and devises are being developed for *in vivo* imaging. Using nano particle images such as in ultrasound and MRI, nano particles are used as contrast. The nano engineered materials are being developed for effectively treating illnesses and diseases such as cancer. With the advancement of nanotechnology, self-assembled biocompatible nano devices can be created which will detect the cancerous cells and automatically evaluate the disease, will cure and prepare reports.

The pharmacological and therapeutic properties of drugs can be improved by proper designing of drug delivery systems, by use of lipid and polymer based nano particles [10]. The strength of drug delivery systems is their ability to alter the pharmacokinetics and bio-distribution of the drug. Nano particles are designed to avoid the body's defense mechanisms [11] can be used to improve drug delivery. New, complex drug delivery mechanisms are being developed, which can get drugs through cell membranes and into cell cytoplasm, thereby increasing efficiency. Triggered response is one way for drug molecules to be used more efficiently. Drugs that are placed in the body can activate only on receiving a particular signal. A drug with poor solubility will be replaced by a drug delivery system, having improved solubility due to presence of both hydrophilic and hydrophobic environments [12]. Tissue damage by drug can be prevented with drug delivery, by regulated drug release. With drug delivery systems larger clearance of drug from body can be reduced by altering the pharmacokinetics of the drug. Potential nano drugs will work by very specific and well-understood mechanisms; one of the major impacts of nanotechnology and nanoscience will be in leading development of completely new drugs with more useful behavior and less side effects.

Thus nano particles are promising tools for the advancement of drug delivery, as diagnostic sensors and bio imaging. The bio-distribution of these nanoparticles is still imperfect due to the complex host's reactions to nano- and micro sized materials and the difficulty in targeting specific organs in the body. Efforts are made to optimize and better understand the potential and limitations of nano particulate systems. In the excretory system study of mice dendrimers are encapsulated for drug deliver of positively-charged gold nano particles, which were found to enter the kidneys while negatively-charged gold nanoparticles remained in the important organs like spleen and liver. The positive surface charge of the nanoparticle decreases the rate of opsonization of nanoparticles in the liver, thus affecting the excretory pathway. Due to small size of 5 nm, nano particles can get stored in the peripheral tissues, and therefore can get collected in the body over time. Thus nano particles can be used successfully and efficiently for targeting and distribution, further research can be done on nano toxicity so that its medical uses can be increased and improved [13].

The applications of nano particles in drug delivery

Abraxane, is albumin bound paclitaxel, a nano particle used for treatment of breast cancer and non-small- cell lung cancer (NSCLC). Nano particles are used to deliver the drug with enhanced effectiveness for treatment for head and neck cancer, in mice model study ,which was carried out at from Rice University and University of Texas MD Anderson Cancer Center. The reported treatment uses Cremophor EL which allows the hydrophobic paclitaxel to be delivered intravenously. When the toxic Cremophor is replaced with carbon nano particles its side effects diminished and drug targeting was much improved and needs a lower dose of the toxic paclitaxel [14].

Nano particle chain was used to deliver the drug doxorubicin to breast cancer cells in a mice study at Case Western Reserve University. The scientists prepared a 100 nm long nano particle chain by chemically linking three magnetic, iron-oxide nano spheres, to one doxorubicin-loaded liposome. After penetration of the nano chains inside the tumor magnetic nanoparticles were made to vibrate by generating, radiofrequency field which resulted in the rupture of the liposome, thereby dispersing the drug in its free form throughout the tumor. Tumor growth was halted more effectively by nanotechnology than the standard treatment with doxorubicin and is less harmful to healthy cells as very less doses of doxorubicin were used [15,16].

Polyethylene glycol (PEG) nano particles carrying payload of antibiotics at its core were used to target bacterial infection more precisely inside the body, as reported by scientists of MIT. The nano delivery of particles, containing a sub-layer of pH sensitive chains of the amino acid histidine, is used to destroy bacteria that have developed resistance to antibiotics because of the targeted high dose and prolonged release of the drug. Nanotechnology can be efficiently used to treat various infectious diseases [17,18].

Researchers in the Harvard University Wyss Institute have used the biomimetic strategy in a mouse model .Drug coated nano particles were used to dissolve blood clots by selectively binding to the narrowed regions in the blood vessels as the platelets do [19]. Biodegradable nano particle aggregates were coated with tissue plasminogen activator, tPA, were injected intravenously which bind and degrade the blood clots. Due to shear stresses in the vessel narrowing region dissociation of the aggregates occurs and releases the tPA-coated nano particles. The nano therapeutics can be applied greatly to reduce the bleeding, commonly found in standard thrombosis treatment.

The researchers in the University of Kentucky have created X-shaped RNA nano particles, which can carry four functional modules. These chemically and thermodynamically stable RNA molecules are able of remaining intact in the mouse body for more than 8 hours and to resist degradation by RNAs in the blood stream. These X-shaped RNA can be effectively performing therapeutic and diagnostic functions. They regulate gene expression and cellular function, and are capable of binding to cancer cells with precision, due to its design [20,21].

'Minicell' nano particle are used in early phase clinical trial for drug delivery for treatment of patients with advanced and untreatable cancer. The minicells are built from the membranes of mutant bacteria and were loaded with paclitaxel and coated with cetuximab, antibodies and used for treatment of a variety of cancers. The tumor cells engulf the minicells. Once inside the tumor, the anti-cancer drug destroys the tumor cells. The larger size of minicells plays a better profile in side-effects. The minicell drug delivery system uses lower dose of drug and has less side-effects can be used to treat a number of different cancers with different anti-cancer drugs [22,23].

Nano sponges are important tools [24] in drug delivery, due to their small size and porous nature they can bind poorly-soluble drugs within their matrix and improve their bioavailability. They can be made to carry drugs to specific sites, thus help to prevent drug and protein degradation and can prolong drug release in a controlled manner.

Proteins and Peptide Delivery

Protein and peptides are macromolecules and are called biopharmaceuticals. These have been identified for treatment of various diseases and disorders as they exert multiple biological actions in human body. Nano materials like nano particles and dendrimers are called as nano biopharmaceuticals , are used for targeted and/or controlled delivery.

Applications

Nano particles were found useful in delivering the myelin antigens, which induce immune tolerance in a mouse model with relapsing multiple sclerosis. In this technique, biodegradable polystyrene micro particles coated with the myelin sheath peptides will reset the mouse's immune system and thus prevent the recurrence of disease and reduce the symptoms as the protective myelin sheath forms coating on the nerve fibers of the central nervous system. This method of treatment can potentially be used in treatment of various other autoimmune diseases [25,26].

Cancer

Due to the small size of nano particles can be of great use in oncology, particularly in imaging. Nano particles, such as quantum dots, with quantum confinement properties, such as size-tunable light emission, can be used in conjunction with magnetic resonance imaging, to produce exceptional images of tumor sites. As compared to organic dyes, nano particles are much brighter and need one light source for excitation. Thus the use of fluorescent quantum dots could produce a higher contrast image and at a lower cost than organic dyes used as contrast media. But quantum dots are usually made of quite toxic elements.

Nano particles have a special property of high surface area to volume ratio, which allows various functional groups to get attached to a nano particle and thus bind to certain tumor cells. Furthermore, the 10 to 100 nm small size of nanoparticles, allows them to preferentially accumulate at tumor sites as tumors lack an effective lymphatic drainage system. Multifunctional nano particles can be manufactured that would detect, image, and then treat a tumor in future cancer treatment [27]. Kanzius RF therapy attaches microscopic nano particles to cancer cells and then "cooks" tumors inside the body with radio waves that heat only the nanoparticles and the adjacent (cancerous) cells.

Nano wires are used to prepare sensor test chips, which can detect proteins and other biomarkers left behind by cancer cells, and detect and make diagnosis of cancer possible in the early stages from a single drops of a patient's blood [28].

Nano technology based drug delivery is based upon three facts: i) efficient encapsulation of the drugs, ii) successful delivery of said drugs to the targeted region of the body, and iii) successful release of that drug there.

Nano shells of 120 nm diameter, coated with gold were used to kill cancer tumors in mice by Prof. Jennifer at Rice University. These nano shells are targeted to bond to cancerous cells by conjugating antibodies or peptides to the nano shell surface. Area of the tumor is irradiated with an infrared laser, which heats the gold sufficiently and kills the cancer cells [29].

Cadmium selenide nano particles in the form of quantum dots are used in detection of cancer tumors because when exposed to ultraviolet light, they glow. The surgeon injects these quantum dots into cancer tumors and can see the glowing tumor, thus the tumor can easily be removed.

Nano particles are used in cancer photodynamic therapy, wherein the particle is inserted within the tumor in the body and is illuminated with photo light from the outside. The particle absorbs light and if it is of metal, it will get heated due to energy from the light. High energy oxygen molecules are produced due to light which chemically react with and destroy tumors cell, without reacting with other body cells. Photodynamic therapy has gained importance as a noninvasive technique for dealing with tumors.

The applications of various nano systems in cancer therapy [30] are summarized as:

- **Carbon nano tubes,** 0.5–3 nm in diameter and 20–1000 nm length, are used for detection of DNA mutation and for detection of disease protein biomarker.
- **Dendrimers,** less than 10 nm in size are useful for controlled release drug delivery, and as image contrast agents.
- **Nano crystals,** of 2-9.5 nm size cause improved formulation for poorly-soluble drugs, labeling of breast cancer marker HeR2 surface of cancer cells.
- **Nano particles** are of 10-1000 nm size and are used in MRI and ultrasound image contrast agents and for targeted drug delivery, as permeation enhancers and as reporters of apoptosis, angiogenesis.
- **Nano shells** find application in tumor-specific imaging, deep tissue thermal ablation.
- **Nano wires** are useful for disease protein biomarker detection, DNA mutation detection and for gene expression detection.
- Quantum dots, 2-9.5 nm in size, can help in optical detection of genes and proteins in animal models and cell assays, tumor and lymph node visualization.

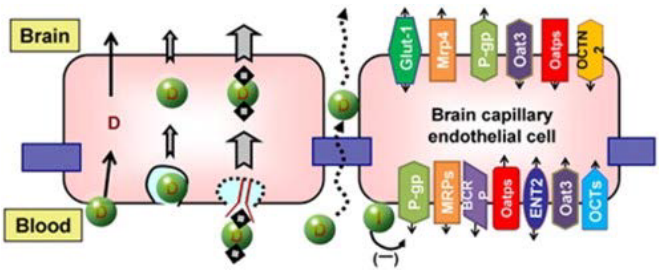

Figure 7: Delivery of nano medicine to CNS through BBB.

Nanotechnology in the treatment of neurodegenerative disorders

One of the most important applications of nanotechnology is in the treatment of neuro degenerative disorders [31]. For the delivery of CNS therapeutics, various nano carriers such as, dendrimers, nano gels, nano emulsions, liposomes, polymeric nano particles, solid lipid nano particles, and nano suspensions have been studied. Transportation of these nano medicines has been effected across various *in vitro* and *in vivo* BBB models by endocytosis and/or transcytosis, and early preclinical success for the management of CNS conditions such as, Alzheimer's disease, brain tumors, HIV encephalopathy and acute ischemic stroke has become possible. The nanomedicine can be advanced further by improving their BBB permeability and reducing their neurotoxicity (Figure 7).

Parkinson's disease: This can improve current therapy of Parkinson's disease (PD). Parkinson's disease (PD) is the second most common neurodegenerative disease after Alzheimer's disease and affects one in every 100 persons above the age of 65 years, PD is a disease of the central nervous system; neuro inflammatory responses are involved and leads to severe difficulties with body motions. The present day therapies aim to improve the functional capacity of the patient for as long as possible but cannot modify the progression of the neurodegenerative process.

Aim of applied nanotechnology is regeneration and neuro protection of the central nervous system (CNS) and will significantly benefit from basic nanotechnology research conducted in parallel with advances in neurophysiology, neuropathology and cell biology. The efforts are taken to develop novel technologies that directly or indirectly help in providing neuro protection and/or a permissive environment and active signaling cues for guided axon growth. In order to minimize the peripheral side-effects of conventional forms of Parkinson's disease therapy, research is focused on the design, biometric simulation and optimization of an intracranial nano-enabled scaffold device (NESD) for the site-specific delivery of dopamine to the brain, as a strategy. Peptides and peptidic nano particles are newer tools for various CNS diseases.

Nanotechnology will play a key role in developing new diagnostic and therapeutic tools. Nanotechnology could provide devices to limit and reverse neuro pathological disease states, to support and promote functional regeneration of damaged neurons, to provide neuro protection and to facilitate the delivery of drugs and small molecules across the blood–brain barrier. For the delivery of CNS therapeutics, various nanocarriers such as dendrimers, nano gels, nano emulsions, liposomes, polymeric nano particles, solid lipid nano particles, and nano suspensions have been studied. Transportation of these nano

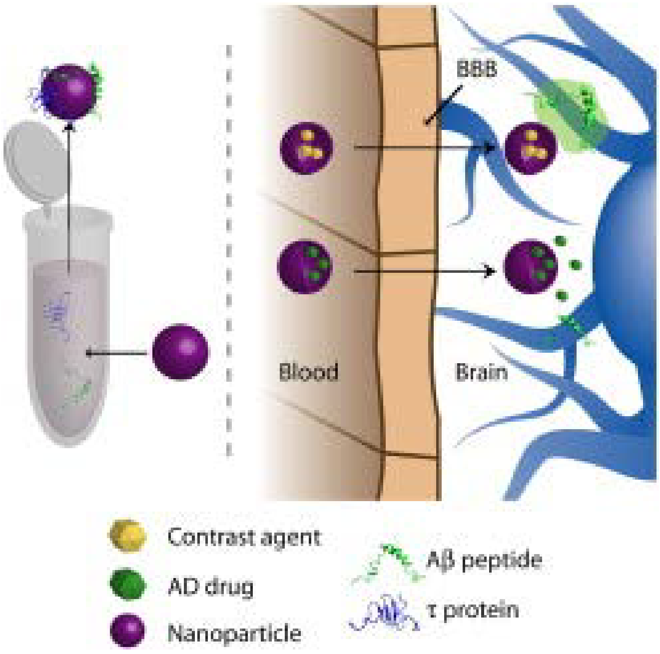

Figure 8: Use of nano particles in Alzheimer's disease.

medicines has been effected across various *in vitro* and *in vivo* BBB models by endocytosis and/or transcytosis, and early preclinical success for the management of CNS conditions such as, Alzheimer's disease, brain tumors, HIV encephalopathy and acute ischemic stroke has become possible. Future development of CNS nanomedicines needs to focus on increasing their drug-trafficking performance and specificity for brain tissue using novel targeting moieties.

Alzheimer's disease: Worldwide, more than 35 million people are affected by Alzheimer's disease (AD), which is the most common form dementia. Nano technology finds significant applications in neurology. These approaches are based on the, early AD diagnosis and treatment is made possible by designing and engineering of a plethora of nanoparticulate entities with high specificity for brain capillary endothelial cells. Nano particles (NPs) have high affinity for the circulating amyloid-β (Aβ) forms and therefore may induce "sink effect" and improve the AD condition. In vitro diagnostics for AD has advanced due to ultrasensitive NP-based bio-barcodes and immune sensors, as well as scanning tunneling microscopy procedures capable of detecting $A\beta_{1-40}$ and $A\beta_{1-42.}$ The recent research on use of nano particles in the treatment of Alzheimer's disease is as shown in Figure 8 [32].

Tuberculosis treatment: Tuberculosis (TB) is the deadly infectious disease. The long duration of the treatment and the pill burden can hamper patient lifestyle and result in the development of multi-drug-resistant (MDR) strains. Tuberculosis in children constitutes a major problem. There is commercial non availability of the first-line drugs in pediatric form. Novel antibiotics can be designed to overcome drug resistance, cut short the duration of the treatment course and to reduce drug interactions with antiretroviral therapies. A nanotechnology is one of the most promising approaches for the development of more effective and compliant medicines. The advancements in nano-based drug delivery systems for encapsulation and release of anti-TB drugs can lead to development of a more effective and affordable TB pharmacotherapy.

The clinical application of nanotechnology in operative dentistry

Nanotechnology aims at the creation and utilization of materials and devices at the atomic, and molecular level, supra molecular structures, and in the exploitation of unique properties of particles of size 0.1 nm to 100 nm. Nano filled composite resin materials are believed to offer excellent wear resistance, strength, and ultimate aesthetics due to their exceptional polishability and luster retention. In operative dentistry, nano fillers constitute spherical silicon dioxide (SiO_2) particles with an average size of 5-40 nm. The real innovation about nano fillers is the possibility of improving the load of inorganic phase. The effect of this high filler load is widely recorded in terms of mechanical properties. Micro hybrid composites with additional load of Nano fillers are the best choice in operative dentistry. It is expected that in near future, it would be possible to use a filler material in operative dentistry, whose shape and composition would closely mimic the optical and mechanical characteristics of the natural hard tissues (enamel and dentin). It also explains the basic concepts of fillers in composite resins, scanning electron microscopy and energy dispersive spectroscopy evaluation, and filler weight content. Nanocomposite resins are non-agglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nanocomposites have been successfully manufactured by nano products Corporation. The nano-filler used is aluminosilicate powder with a mean particle size of 80 ran 1:4 M ratio of alumina to silica and a refractive index of 1.508. These nano composites have superior hardness, flexural strength, modulus of elasticity, decreased polymerization shrinkage and also have excellent handling properties particle size of 80 ran 1:4 M ratio of alumina to silica and a refractive index of 1.508 [33,34].

Applications in Ophthalmology

The aim of nano medicine is the to monitor, control, construct, repair, defense, and improve human biological systems at the molecular level, with the help of nano devices and nanostructures that operate massively in parallel at the unit cell level, in order to achieve medical benefit. Principles of nanotechnology are applied to nano medicine such as bio mimicry and pseudo intelligence. Some applications of nanotechnology to ophthalmology are include treatment of oxidative stress; measurement of intraocular pressure; theragnostics; use of nano particles for treatment of choroidal new vessels, to prevent scars after glaucoma surgery, and for treatment of retinal degenerative disease using gene therapy; prosthetics; and regenerative nano medicine. The current therapeutic challenges in drug delivery, postoperative scarring will be revolutionized with the help of nanotechnology and will help in various unsolved problems such as sight-restoring therapy for patients with retinal degenerative disease [35]. Treatments for ophthalmic diseases are expected from this emerging field. A novel nanoscale-dispersed eye ointment (NDEO) for the treatment of severe evaporative dry eye has been successfully developed [36]. The excipients used as semisolid lipids were petrolatum and lanolin, as used in conventional eye ointment, which were coupled with medium-chain triglycerides (MCT) as a liquid lipid; both phases were then dispersed in polyvinyl pyrrolidone solution to form nanodispersion. A transmission electron micrograph showed that the ointment matrix was entrapped in the nano emulsion of MCT, with a mean particle size of about 100 nm. The optimized formulation of NDEO was stable when stored for six months at 4°C, and demonstrated no cytotoxicity to human corneal epithelial cells when compared with commercial polymer-based artificial tears (Tears Natural® Forte). The therapeutic effects of NDEO were evaluated and demonstrated therapeutic improvement, displaying a trend of positive correlation with higher concentrations of ointment matrix in the NDEO formulations compared to a marketed product. Histological evaluation demonstrated that the NDEO restored the normal corneal and conjunctival morphology and is safe for ophthalmic application. Recent research [37] shows applications of various nanoparticulate systems like microemulsions, nanosuspensions, nanoparticles, liposomes, niosomes, dendrimers and cyclodextrins in the field of ocular drug delivery and also depicts how the various upcoming of nanotechnology like nanodiagnostics, nanoimaging and nanomedicine can be utilized to explore the frontiers of ocular drug delivery and therapy.

Surgery

The technique developed by Rice University, two pieces of chicken meat is fused by a flesh welder, by placing two pieces of chicken touching each other. In this technique, green liquid containing gold-coated nano shells is allowed to dribble along the seam and two sides are weld together. This method can be used arteries which have been cut during organ transplant. The flesh welder can be used to weld the artery perfectly [38].

Visualization

Drug distribution and its metabolism can be determined by tracking movement. Cells were dyed by scientists to track their movement throughout the body. These dyes excited by light of a certain wavelength to glow. Luminescent tags were used to dye various numbers of cells. These tags are quantum dots attached to proteins which penetrate cell membranes. The dots were of various sizes and bio-inert material. As a result, sizes are selected so that the frequency of light used to make a group of quantum dots fluoresce, and used to make another group incandesce. Thus both groups can be lit with a single light source.

Tissue engineering

In tissue engineering, nanotechnology can be applied to reproduce or repair damaged tissues. By using suitable nanomaterial-based scaffolds and growth factors, artificially stimulated cell proliferation, in organ transplants or artificial implants therapy nano technology can be useful, which can lead to life extension.

Antibiotic resistance

Antibiotic resistance can be decreased by use of nano particles in combination therapy. Zinc Oxide nano particles can decrease the antibiotic resistance and enhance the antibacterial activity of Ciprofloxacin against microorganism, by interfering with various proteins that are interacting in the antibiotic resistance or pharmacologic mechanisms of drugs [39].

Immune response

The nano device bucky balls have been used to alter the allergy/immune response. They prevent mast cells from releasing histamine into the blood and tissues, as these bind to free radicals better than any anti-oxidant available, such as vitamin E [40].

Nano pharmaceuticals

Nano pharmaceuticals can be used to detect diseases at much earlier stages and the diagnostic applications could build upon conventional procedures using nanoparticles. Nano pharmaceuticals are an emerging field where the sizes of the drug particle or a therapeutic delivery system work at the nanoscale. Delivering the appropriate dose of a particular active agent to specific disease site still remains difficult in the pharmaceutical industry. Nano pharmaceuticals have enormous potential in addressing this failure of traditional therapeutics which offers site-specific targeting of active agents. Nano pharmaceuticals can reduce toxic systemic side effects thereby resulting in better patient compliance.

Pharmaceutical industry faces enormous pressure to deliver high-quality products to patients while maintaining profitability. Therefore pharmaceutical companies are using nanotechnology to enhance the drug formulation and drug target discovery. Nano pharmaceutical makes the drug discovery process cost effective, resulting in the improved Research and Development success rate, thereby reducing the time for both drug discovery and diagnostics.

Application of Nanotechnology in Modified Medicated Textiles

Using nanotechnology newer antibacterial cotton has been developed and used for antibacterial textiles. Developmental works using nanotechnology, new modified antibacterial textiles have been developed. Application of conventional antimicrobial agents to textiles has been already reported. This technique has been advanced by a focus on inorganic nano structured materials that acquire good antibacterial activity and application of these materials to the textiles [41].

Conclusion

Nano materials have increased surface area and nano scale effects, hence used as a promising tool for the advancement of drug and gene delivery, biomedical imaging and diagnostic biosensors. Nano materials have unique physicochemical and biological properties as compared to their larger counterparts. The properties of nano materials can greatly influence their interactions with bio molecules and cells, due to their peculiar size, shape, chemical composition, surface structure, charge, solubility and agglomeration. For example, nano particles can be used to produce exceptional images of tumor sites; single-walled carbon nanotubes, have been used as high-efficiency delivery transporters for biomolecules into cells. There is a very bright future to nano technology, by its merging with other technologies and the subsequent emergence of complex and innovative hybrid technologies. Biology-based technologies are intertwined with nanotechnology-nanotechnology is already used to manipulate genetic material, and nano materials are already being built using biological components. The ability of nanotechnology to engineer matter at the smallest scale is revolutionizing areas such as information technology cognitive science and biotechnology and is leading to new and interlinking these and other fields. By further research in nanotechnology, it can be useful for every aspect of human life. Medicine, regenerative medicine, stem cell research and nutraceuticals are among the leading sectors that will be modified by nanotechnology innovations.

References

1. Yousaf SA, Salamat A (2008) Effect of heating environment on fluorine doped tin oxide (f: SnO/sub 2/) thin films for solar cell applications. Faculty of Engineering & Technology. Islamabad.
2. Khan Y (2007) The great partition: The making of India and Pakistan.
3. Wang Z, Ruan J, Cui D (2009) Advances and prospect of nanotechnology in stem cells. Nanoscale Res Lett 4: 593-605.
4. Ricardo PN e Lino F (2010) Stem cell research meets nanotechnology. Revista Da Sociedade Portuguesa D Bioquimica, CanalBQ 7: 38-46.
5. Deb KD, Griffith M, Muinck ED, Rafat M (2012) Nanotechnology in stem cells research: advances and applications. Front Biosci (Landmark Ed) 17: 1747-1760.
6. Boisseau P, Loubaton B (2011) Nanomedicine, nanotechnology in medicine. Comptes Rendus Physique 12: 620-636.
7. (2010) Nanotechnology in Targeted Cancer Therapy. University of Waterloo.

8. LaVan DA, McGuire T, Langer R (2003) Small-scale systems for in vivo drug delivery. Nat Biotechnol 21: 1184-1191.

9. Cavalcanti A, Shirinzadeh B, Freitas RA, Hogg T (2008) Nano robot architecture for medical target identification. Nanotechnology 19: 15.

10. Allen TM, Cullis PR (2004) Drug delivery systems: entering the mainstream. Science 303: 1818-1822.

11. Bertrand N, Leroux JC (2012) The journey of a drug-carrier in the body: an anatomo-physiological perspective. J Control Release 161: 152-163.

12. Nagy ZK, Balogh A, Vajna B, Farkas A, Patyi G, et al. (2012) Comparison of electrospun and extruded SoluplusÂ®-based solid dosage forms of improved dissolution. J Pharm Sci 101: 322-332.

13. Minchin R (2008) Nanomedicine: sizing up targets with nanoparticles. Nat Nanotechnol 3: 12-13.

14. Hollmer M (2012) Carbon nanoparticles charge up old cancer treatment to powerful effect. Fierce drug delivery.

15. Garde D (2012) Chemo bomb' nanotechnology effective in halting tumors. Fierce drug delivery.

16. Peiris PM, Bauer L, Toy R, Tran E, Pansky J, et al. (2012) Enhanced delivery of chemotherapy to tumors using a multicomponent nanochain with radio-frequency-tunable drug release. ACS Nano 6: 4157-4168.

17. Trafton A (2012) Target: Drug-resistant bacteria. MIT news.

18. Radovic-Moreno AF, Lu TK, Puscasu VA, Yoon CJ, Langer R, et al. (2012) Surface charge-switching polymeric nanoparticles for bacterial cell wall-targeted delivery of antibiotics. ACS Nano 6: 4279-4287.

19. Wyss Institute (2012) Harvard's Wyss Institute Develops Novel Nano therapeutic that Delivers Clot-Busting Drugs Directly to Obstructed Blood Vessels.

20. Nourmohammadi N (2012) New Study Shows Promise in Using RNA Nanotechnology to Treat Cancers and Viral Infections. Nanomedicine: Notes, Fierce Drug Delivery.

21. Haque F, Shu D, Shu Y, Shlyakhtenko LS, Rychahou PG, et al. (2012) Ultrastable synergistic tetravalent RNA nanoparticles for targeting to cancers. Nano Today 7: 245-257.

22. Suzanne E (2012) Bacterial 'minicells' deliver cancer drugs straight to the target Fierce Drug Delivery.

23. (2012) First trial in humans of 'minicells': A completely new way of delivering anti-cancer drugs. The European CanCer Organisation (ECCO) Science daily.

24. Ahmed RZ, Patil G, Zaheer Z (2013) Nanosponges - a completely new nano-horizon: pharmaceutical applications and recent advances. Drug Dev Ind Pharm 39: 1263-1272.

25. Laurance J (2012) Scientists develop nanoparticle method to help tackle major diseases. The Independent.

26. Miller Stephen, Getts D, Martin A, McCarthy D, Terry R, et al. (2012) Micro particles bearing encephalitogenic peptides induce T-cell tolerance and ameliorate experimental autoimmune encephalomyelitis. Nature Biotechnology 30: 1217-1224.

27. Nie S, Xing Y, Kim GJ, Simons JW (2007) Nanotechnology applications in cancer. Annu Rev Biomed Eng 9: 257-288.

28. Zheng G, Patolsky F, Cui Y, Wang WU, Lieber CM (2005) Multiplexed electrical detection of cancer markers with nanowire sensor arrays. Nat Biotechnol 23: 1294-1301.

29. Loo C, Lin A, Hirsch L, Lee MH, Barton J, et al. (2004) Nanoshell-enabled photonics-based imaging and therapy of cancer. Technol Cancer Res Treat 3: 33-40.

30. Nahar M, Dutta T, Murugesan S, Asthana A, Mishra D, et al. (2006) Functional polymeric nanoparticles: an efficient and promising tool for active delivery of bioactives. Crit Rev Ther Drug Carrier Syst 23: 259-318.

31. Wong HL, Wu XY, Bendayan R (2012) Nanotechnological advances for the delivery of CNS therapeutics. Adv Drug Deliv Rev 64: 686-700.

32. Davide B, Benjamin LD, Nicolas J, Hossein S, Lin-Ping Wu, et al. (2011) Nanotechnologies for Alzheimer's disease: diagnosis, therapy and safety issues. Nano medicine: Nanotechnology, Biology and Medicine 7: 521-540.

33. Freitas RA Jr (2005) Nanotechnology, nanomedicine and nanosurgery. Int J Surg 3: 243-246.

34. Sivaramakrishnan SM, Neelakantan P (2014) Nanotechnology in Dentistry - What does the Future Hold in Store? Dentistry 4: 2.

35. Zarbin MA, Montemagno C, Leary JF, Ritch R (2013) Nanomedicine for the treatment of retinal and optic nerve diseases. Curr Opin Pharmacol 13: 134-148.

36. Zhang W, Wang Y, Lee BT, Liu C, Wei G, et al. (2014) A novel nanoscale-dispersed eye ointment for the treatment of dry eye disease. Nanotechnology 25: 125101.

37. Sahoo SK, Dilnawaz F, Krishnakumar S (2008) Nanotechnology in ocular drug delivery. Drug Discov Today 13: 144-151.

38. Gobin AM, O'Neal DP, Watkins DM, Halas NJ, Drezek RA, et al. (2005) Near infrared laser-tissue welding using nanoshells as an exogenous absorber. Lasers Surg Med 37: 123-129.

39. Banoee M, Seif S, Nazari ZE, Jafari FP, Shahverdi HR, et al. (2010) ZnO nano particles enhanced Antibacterial activity of ciprofloxacin against Staphylococcus aureus and Escherichia coli. J Biomed Mater Res B Appl Biomater 93: 557-561.

40. Abraham SA (2010) Researchers Develop Bucky balls to Fight Allergy. Virginia Commonwealth University Communications and Public Relations.

41. Fouda MM, Abdel-Halim ES, Al-Deyab SS (2013) Antibacterial modification of cotton using nanotechnology. Carbohydr Polym 92: 943-954.