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RECENT UPDATES IN NANOTECHOTECHNOLOGY AFFECTING HEALTH –CARE AND MEDICINE

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ABSTRACT Nanotechnology is the art and science of dealing with matter in the scale of nanometer (0.1-100 nm).This involves the naturally produced or engineered products of miniature sizes or "nano" structures. These small sized structures can be viewed only via sophisticated instruments of microscopy techniques such as scanning tunneling microscopy, magnetic force microscopy and electron microscopy. There are wide applications of Nanotechnology .these include a diverse array of fields such as medicine, pharmaceuticals, agriculture, textile, food , optics, quantum computers, cosmetics etc. Some of the " novel" materials manufactured related to Nanotechnology include nanoparticles, nanomaterials, nanofluids, nanocrystals, nanofibres, nanooptics, metallic nanoparticles, liposomes, dendrimers, nanorobotics, nanodiamonds, carbon nanotubes. The application of Nanotechnology in healthcare and medicine has been majorly focused upon. The technique has been utilized in the diagnosis, treatment and prevention of diseases such as cancer, cardiovascular diseases, ophthalmic diseases, brain diseases, HIV /AIDs, Covid -19 disease, tuberculosis, bone diseases , diabetes , dentistry .Recent innovative devices generated using nanotechnology include biochemical sensors or biosensors, magic bullets, biomarkers and food nanotechnology. Benefits of nanotechnology in medicine are inclusive of nanodevices, drug -delivery systems, early detection of diseases, tissue repair in skin. There are some health risks posed which may be averted due to increase in research and development in technique of nanotechnology in future. Although, this article has only focused directly and majorly upon the application of Nanotechnology in the area of health-care and medicine; nanotechnology is potentially useful in all areas of human inventions such as electronic, transportation, energy, environment, food, agriculture and even space exploration!

KEYWORDS : Nano, Nanotechnology, Nanodevices, Health-care, Medicine

INTRODUCTION

The art and science of manipulating matter of comparable width measuring 1/100,000 of a strand of human hair to create new, unique and potentially beneficial material to the human race is known as Nanotechnology [1] . Nanotechnology refers to the study of extremely small structures. The word "nano" means very small or miniature size or dwarf in Greek. The treatment hence conversion of atoms, molecules or compounds into structures which are materials and devices that possess special properties is known as Nanotechnology. This involves reduction of structures from their large to small or even conversion of atoms or molecules into larger nanostructures described as "top down" and " bottom up" respectively [2].

Nanometer scale means usually 0.1-100 nm (nanometer) wherein 1 nanometre is one-billionth of a meter (1).This small measurement requires sophistication in terms of microscopy techniques such as scanning tunneling microscopy, magnetic force microscopy and electron microscopy [3].

Sometimes nanomaterials occur naturally or can be engineered. Nanosizes are responsible for their unique physical and chemical properties. Their large surface –area to volume ratios causes these nanomaterials to be highly reactive. The study of nanomaterials is known as Nanoscience [4].

Nanomedicine is the multiple applications of nanotechnology by integrating science and technology with a wide variety of usages such as diagnosis, pain reduction, personalized medical procedures, drug delivery vehicles, research and clinical usage. By applying interdisciplinary approach with biotechnology, nanomaterials, biomedical robotics and genetic engineering are categorized as Nanomedicine. Due to nanoscaling of technologies in medicine increased efficiency, rapid response rate, effectiveness of most biological and chemical processes functionally occurs during manufacture of medical materials. The applications of Nanomedicine are directly proportional to the constantly evolving and current research developments day-to -day [5].

The applications of nanotechnology in the pharmaceutical industry aids in overcoming the drawbacks of conventional medicinal dosages in the form of tablets, capsules etc. Pharmaceutical nanotechnology assists in the detecting disease associated antigens, microbes and viruses by combating multiple diseases. The conventional drug forms have drawbacks such as poor bio-availability, low patient compliance, low cytotoxicity and damage to healthy cells which are overcome by pharmaceutical nanotechnology [6].

Apart from medicine and pharmaceutical nanotechnology has laid its foundation in diverse fields like Energy, Environment, Agriculture, Textiles, Food , Optics, Quantum computers, Cosmetics etc. Biomedical nanotechnology refers to the application of nanotechnology and its association with pathologies such as neurodegenerative diseases, diabetes mellitus, cancer, immunological diseases etc. Nano-technology can be utilized in drug delivery, vaccines, gene delivery, robotic applications as well as " nano" applications in the field of medicine [1].

Novel Materials in Nanotechnology

1) **Nanoparticles:** These are drug carriers which may or may not be biodegradable. They consist of subionized, colloidal synthetic or semisynthetic polymer structures. Nanoparticles maybe encapsulated uniformly in the form of a sphere into a matrix system known as "nanosphere". "Nanocapsule" refers to the drug being enveloped by a unique polymeric membrane. All nanoparticles are classified based on their dimensions, morphology, composition at nano level , uniformity and agglomeration.
2) **Nanomaterials:** Objects having one dimension in nanometer scale (approximately 1-100 nm). These nanomaterials are highly reactive due to increased surface energy, which is a resultant of high specific surface area in relation to the volume. Biomolecules such as proteins, lipids etc are absorbed by nanomaterials whenever contacts occurs with biological fluids. Nanomaterials may be created unintentionally by human beings or occur naturally in nature. However, these nanomaterials can be formed intentionally too. These

nanomaterials are beneficial in drug delivery, achieve therapeutic response, administration via parenteral oral, nasal , ocular routes, active and specific ligands .the drawbacks cited are nanomaterials are limited to drug loading as well as that they are susceptible to bursting and leakage of contents.

3) **Nanofluids:** These are dilute liquids with dimension smaller than 100nm.They are known to possess advanced thermo-physical properties such as thermo-conductivity, thermal diffusivity, viscocity and connective heat transfer co-efficients as compared to other liquids eg water or oil.
4) **Nanocrystals:** These are crystals which are assimilated into tablets, capsules, fast-melts and by lyophilized for sterile product applications; with nanometer scale dimensions. These have crystalline characteristics. But in liquid medium these nanocrystals are dispersed to form " nanosuspensions" which differ from " microsuspensions" and " macrosuspensions". These dispersed particles are stabilized by surfactants or polymeric stabilizers. However, dispersion media may be water, aqueous solutions or non-aqeuous media e.g. liquid polyethylene glycol (PEG), oils etc. Benefits of nanocrystals include enhanced solubility and bioavailability capacity to be administered via any route, rapid dissolution and tissue targeting by intravenous administration, higher –drug loading, higher physical and chemical stability. Risks involved with nanocrystals include bulkiness, needs sufficient care during handling and transport, uniform and accurate dosage of drug is difficult to attain.
5) **Nanofibres:** These are fibres with dimensions in nanoscale (less than 100 nm). Polymers are converted to Nanofibres by electrospinning technique e.g. collagen, chitosan, gelatin etc. These have large specific surface area as well as small pore size and unique properties in wound healing applications. These have low density, with large surface area to mass, tight –sized high volume pores applicable for fileration purposes.
6) **Nanooptics:** Involves interaction of "photon" or light with nanostructural matter. It is a promising field for new technologies, methods due to interaction between science and engineering, multidisciplinary research field is generated by the convergence of many fields of sciences to nanosciences [7].
7) **Metallic Nanoparticles:** Metallic nanoparticles are utilized in drug delivery, cancer treatment and in biosensors. Various metals such as silver, gold, zinc are utilized in the formation of nanoparticles which are important bio medically.
8) **Liposomes:** These are being utilized extensively as nanocarriers for novel and targeted drug delivery. Liposomes vary in size from 50 -200 nm. Closed vesicles of liposomes are formed when dry phospholipids are hydrated. The efficiency, biocompatibility and entrapment capacity is excellent. It is useful in the active and passive delivery of gene, protein and peptides.
9) **Dendrimers:** These are highly branched and tree- like structures. Differentiated into three regions such as core moiety, branching units, and closely packed surface.
Though its size is less than 10 nm, it is spherical and has internal cavities. These cavities are useful for the controlled delivery of bioactive material, targeted delivery of bioactive material to a particular cell such as macrophages or organ such as liver [2].
10) **Nanorobotics:** Is concerned with the controlled manipulation of nanometer-scale objects wherein nanomanipulation is the most effective process. It involves with the construction and programming of robots in terms of dimensions of nanoscale. Nanorobots are being researched such that it is utilized currently in the treatment of the common diseases. Nanorobotic science aids to prevent cardiac diseases, skin diseases, dental treatment of common diseases .Nanorobotic science aids to prevent cardiac diseases, skin diseases, dental treatments as well as in the field of immunology to study the immune system in-depth and detail [8].
11) **Nanodiamonds:** Diamondoid Molecules): these are saturated hydrocarbons containing diamond related fused ring structures and are variants of a molecule called adamantine.. Adamantane is the Greek word for diamonds. These are utilized as building blocks in the field of nanotechnology.
12) **Carbon Nanotubes:** Possess dimensions in nanometer scale is majorly consisting of carbon structures with gaps in between.It was discovered using electron microscope. The variants arte single-walled and multi-walled. They form thin layers that are utilized to make preparation of bicycle parts, nantapes that are adhesive tapes which are two sided , tips of atomic force microscope and in tissue engineering for scaffolding of human bone growth [9].

Applications of Nanotechnology in Health –Care and Medicine:

Nanotechnology can be integrated into various subjects thereby helpful in the better understanding of these subjects, create newer innovations in these subjects and therefor benefiting human race. These subjectsa include physics, chemistry, materials, biology, medical sciences , engineering etc.

1) **Cancer:** Nanotechnology in combination with biology can create nanobiological cells with the adaptability and recognition capacity absorb biological medicine that can prevent the growth of cancerous cells. These can be used to full advantage by injecting it into the human body to kill cancerous cells [10].
Various nano systems are utilized in cancer therapy such as carbon nanotubes are used for the detection of DNA mutation and protein biomarkers of cancer, dendrimers are utilized for image contrast agents and for controlled drug delivery, nanocrystals help in solubilizing drugs and labeling the receptor HeRz on surfaces of breast cancer cells. Nanoparticles are beneficial in magnetic resonance imaging (MRI) and ultrasound image contrast agents in the targeted drug delivery, enhancers in permeation and reporters of apoptosis, angiogenesis, nanoshells in tumor specific imaging and nanowires in detecting DNA mutation, protein biomarker de4tection and gene expression detection [2].
Even biosensors which are small devices which can detect specific biomarkers in the blood or bodily fluids can be indicative of cancer and can be utilized to detect cancer at their early stage [5].
2) **Cardiovascular Diseases:** Nanomedicine promises the diagnosis, treatment and prevention of diseases to provide and maintain quality of life and death. Currently liposomes, micelles, dendrimers, nano-coated stents, gel nanoparticles are being utilized in the prevention and treatment of cardiovascular diseases. Nanoparticles are potentially7 useful in the field of medical imaging due to their good bioavailability, versatility, ease of manipulation. Cardiovascular magnetic resonance (CMR) is a non –invasive method in cardiovascular disease caused inflammation; which detects the changes in myocardial tissue. This will enable the patient-centered therapy and better diagnosis, decide dosages of statin treatment to have better prophylactic effect. For e.g. gold nanoparticles obtained from gold which is a noble and inert metal known for its stability and biocompatible nature. Gold nanoparticles are utilized in optical imaging that is photoacoustic imaging which is based on the detection of both. Ultrasound and optical imaging; wherein light is used for the source of excited, ultrasound detectable sound waves and images of optical absorption created by the targeted tissue [11].
3) **Opthalmic Diseases:** Nanoparticles have been experimented and utilized in ophthalmic patients and showed improved adhesiveness, availability at targeted sites of action, provision of higher drug levels. Polymeric

Nanoparticles , nanogels, liposomes, micelles, dendrimers, chitosan and protein nanoparticles are examined for retinoblastoma, diabetic retinopathy, retinitis pigmentosa and even for the treatment of posteriorly located choroid and retina of eyes . The drug and gene delivered to the target-tissue enhances diagnosis and retinal prosethesis [12].

4) **Brain diseases:** the presence of the blood –brain barrier, which is the boundary between circulating blood and neural tissue of the brain, is overcome by the nanoparticles to efficiently deliver drugs to the brain. Nanoparticles are beneficial in the treatment of neurodegenerative diseases such as Parkinson's disease, Alzheimer disease etc due to the small size, high drug loading ability and enhanced imaging performance. The morphology and charge of the nanoparticles are of importance. Zwitterions and neutral nanoparticles have greater circulation time than positively and negatively charged nanoparticles [13].
5) **HIV /AIDS :** Improvement in the intracellular delivery of the anti-retroviral drugs to the central nervous system has prospects even in HIV ?AIDS prevention and treatment. Nanoparticles create hindrances in the viral replication process and assembly process thereby assist in neutralizing it. The toxicity of HIV/AIDS vaccine are decreased by nanoparticles [14].
6) **Covid -19 Disease :** Due to nanotechnology vaccines can be produced within a short-time frame even for coronavirus. Nanoparticles such a iron oxide, silver, iron oxide, carbon based particles possess such physical and chemical properties that enable the virucidal activities. Nanoparticles can be applied for co-encapsulated of drugs such as Remdesivir and hydroxychloroquine to treat Covid -19.Carbon nanoparticles known to be active against coronavirus in concentration –dependent manner; carbon quantum dots interact with receptors of the virus and inhabit viral replication [8].
7) **Tuberculosis:** the long duration of the deadly infectious disease and the pill burden can interfere with the patient lifestyle and result in development of multi-drug resistant strain (MDR) strains in Tuberculosis. Due to nanotechnology more efficient drugs can be produced which can reduce the drug resistance, duration of treatment and interactions with antiretroviral therapies. The advancements are based on the drug-delivery system for encapsulation and release of anti-TB drugs which lead to research and development of highly effective and affordable TB pharmacotherapy [2].
8) **Bone Diseases :** Nanotechnology is being utilized in creation of new bone tissue or enable healing of the bone tissue with materials that aid bone growth i.e. bone regeneration technology. Bone regeneration technology facilitates efficient, precise and targeted materials for enabling bone growth. Nanoparticles are useful to create scaffold that mimic structure of bone, that can cause new bone growth and bone regeneration. 3D- printing technology or synthetic biology utilizes the nanoparticles to create precise, customized implants for bone regeneration, artificial joints, nanoscale collagen mimicking cartilages for knees, hips to aid bone forming cells or osteoblasts. This will enable faster healing, repair , regeneration and improved bone strength and decreased complications [5].
9) **Diabetes :** Patients of diabetes have to constantly monitor their blood glucose levels making it totally uncomfortable and extremely inconvenient at times. Nanorobots are a boon in disguise since the constant monitoring of blood sugar levels is possible and can be observed and monitored [1].
10) **Dentistry:** Nanotechnology has proven benefits in dentistry. New innovations in the field of dentistry is dealing with native anesthesia , completely dealing with hypersensitivity , dentition, denaturation, desired orthodontic readjustment in a single appointment at the dentist. Usually covalently attached diamondized enamel, regular oral health preservations and mechanical dentist robots (Nanorobotic dentrifice) are potential advantages' in the dental field. It is useful to get rid of caries- causing microbes and fixation of teeth decay blemishes [15].

New Applications of Nanotechnology in Health Care and Medicine Biochemical Sensors:

A biosensor comprises of a specific and sensitive biochemical recognition feature connected to a physiochemical detector and transducer between to amplify and tr4ansmit the signals generated in a quantifiable version.

These devices are utilized to detect specific pathological proteins, physiological biochemical markers associated with pathology or aberrant biochemical metabolism. A radio sensor or nanosensor is a biosensor with dimensions on the order of a nanometer. The basis of nanoparticles is catalytic function in biochemical reactions. Excellent biocompatibility of nanomaterials and immobility of biomolecules are important in biosensor manufacture. Examples of biosensors are

1) Triglyceride nanosensors are useful to detect hyper-lipidemia
2) Gold colloids are optical biosensors useful of qualitative and quantitative determination of immunosensing, nucleic acid detection, toxin quantitation.
3) Oligonucleotide capped gold nanoparticles are beneficial for polynucleotides or protein detection or protein detection by various methodologies such atomic force microscopy, gel electrophoresis, Raman Spectroscopy, surface plasmon resonance imaging [12].

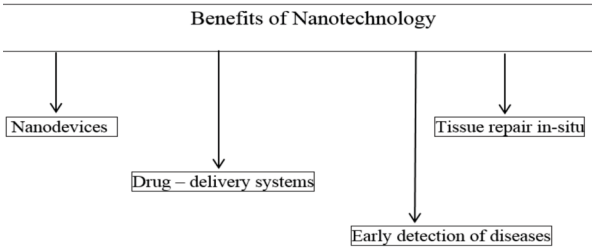
Magic Bullet Delivery

Directed towards specific in-situ locations in the body that cannot be reached by standard medications easily. Simultaneously extra dosages of medications can be prevented to eliminate the harm created thereof. The delivery of such medication are controlled at levels by conversion to nano-sizes in the form of dendrimers, empty polymer cases and nano-shells. Highly beneficial for imaging application these magic bullets deliver payload (radiation, chemotherapy or quality treatment).

Invention of Biomarkers

Nano biotechnology has improved and rectified the discovery of biomarkers. Assortment of designated biomarkers in the form of nanoscale particles are accessible and are highly –sensitive proteomic tests. The most commonly utilized are nanoparticles are gold nanoparticles, magnetic nanoparticles and quantum dots. These are good conductivity properties excellent, imaging capacity. Additionally gold nanoparticles and magnetic nanoparticles are useful in image –guided surgery and drug delivery. Metallic nanostructures are developed utilized as Surface Enhanced Raman Spectroscopy (SERS).These are also engineered with photo-thermal properties , useful in laser ablation therapy. Nanodevices have improved sensitivity, important clinical applications. Nano-plasmonic sensors are beneficial in various fields of medicine and environmental studies. Nano-detectors are helpful in diagnosis of cardiac arrest. Micro –bots are magnetically guided for eye-surgeries or delivery of drugs with precision to specific parts of the body eg posterior region of the eye in the treatment of retinopathy for drug delivery. Lipid encapsulated mRNA vaccine are developed against Covid -19 in the form of aerosol jet 3 D printer to detect the antibodies within a time span of 10 seconds (16).Molecular nanotechnology is emerging interdisciplinary field combining various fields of molecular chemistry, physics, engineering, mechanical design, structural analysis, computer science , electric engineering and systems engineering [17].

Overview of Benefits of Nanotechnology [18]



Food Nanotechnology

Globally the requirement of food is growing contemporary and continually. The most efficient method for tackling this issue is nanotechnology, concerning food industry and area of functional foods. Currently food nanotechnology is an emerging field in the food industry employed in food packaging, food quality and food safety. The research and development is undertaken for food articles that have longer shelf –life due to the nanoparticles [19].

Risks Associated with Nanotechnology

Nanotechnology has diverse benefits but they also present risks to human health and the environment. It should be borne in mind that many aspects of nanotechnology is still under research and development therefore unknown. There are evidences based on reports about inflammation, pulmonary fibrosis and genotoxicity by usage of carbon nanotubes. Nanosilver shows effects on aquatic species in marine environments. Similarly security and safety for the usage of nanoparticles during bio-medical applications both in-vitro cell cultures and in vivo living organisms need to be studied and scrutinized effectively to benefit [4].

CONCLUSIONS

This is a broad spectrum of the field of Nanotechnology. Special focus has been given to the various " novel" terminologies and their distinct meaning. The precise use of these "novel" materials is specially mentioned. However, it should be mentioned that nanotechnology is a constantly evolving field of study and technique. Hence over the future decades we can expect rapid changes and newer innovative developments may occur. Nevertheless, the breakthrough , rapid progressive changes in the diagnosis, treatment and prevention in the many pathologies has been reckoned with and appreciated. The benefits and the risk of thwe nanotechnology has been glanced into. This article has been generally focused only upon the effective usage of nanotechnology in health –care and medicine. However, there are diverse applications of Nanotechnology extending to electronics, transportation, energy , environment and space exploration.

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