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Review Article

Nanotechnology –Emerging weapon in Health care system

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Nanotechnology is one of the very frontiers of science today. In pharmaceutical field, this technology play a very important role, like it enables the delivery of drugs that are poorly water soluble and can provide means of bypassing the liver, thereby preventing the first pass metabolism. Nanotechnology increases oral bioavailability of drugs due to their specialized uptake mechanisms such as absorptive endocytosis and are able to remain in the blood circulation for a long time, releasing the incorporated drug in a controlled fashion, leading to less plasma fluctuations and minimized side-effects. Nanoscale size nanostructures are able to penetrate tissues and are easily taken up by cells, allowing for efficient delivery of drugs to target sites of action. Nanotechnology promises to revolutionize drug delivery by offering targeted administration in addition to more efficient drug dosing. Nanotechnology improves performance and acceptability of dosage forms by increasing their effectiveness, safety, patient adherence, as well as ultimately reducing health care costs. It may also enhance the performance of drugs that are unable to pass clinical trial phases. Nanotechnology definitely promises to serve as drug delivery carrier of choice for the more challenging conventional drugs used for the treatment and management of chronic diseases such as cancer, asthma, hypertension, HIV and diabetes.

Keywords- Nanotechnology, Delivery, Bioavailability, Flactuation, Drug dosing, Clinical trail, conventional drug

INTRODUCTION

Nanotechnology is a multidisciplinary field, convergence of basic sciences and applied disciplines like biophysics, molecular biology, and bioengineering. It has stepped powerful and strong impact in each and every fields of medicine including ophthalmology, cardiology, oncology endocrinology , pulmology, immunology etc., and one of the highly specialized areas like gene delivery, brain targeting, tumor targeting, as well as in oral vaccine formulations. pharmaceutical

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Nanotechnology provides intelligent systems, devices and materials for better applications. [1]

The word 'nano' is derived from Latin word, which means dwarf. Nano size refers to one thousand millionth of a particular unit thus nanometer is one thousand millionth of a meter (i.e., 1nm = 10^{-9}m).

The important applications in pharmacy of nanotechnology is the size reduction. The major objectives of introducing nanotechnology are improving solubility and bioavailability, reducing toxicity,

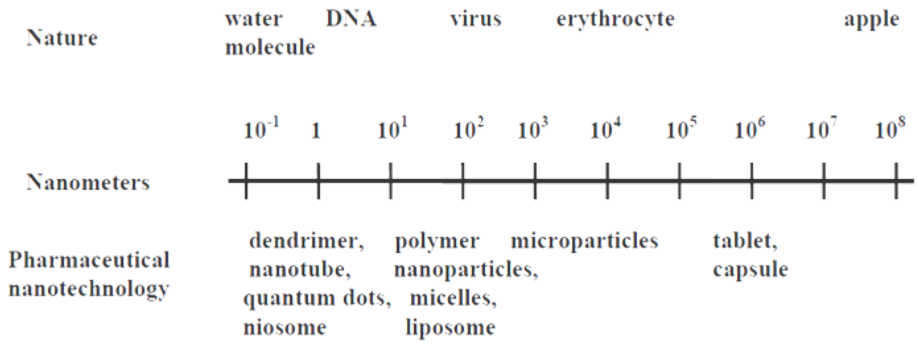

Fig 1: Dimensions of Nanotechnology

enhancing release and providing better formulation opportunities for drugs. In most of the cases, size reduction is limited to micron size range, for example, various pharmaceutical dosage forms like powder, emulsion, suspension etc. Drugs in the nanometer size range enhance performance in a variety of dosage forms. Major advantages of nanosizing include (i) increased surface area, (ii) enhanced solubility, (iii) increased rate of dissolution, (iv) increased oral bioavailability, (v) more rapid onset of therapeutic action, (vi) less amount of dose required, (vii) decreased fed/fasted variability, and (viii) decreased patient-to-patient variability.

Nano – Definitions

'Nanoscience'

It can be defined as study of phenomenon and manipulation of materials at atomic and molecular scales.

'Nanotechnology'

It is related to design characterization, production and applications of structures, devices and systems by controlling shape and size at nanometer scale.

'Pharmaceutical nanotechnology'

It embraces applications of nanoscience to pharmacy as nanomaterials, and as devices like drug delivery, diagnostic, imaging and biosensor.

'Nanomedicine'

It is defined as submicron size (<1um) modules, used for treatment, diagnosis, monitoring, and control of biological system. [2]

Pharmaceutical Nanotechnology Based Systems

Nanomaterials are used as biomaterials in orthopedic or dental implants or as scaffolds for tissue-engineered products. The modified surface or coatings helps to increase or enhance the biocompatibility by supporting the interaction of living cells with the biomaterial. These materials can be sub divided into nanocrystalline and nanostructured materials.

Bulk materials are somewhat less performing but the nano crystalline has

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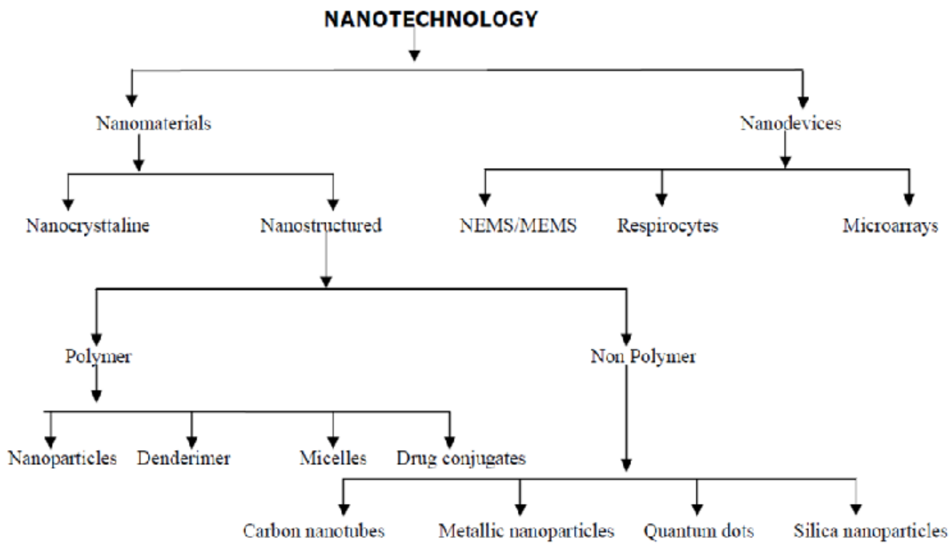

Fig 2: Schematic diagram of various types of pharmaceutical nanosystems

more better performance due to more exposer to the environment. Raw nanomaterials can be used in bone replacement ,drug encapsulation, prostheses (artificial mechanical devices to replace body parts lost in injury and or by birth e.g. artificial limbs, facial prosthetics and neuroprosthetics etc.), and implants.

Nanostructured materials are synthesize through processing of raw nanomaterials that provide special shapes or functionality, for example dendrimers, quantum dots, fullerenes and carbon nanotubes.

Nanodevices are miniature devices in the nanoscale and some of which include nano- and micro-electromechanical systems (NEMS/ MEMS), microfluidics (control and manipulation of micro or nanolitre of fluids), and microarrays(different kind of biological assay e.g. DNA, protein, cell, and antibody. Examples include detector and biosensors to detect trace quantities of, airborne pathogens, bacteria, biological hazards, and disease signatures and some intelligent machines like respirocytes.

Carbon – Nanotubes

Size: 0.5–3 nm diameter and 20–1000 nm length

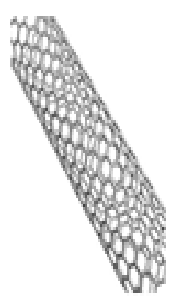

Fig 3(a) SWNTs

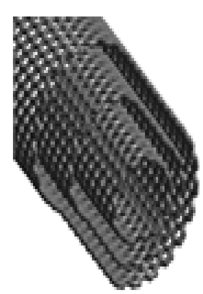

Fig 3(b) MWNTs

Characteristics:

Third allotropic crystalline form of carbon sheets either single layer (single walled nanotube, SWNT) or multiple layer (multi-

Fig 3(a)

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walled nanotube, MWNT). These crystals have remarkable strength and unique electrical properties (conducting, semiconducting, or insulating) [3]

Application:

Functionalization enhanced solubility, penetration to cell cytoplasm and to nucleus, as carrier for gene delivery, peptide delivery

Quantum Dots:

Size: 2–9.5 nm

Characteristics:

Semi conducting material synthesized with II-VI and III-V column element; Size between 10-100 Å; Bright fluorescence, narrow emission, Broad UV excitation and high photo stability.

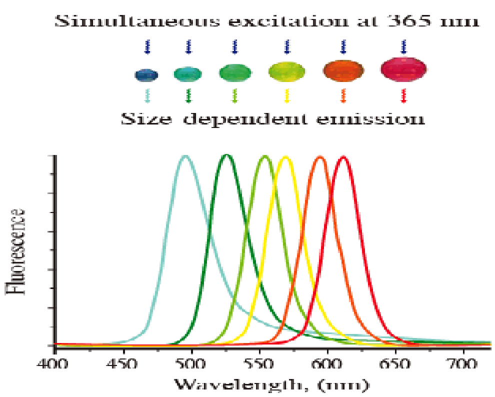

Fig 4: Size dependent representation of a quantum dots

Application:

Long term multiple color imaging of liver cell; DNA hybridization, immunoassay; receptor mediated endocytosis; labeling of breast cancer marker HeR_2 surface of cancer cells.

Dendrimers:

Size: <10 nm

Characteristics:

Highly branched, nearly monodisperse polymer system produced by controlled polymerization; three main parts core, branch and surface.

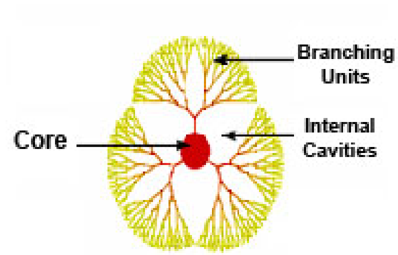

Fig 5: Schematic representation of a dendrimer

Application:

Long circulatory, controlled delivery of bioactives, targeted delivery of bioactives to macrophages, liver targeting. [4]

Polymeric Nanoparticles

Size: 10-1000nm

Characteristics:

Biocompatible, biodegradable, offer complete drug protection

Fig 6: Electron Microscopy image of a Polymeric Nanoparticles

Application:

Excellent carrier for controlled and sustained delivery of drugs, Stealth and surface modified nanoparticles can be used for active and passive delivery of bioactives.

Metallic Nanoparticles

Size: <100 nm

Characteristics:

Gold and silver colloids and very small size resulting in high surface area available for functionalization.

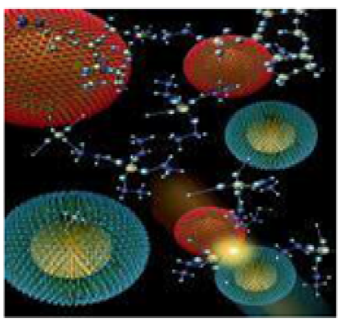

Fig 7: Surface functionalized gold nanoparticles

Application:

Drug and gene delivery, highly sensitive diagnostic assays, thermal ablation and radiotherapy enhancement.

Liposome:

Size: 50 – 100 nm

Characteristics:

Phospholipid vesicles, biocompatible,

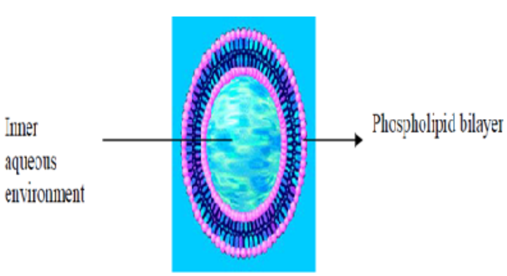

Fig 8: Liposome

versatile, good entrapment efficiency, offer easy surface functionalization. [5]

Application:

Long circulatory, offer passive and active delivery of gene, protein, peptide and various other bioactives.

Polymeric Micelles:

Size: 10-100nm

Characteristics:

Block amphiphilic copolymer micelles, high drug entrapmen

Fig 9: Structure of block copolymer micelles

t, payload, biostability.

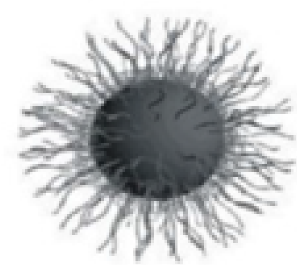

Fig 9: Structure of block copolymer micelles

Application:

Long circulatory, target specific active and passive drug delivery, diagnostic value.

Application of Nanotechnology:

Nanotechnology is the technology in which there is a application of biotechnology to clinical medicine.It can deliver medicament to specific part of the body without any side effect or harmful to any other body pat. It is prepared by using variety of material such as polysaccharide, protein, Iron oxide, synthetic polymer, gold, silicon iron magnetic silicate, zinc oxide can be used as nanoparticle.

Drug Delivery:

Nanotechnology has provided the possibility of idea of delivering drugs to specific cells using nanotechnology i.e nanoparticles. The overall drug consumption and side-effects may be decreased significantly by depositing the active agent in the morbid region only and in no higher dose than required. This highly selective approach would reduce costs and human suffering. An example can be found in dendrimers and nanoporous materials. Another example is to use block co-polymers, which form micelles for drug encapsulation. They could hold small drug molecules transporting them to the required location. Another vision is based on small electromechanical systems; nanoelectro mechanical systems are being investigated for the active release of drugs. Some potentially important applications include treatment of cancer with gold shells or iron nanoparticles . Targeted drug delivery is intended to reduce the side effects of drugs with concomitant decreases in consumption and treatment expenses. [6] The increased efficiency of delivery results in overall societal benefit by reducing the amount of drug needed in an equipotent preparation of said therapy, and thus reduced cost to the consumer.

Nanomedical approaches to drug delivery center on developing nanoscale particles or molecules for improvement of drug bioavailability. [7] Bioavailability refers to the appearance of drug molecules where they are required in the body and where they will give the better result. Drug delivery focuses on maximizing bioavailability both at specific places in the body and over a long period of time. This can potentially be gained by molecular targeting by nanoengineered devices. It is all about targeting the molecules and delivering drugs with cell precision. More than $65 billion are wasted each year due to poor bioavailability. *In vivo* imaging is another area where device and tools are being

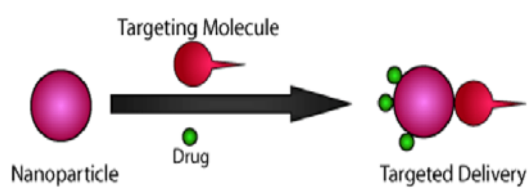

Fig 10: Targeted Delivery

developed. Using nanoparticle contrast agents, images such as MRI and ultrasound have a favorable distribution and improved better contrast. The new methods of nanoengineered materials that are being developed might be effective in treating in disease and illnesses such as cancer. What nanoscientists will be able to achieve in the future is beyond current imagination. This might be accomplished

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by self-assembled biocompatible nanodevices that will detect, evaluate, treat and report to the clinical doctor automatically.

Oncology:

The small size of nanoparticles endows them with properties that can be very important and useful in oncology, particularly in imaging. Quantum dots (nanoparticles with quantum confinement properties, such as size-tunable light emission), when used in conjunction with MRI (magnetic resonance imaging), can produce exceptional images of tumor sites. These nanoparticles are much brighter than organic dyes and only need one light source for excitation. This means that the use of fluorescent quantum dots could produce a higher contrast image and at a lower cost than today's organic dyes used as contrast media. [8] The downside, however, is that quantum dots are usually made of quite toxic elements.

Another nano property, high surface area to volume ratio, allows many functional groups to be attached to a nanoparticle, which can seek out and bind to certain tumor cells. Additionally, the small size of nanoparticles (10 to 100 nanometers), allows them to preferentially accumulate at tumor sites (because tumors lack an effective lymphatic drainage system). Research into multifunctional nanoparticles that would detect, image, and then proceed to treat a tumor is under way. A promising new cancer treatment that may one day replace radiation and chemotherapy is edging closer to human trials. Kanzius RF therapy attaches microscopic nanoparticles to cancer

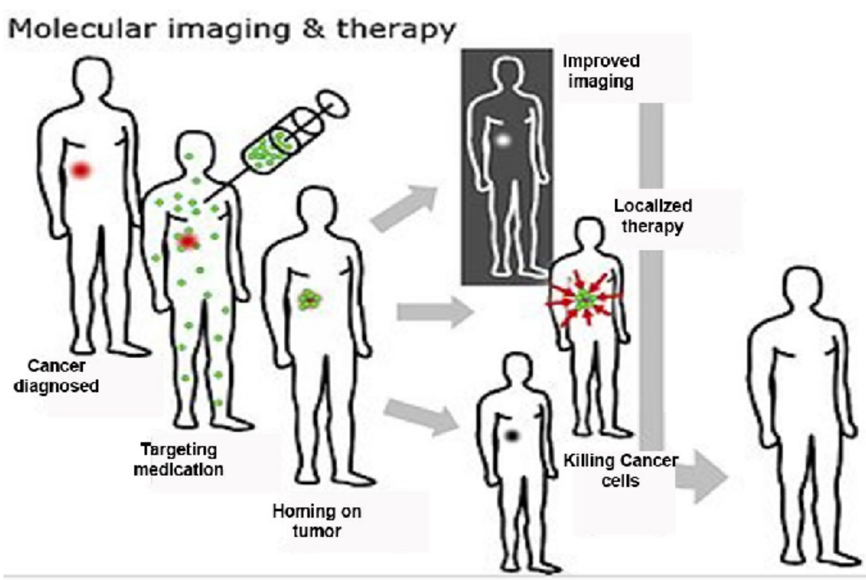

Fig 11: Schematic illustration showing how nanoparticles or other cancer drugs might be used to treat cancer.

cells and then "cooks" tumors inside the body with radio waves that heat only the nanoparticles and the adjacent (cancerous) cells. [9]

Sensor test chips containing thousands of nanowires, able to detect proteins and other biomarkers left behind by cancer cells, could enable the detection and diagnosis of cancer in the early stages from a few drops of a patient's blood. [10]

The basic point to use drug delivery is based upon three facts:

a) Efficient encapsulation of the drugs,

b) Successful delivery of said drugs to the required or targeted region of the body, and

c) Successful release of that drug there

Nanovaccines:

DNA vaccines, also reffered to as genetic vaccines, are generating significant clinical and preclinical interest. It has been proven that the expression of an antigen or antigens from plasmid DNA (pDNA) may elicit both and cellular and humoral immune responses. Therefore, DNA vaccines may have potential as new vaccines for important diseases such as HIV, hepatitis C, tuberculosis, and malaria. However, DNA vaccine delivery does not give good result so it is not satisfactory. Relative high dose of pDNA are needed to elicit a response. The clinical result using “naked” pDNA have been disappointing in the breadth and depth of the immune response. Clinical trials with the gene gun have been promising, but it is unclear whether this technology will be commercially viable. Therefore, there is a need for new vaccine delivery systems that can be administered at low doses to elicit strong humoral and cellular immune responses. Use of nanotechnology has been explored for this purpose.

Protein and Peptide Delivery:

Protein and peptides exert more than one biological action in the human body and they have been identified as showing great promise for treatment of various diseases and disorders. These macromolecules are called biopharmaceuticals. Targeted and/or controlled delivery of these biopharmaceuticals using nanomaterials like Dendrimers and nanoparticles is an emerging field called nanobiopharmaceutics, and these products are called nanobiopharmaceuticals.

Nanorobots:

Nanorobots could be employed for the targeted drug dispensation, diagnostics,

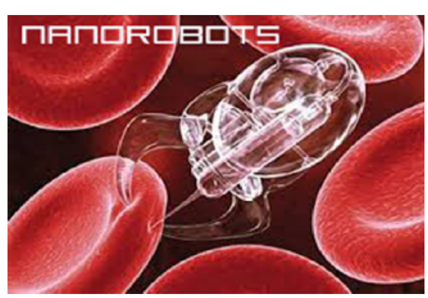

Fig 12: Illustration of Nanorobot

elimination of xenogenous particles from the body, and repair of cells and tissues, e.g. the skin and teeth.35 Nanorobots could also be programmed to perform delicate surgeries or remove obstructions in the circulatory system.[11]

CONCLUSION:

Pharmaceutical nanotechnology is an emerging field that could potentially make a major impact on human health or disease. Nanomaterials promise to revolutionize medicine and are increasingly used in drug delivery or tissue engineering applications. Newly developed hybrid systems seem promising for future applications in human. Functional and multifunctional approaches have tremendous potential in temporal and spatial controlled delivery of bioactives. A modular approach to construct delivery systems that combine targeting, imaging and therapeutic functionalities into nanoplateforms is emerging as intelligent concept. These multifunctional nanoplateforms would localize to target cells, enable diagnostics and subsequently deliver therapeutics with great precision. But such approaches to nanodevice construction are inherently complex. One very interesting and novel future strategy is to devise a nanomachine, which can detect and attack pathogen simultaneously, detect the change in molecular event during diseased state, and also monitor the efficacy of treatment. However such intelligent machine (also known as nanorobots which can serves as mini onboard computer in human body) is very far reaching concept. In short, recent development, market realization of various pharmaceutical nanotools and global interest shown by scientists, governments and industries ensure that there is tremendous potential and scope of nanobased drug delivery system in near future. There is no doubt to presume that in next ten years market will be flooded with nano-enabled delivery devices and materials.

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