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NANOTECHNOLOGY APPLICATIONS IN DRUG DELIVERY

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ABSTRACT
The present state of medication formulations using nanotechnology has made it possible to address and treat difficult disorders. Although they vary in size, nanoparticles typically have a size between 100 and 500 nm. It is possible to develop complex techniques that encapsulate pharmaceutical and imaging substances while maintaining their stealth qualities by varying the size, surface characteristics, and composition of the nanoparticles. These gadgets might additionally deliver medications to specific areas and provide controlled release therapy. Patients take fewer doses of the drug when it is delivered in a targeted and sustained way, which also lessens the toxicity of the treatment. Nanotechnology has demonstrated potential in the management of several illnesses, such as cancer and AIDS, among many others. Advanced diagnostic tests are also included. The benefits and drawbacks of employing nano medicines to transfer medications from synthetic or natural sources to therapeutic settings are also covered. Additionally, we have included information about current trends and viewpoints in the field area of Nano medicine.
Key words: nanoparticles, medication, Drug, gadgets

INTRODUCTION

A diversity of diseases has been treated in the past with drug delivery systems (DDSs). Metabolites with pharmacological activity, or pharmaceuticals, are the basis for all medications that treat a wide range of ailments. Some drug classes are designed to be inactive metabolites with earlier; yet, after transformation, they become active in the body, enhancing the effectiveness of therapy. The way they are administered affects their efficacy. Using conventional drug delivery systems, drugs were often administered in a variety of methods, such as oral, nasal, inhalation, and mucosal.In addition to harming unaffected regions, conventionally delivered drugs were rapidly absorbed, disseminated irregularly, excreted early, and took longer to cure illnesses [24].

They were less effective because of a number of barriers, including their fast release that enhanced toxicity in blood, multiple mucosal barriers, enzymatic breakdown or pH imbalance, and off-target effects. Through the use of Nano structures and Nano phases in several scientific fields, in particular in medication delivery systems based on nanotechnology and nanomedicine, Drug delivery methods within nanotechnology have been shown to transcend the boundaries of the medical and physical science area of significant interest such particle sizes. A material is called a nanomaterial if its size is between 1 and 100 nanometers. This size of material affects several areas of Nano medicine, such as drug delivery, tissue engineering, biosensors, microfluidics, and microarray testing. Due to their composition of materials with atomic or molecular structures, nanoparticles are typically tiny nanospheres. They can thus move around

inside the human body more freely than bigger materials can. Special biological, mechanical, chemical, electrical, magnetic, and structural properties are present in nanoparticles [19].
Nanomedicine is the application of scientific understanding and techniques from nanoscience to medical biology, illness prevention, and treatment. For example, a nanoparticle-based strategy that combines treatment with imaging modalities for cancer diagnostics has been created. Because nanotechnology delivers medication in a target- and site-specific manner, it can help treat a variety of chronic human illnesses. However, there is a severe issue over the paucity of information on the toxicity of nanostructures, which demands further research to improve both safety and efficacy and enable the safer practical use of these drugs [28].

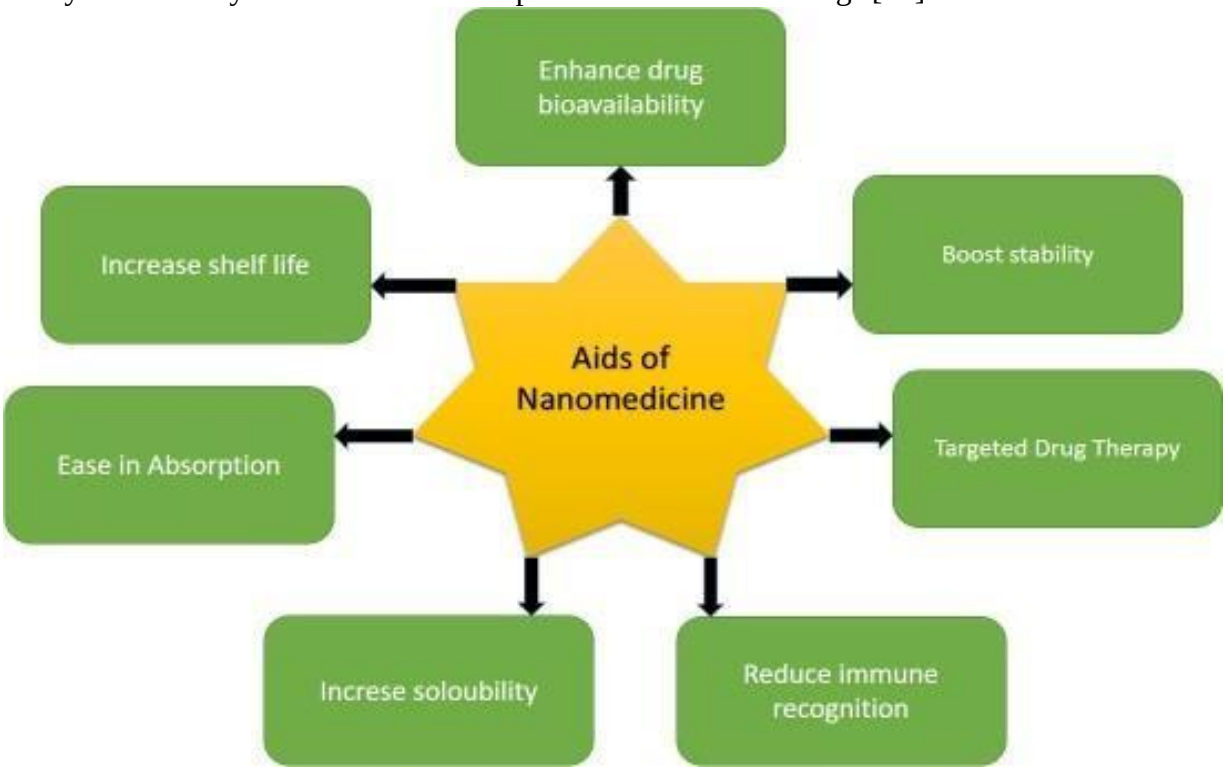

Figure1:AidsofNanoMedicine

TYPES OF NANO MEDICINE: Materials classified as nanometer-diameter-scale materials (NDDS) have at least 1 nanometer-scale or are made up of them in three dimensions. Since NDDS improve drug distribution, a lot of research has been done on them in the fields of pharmacy and contemporary biomedicine.

- **Liposomes**:Liposomes as lipid vesicles that frequently consist of a phospholipid bilayer that is structured and has a structure akin to a cell [15]. Liposomes are a kind of drug carrier with several benefits, including less adverse effects, non-toxicity, non-immunogenicity, sustained-release drugs, extended duration of therapeutic action, altered drug distribution in vivo, and more [31]. Not only are liposomes readily generated for ensnaring ionic and hydrophilic molecules, but they are also compatible with drugs that are hydrophobic [36]. The liposome drug delivery system containing hydrophilic as well as lipophilic for specific genes, whereas the bimolecular structure of phospholipids can encircle hydrophobic drugs. Different lipid materials may be modified to change the surface chemistry, potential, and particle size.
- **Polymer Micelle Co-delivery System**:Polymer nanoparticles, which come in two varieties— biodegradable and non-biodegradable—are an additional kind of drug delivery vehicle. The majority of medications may coexist happily with their breakdown products, such as oligomerization and end products, and they won't cause any damage to cells. The three primary categories of natural polymers are cyclodextrin inclusion complexes, peptides, and polysaccharides. Amphiphilic block copolymer self- assembly

often produces polymer nanoparticles, which are stable at the core and useful for capturing insoluble medications. When taken orally, the effects of the gastrointestinal environment can be successfully countered by the regularity of drug release and the stable structure of polymer nanoparticles. Unfortunately, certain polymer nanoparticles have drawbacks. For example, the natural polymer chitosan is not compatible with biological fluids, which might lead to reduced productivity and particle disintegration. Its flaw can be resolved by changing the structure [3, 4].

- **Dendritic Macromolecules**:Macrophages are synthetic, often branching, and have a variety of shapes. Spiral-shaped macromolecules may be organized in monodisperse space and are primarily utilized as nano-carriers to administer and dissolve specific, intractable medications. Dendritic macromolecules are monodispersed, have controlled molecular weights, and have a characteristic branch topology [6, 29]. The package is an excellent drug delivery medium since it also contains a hydrophobic environment and several pre-made surface functional groups [17].
- **Metal Nanomaterial's**:The most often employed type of metal nanomaterials are those composed of gold and silver, including nanoparticles, nanorods, nanocapsules, nanocuboids, and nanowire [14]. In addition to being used as surface-enhanced Raman spectroscopy and CT nano-contrast agents, rheumatoid arthritis and cancer can treat with gold nanoparticles used in photo thermal therapy [9]. Silver nanoparticles are mostly used in areas where they exhibit antibacterial, anti-infection, and anti-tumor characteristics, according to a number of studies [26]. To accomplish targeted drug delivery, some therapeutic medications can also be chemically attached to the surface of nanoparticles or physically inserted into hollow gold or silver nanostructures. However, because silver ions are poisonous in vivo and the body cannot eliminate gold nanoparticles.
- **Inorganic Non-metallic Nanomaterial's**:Silicon, graphene, iron oxide, quantum dots, and other materials fall under the main groups of inorganic non- metallic nanomaterials. Iron oxide nanoparticles are mostly used in the search for novel magnetic resonance imaging contrast agents, but semiconductor nanocrystals, or QDs, are especially well-suited for use in fluorescence imaging due to their distinct brightness [10]. Those Inorganic nanoparticles can be used to boost gene transfer and drug effectiveness in mammalian cells by combining different functional groups. However, a major barrier to their use in clinical settings would be their inorganic non-metallic nanoparticles' biosafety.
- **Composite Nanomaterial's**:In addition to the previously mentioned nanoparticles, a number of research are concentrating on the synthesis of composite nanomaterials with various characteristics. For instance, polymer or lipid nanomaterials are combined with metal or inorganic non-metallic nanoparticles to form multifunctional NDDSs that carry both pharmaceuticals and contrast agents. In addition, different metals and inorganic materials can be mixed to produce NDDSs with distinct properties and functions [5].

Characteristic of Nanoparticles: Three primary methods by which Nano Particle can enter into body are; injection, inhalation, oral. Once they enter the systemic circulation and are subsequently dispersed to many organs, particle- protein interaction takes place. Two to three primary purposes of this system are related to the delivery of drugs. It is maybe the most pertinent to this subject as it deals with immunity. The system removes extra fluid from the body while also removing chemicals and foreign cells from the tissues. Macrophages will take up and remove everything that they identify as foreign from the body [1].

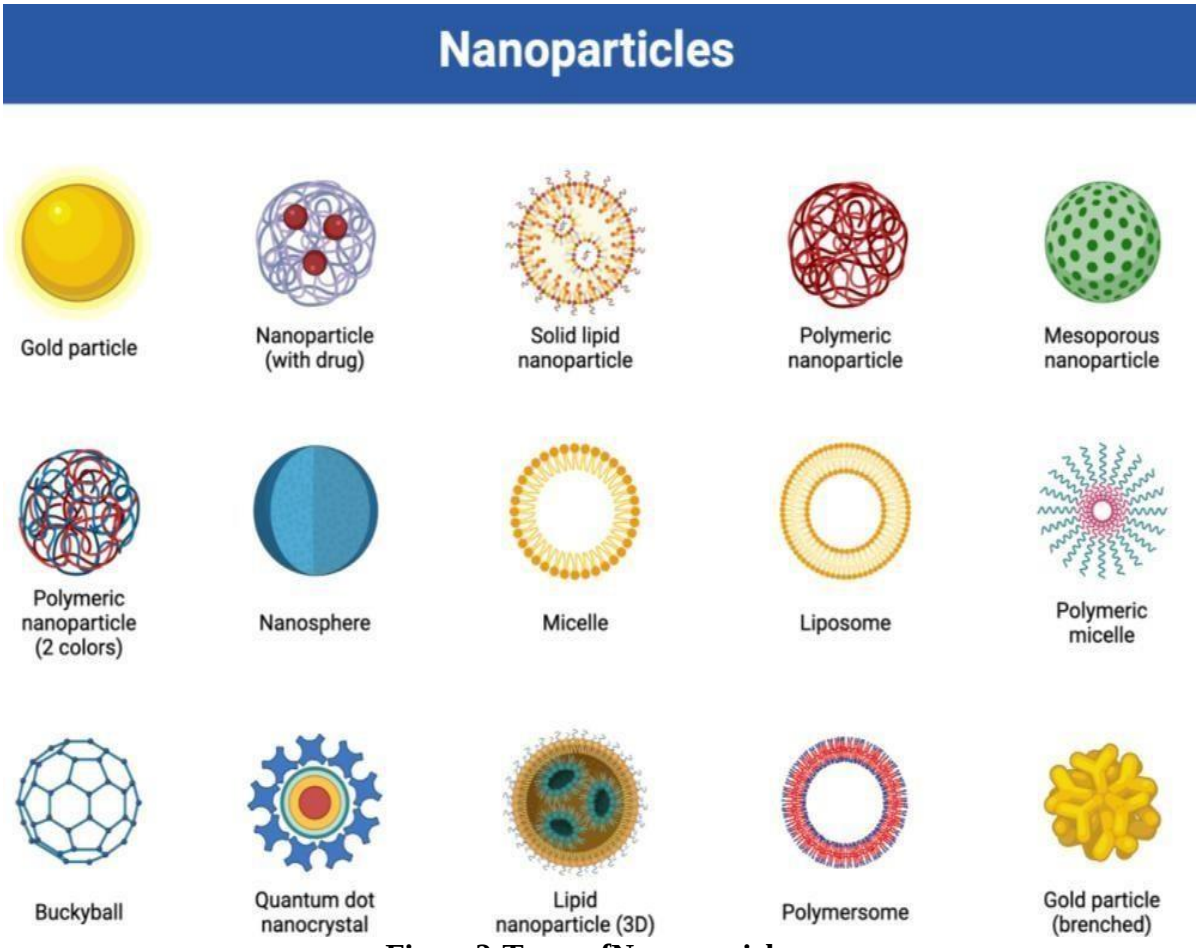

Figure2:TypesofNanoparticles

- **Size of particle**:Size and Shape of Nanoparticles influence how the cells "see", as well as how they disseminate, become poisonous, and target. Not only may additional targets be reached, but this method can be adjusted to regulate the flow of drugs. As stated by (Desai et al., 1997), 100 nm nanoparticles were shown to have a six-fold higher concentration than 10 μm particles and 2.5-fold larger absorption than 1 mm particles [21].The significance of nanoparticle drug delivery systems has been explored; however, if the medication is not released or is not released efficiently, these systems would be useless [16].

  This would suggest that, rather than a bigger molecule, extra of the drug is present closer to the atom's surface. Medication would release more quickly if it were at or close to the surface [13]. Nanoparticle systems with a high surface area to volume ratio can be advantageous, this is an additional component that has to be designed into the perfect nanoparticle system. Due to large space to capacity ratio, the particle may administer enough medication at this size while avoiding quick clearance by the lymphatic system and passing past the blood-brain barrier.
- **Surface properties**: The effectiveness of nanoparticle-based medicine formulations has been demonstrated to be influenced by size, but surface characteristic change provides an additional means of designing the ideal system [7]. First things first, the nanosystems must be cleared. The body's intrinsic immunological response to foreign substances can impact nanoparticles as the lymphatic system is able to recognize them. Blood components are more likely to be eliminated because they stick to hydrophobic nanoparticles more firmly [33]. Hydrophilic surface modification would seem to extend the half-lives of hydrophobic nanoparticles, as the former are easily expelled from the body.When added to the surface of nanoparticles, PEG, a hydrophilic and comparatively inert polymer, prevents plasma protein binding (opsonization) and, as a result,

significantly reduces the amount of the administered dosage.

The reticuloendothelial system (RES) often refers to PEGylated nanoparticles as "stealth" nanoparticles since they do not go through opsonization. Polymer complexes have been shown to be effective in resolving clearance issues; yet, owing to their large surface area, small particles continue to agglomerate. A number of tactics have been used to stop the particles from aggregating, including covering them with capping chemicals and changing their surface charges, or zeta potential [35].All of these techniques and hypotheses may be boiled down to one concept: the particle size needs to be big enough to prevent leaking into blood vessels while being small enough to be removed by macrophages.

- **Drug loading and release**: Matrix erosion is the mechanism by which drugs are released from nanospheres—matrix systems in which the drug is physically and evenly distributed. Since the medication is weakly bound and the nanoparticle has a high surface area, there is a transient burst of drug release followed by a continual release [34].Ionically interacting polymer and medication will form complexes that keep the drug from dissolving in the capsule. PEO-PPO is one additional auxiliary agent that may be used to prevent this.
- **Targeted drug Delivery**:After understanding how important it is to modify nanoparticles in order to produce an efficient drug delivery system, the development of tailored medicine administration makes sense. The ideal drug delivery system for nanoparticles (Fig. 1) should be able to approach, identify, bind, and distribute its load to the targeted sick tissues while causing the least amount of damage to the healthy tissues. The most common strategy involves covering the surface of nanoparticles with a specific targeted ligand or ligands [11].

APPLICATION OF NANO TECHNOLOGY

- **Cancer therapy**: Many lives have been saved by the cancer therapies that are currently available, but because the chemotherapeutic drugs are non-specific, the severe side effects of the therapy affect every organ of the body [12]. Cancer is frequently described as a disease of many ailments due to its intricacy. Malignant cells have the ability to divide and replicate rapidly [27]. Chemotherapy's primary goal these days is to destroy any cells that divide quickly. Additionally, micelles are an excellent way to create drugs that are stubbornly solubility because to their hydrophobic core and hydrophilic surface. Higher drug concentrations in tumors will result from additional PEGylation of the micelle's surface, which will improve the nanocarriers' capacity to passively carry drugs across the fenestrated vasculature of tumors and inflammatory tissue. According to Zhang et al. (2014), one such system is approved for use in breast cancer patients: Genexol- PM (paclitaxel) [43].Carbon nanotubes are one of the more recent systems to show promise in the therapy of cancer, despite the fact that numerous other kinds of nanoparticles have also shown promise. According to Dinesh et al. (2016), the huge surface area enables outer surface functionalization, which may be tailored for a specific cancer receptor and contrast chemicals. Reactive oxygen species (ROS) are effectively scavenged by fullerene C60, which has the ability to bind up to six electrons [23]. It has been shown to increase the cytotoxicity of chemotherapeutic drugs; as a result, additional research may be done on Nano-C60 adjunct chemotherapy [42]. Another investigation employing the Fullerene C60 and Doxorubicin combination was carried out by (Prylutska et al. 2015) [37]. Moreover, it is believed that the C60 + Dox complex acts on tumor cells directly in addition to having an immune modulatory impact.
- **Diagnostic testing**:Although not yet ready for clinical usage, the use of nanoparticles for diagnostics is a field that has received a lot of attention in academics [32]. Fluorescent nanoparticles offer researchers a way around the shortcomings of fluorescent markers,

which limit the use of dyes due to bleeding effects, color matching issues, and fluorescence fading after a single use, among other issues that impede current diagnostic testing technology [41]. Quantum dot tagging has several benefits. White light is what initially excites them. Secondly, in order to investigate various bio-mechanisms, they may be linked to biomolecules that have the capacity to remain in a biological system for an extended period of time. By attaching colored nanodots to different biological molecules, this method also makes it possible to monitor many biological processes at once [20].

- **HIV and AIDS treatment**:When this condition was first being treated, the majority of people may have to take 30 to 40 medications every day. It was a laborious process. The number of medications used daily can now be decreased to a small number because to therapeutic advancements throughout the past 10 years [8]. Highly effective antiretroviral treatment, or HAART, consists of three or more medications to aggressively combat HIV progression and avoid the emergence of resistance [18]. Antiretroviral medication delivery and compliance have greatly benefited from nanotechnology [28]. Antiretroviral medications must be able to pass through the mucosal epithelial barrier when administered sublingually or by non-parental means (such as patches and suppositories). HIV mostly multiplies and infects lymphoid organs [22].
- **Nutraceutical delivery**:Nutraceuticals are components of food that have been standardized and shown to have noticeable health benefits. They are often utilized to provide extra health benefits and reduce the risk of acquiring certain chronic illnesses when combined with other allopathic therapy [2]. Nanotechnology offers comprehensive assistance, and most research has concentrated on improving the dissolving processes of nutraceuticals through the use of nanoparticle formulations [44]. Numerous nutraceuticals have demonstrated anti- inflammatory, antioxidative, antiapoptotic, and antiangiogenic effects; the most well-studied and well- known of them is curcumin (diferuloylmethane). Curcumin's oral bioavailability rose nine times when piperine, an absorption booster, was also provided [38]. According to Summerlin et al. (2015), it has anti-inflammatory, cardioprotective, antioxidant, and anticancer properties [39]. Although resveratrol is somewhat bioavailable and has a low solubility, it is quickly metabolized and excreted from the body [30, 40].

CONCLUSION

As a genuinely interdisciplinary field of study, nanotechnology has benefited greatly from the contributions of chemists, physicists, biologists, and pharmaceutical scientists in the development of innovative therapeutic and diagnostic approaches. The application of nanotechnology has advanced non- invasive imaging, nutraceutical delivery, cancer and HIV/AIDS treatment, and more. In the end, researchers are able to administer medications for longer periods of time with less frequent doses (sustained release), higher accuracy, and penetration in difficult-to-access tissues through the alteration of molecule size and surface features.

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