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Drug Delivery Systems based on Nanotechnology

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Opinion

Nanotechnology has been shown to bridge the gap between biological and physical sciences by employing nanostructures and nanophases in a variety of fields, including nanomedicine and nano-based drug delivery systems, where such particles are of particular interest. Nanomaterials are materials of sizes ranging from 1 nm to 100 nm that impact the frontiers of nanomedicine, from biosensors to microfluidics, drug delivery, and microarray experiments to tissue engineering. To build nanomedicines, nanotechnology hires curative agents at the nanoscale stage. Nanoparticles also fueled the world of biomedicine, which includes nanobiotechnology, drug delivery, biosensors, and tissue engineering. Nanoparticles are usually thin nanospheres made up of materials engineered at the atomic or molecular level. As a result, they can travel more naturally inside the human body than larger materials. The structural, chemical, electronic, magnetic, electrical, and biological properties of nanoscale particles are all distinct. Nanomedicines have gained popularity in recent years as a result of their ability to encapsulate drugs or bind therapeutic drugs to nanostructures and distribute them to target tissues more accurately and with a controlled release. Nanomedicine is a new discipline that applies nanoscience knowledge and techniques to medical biology and disease prevention and treatment. It refers to the use of nanoscale materials in live cells, such as nanorobots, nanosensors, and actuates materials for diagnosis, distribution, and sensory purposes. For example, a nanoparticle-based approach was developed that merged cancer diagnosis treatment and imaging modalities. Lipid structures including liposomes and micelles, which are now FDA-approved, were used in the first wave of nanoparticle-based therapy. Inorganic nanoparticles such as gold or magnetic nanoparticles can be found in these liposomes and micelles. These characteristics have led to a rise in the use of inorganic nanoparticles for drug delivery, imaging, and therapeutic purposes. Furthermore, nanostructures are said to assist in the delivery of sparingly water-soluble drugs to their target site, as well as avoiding drug tarnishing in the gastrointestinal region. Since nano drugs have traditional absorptive endocytosis absorption pathways, they have a higher oral bioavailability.

Nanostructures remain in the blood circulatory system for a long time, allowing amalgamated drugs to be released at the precise dosage. As a result, they cause less plasma variations and have fewer side effects. Since these materials are nanoscale, they can easily penetrate the tissue layer, allowing for fast drug ingestion by cells, rapid drug distribution, and action at the desired site. Nanostructures are taken up by cells at a significantly higher rate than large particles varying in scale from 1 µm to 10 µm. As a result, they work together to treat diseased cells more effectively and with less to no side effects.

Nanoparticles have been shown to be helpful in collecting knowledge at all levels of clinical practice due to their use in various novel assays to cure and diagnose diseases. The key advantages of these nanoparticles are related to their surface properties, which enable different proteins to attach to the surface. Gold nanoparticles, for example, are used as biomarkers and tumor identifiers in a variety of biomolecule identification procedures.

When it comes to the use of nanomaterials in drug delivery, the nanoparticles are chosen depending on the physicochemical properties of the medicines. The combination of nanoscience and bioactive natural compounds is very appealing, and it has been rising steadily in recent years. It has a number of benefits when it comes to delivering herbal drugs for the treatment of cancer and a variety of other diseases. Because of their diverse properties, such as stimulating tumor-suppressing autophagy and functioning as antimicrobial agents, natural compounds have been extensively studied in the treatment of diseases.

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Curcumin and caffeine have been shown to induce autophagy, while cinnamaldehyde, carvacrol, curcumin, and eugenol have antimicrobial properties. By adding nanoparticles, they were able to improve their properties such as bioavailability, targeting, and controlled release. For example, after being encapsulated in a lipid nanocarrier, thymoquinone, a bioactive compound found in *Nigella sativa*, is studied. In addition to free thymoquinone, it demonstrated a sixfold improvement in bioavailability after encapsulation, protecting the gastrointestinal tract. It also improved the natural product's pharmacokinetic properties, resulting in improved medicinal effects.

Target-specific drug delivery mechanisms also use metallic, chemical, inorganic, and polymeric nanostructures, such as dendrimers, micelles, and liposomes. These nanoparticles are specifically used to brand drugs with low solubility and absorption ability. The effectiveness of these nanostructures as drug delivery vehicles, however, varies depending on their scale, form, and other biophysical/chemical properties. Polymeric nanomaterials with diameters ranging from 10 nm to 1000 nm, for example, have properties that make them suitable for use as a distribution vehicle. Various synthetic polymers, such as polyvinyl alcohol, poly-l-lactic acid, polyethylene glycol, and poly (lactic-co-glycolic acid), and natural polymers, such as alginate and chitosan, are widely used in the nanofabrication of nanoparticles due to their high biocompatibility and biodegradability properties. Nanospheres and nanocapsules are two types of polymeric nanoparticles that are both effective drug delivery mechanisms. Compact lipid nanostructures and phospholipids, such as liposomes and micelles, are also very useful in drug delivery.

As a result, nanotechnology provides many advantages in the treatment of chronic human diseases by allowing for site-specific and target-oriented drug delivery. However, a lack of understanding about nanostructure toxicity is a major concern, and further research is certainly needed to increase effectiveness while still increasing safety, allowing for a safer practical application of these medicines. As a result, carefully planning these nanoparticles can be beneficial in addressing the issues associated with their application. In light of the above, the aim of this analysis is to present various nano-based drug delivery systems, as well as significant applications of natural compound-based nanomedicines, bioavailability, targeting sites, and controlled release of nano-drugs, as well as other challenges associated with nanomaterials in medicine.