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The Emerging Nanomedicine Prospect

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Advances on nanotechnology in drug delivery, imaging and diagnostics, etc. will certainly change the medical treatment scenario which includes site-specific or targeted drug delivery and theranostics (a combination of diagnostics and therapy). Nanomedicine has been defined by National Institutes of Health as “an offshoot of nanotechnology, which refers to highly specific medical interventions at the molecular scale for curing disease or repairing damaged tissues, such as bone, muscle, or nerve”. Are nanomaterials natures’ gift or scientist’s brain child? It has been present in nature for millions of years as a giant laboratory of nanoscience and engineering. Nanotechnology has been practiced from ancient time without even being known about it. Nature is all about nanoscale structures. Silk is the best example of nature nanotechnology where the molecules are arranged in a specific set to form crosslinks giving its strength. Bone is another example where nanocrystals of calcium phosphate and nanofibres of collagen form a strong natural composite. The present-day trend around the world is to translate nanotechnology research into commercialization. The first nanoparticle-based drug approved by FDA is Abraxane. Today there are over fifty commercial nanomedicine products based on nanotechnology. Disease diagnosis, treatment, and prevention will be revolutionized with the development of a wide range of products with nanoscale technologies. Nanomedicine includes nanoparticles, nanofibers, polymeric nanocomposites, metallic and semiconductor nanocrystals and quantum dots (QDs). These structures have application in drug delivery for fungal infections, cancer hepatitis, immunodeficiency diseases, chronic kidney disease, immunodeficiency disease, lipid regulation, etc.; in vivo imaging for liver tumors and imaging of abdominal structures; in vitro diagnostics such as for pregnancy, ovulation, HIV, immunodiagnostics etc.; biomaterial nanocomposites for dental filling, restoration and repair, bone defects and antimicrobial wound care etc.

The worldwide market value of nanomedicine was $50.1 billion in 2011 reaching $ 121.9 billion in the year 2018 and expected to reach $ 350 billion by the year 2025 with a growth rate (CAGR) of 17.1%. This accounts for 10 to 15% of total pharma sales and includes the central nervous system, anti-cancer, cardiovascular and antibacterial products. Anticancer products had the highest market share with central nervous systems products following close. As per the world health organization (WHO) factsheet, the major cause of mortality and morbidity worldwide was found to be cancer. Therefore, nanomedicine for cancer treatment seems to be of high demand in order to fight the high incidence rate of cancer. The global market for the cardiovascular segment is also expected to grow at the fastest pace owing to the increasing prevalence of cardiovascular diseases demanding drugs with improved efficacy and therapeutic properties.

Because nanotechnology focuses on the very small, it is uniquely suited to creating systems that can better deliver drugs to tiny areas within the body. Nano-enabled drug delivery also makes it possible for drugs to permeate through cell walls, which is of critical importance to the expected growth of genetic medicine over the next few years. The targeting ability and controlled release have been achieved by physicochemical modification of these nanoparticles. The important aspect of nanoparticles is its high effective surface area. This further helps in conjugating multiple ligands that induce a synergistic therapeutic effect. Iron oxide nanoparticles are extremely useful in active targeting and imaging. Similarly, gold nanoparticles can achieve controlled delivery in response to near IR irradiation and extremely useful in diagnostics. There are other metal nanoparticles such as silver nanoparticles, alumina nanoparticles, gadolinium oxide nanoparticles, and other polymer conjugates, hydrogel nanoparticles, dendrimers and inorganic nanoparticles that find application in *in vivo* imaging, targeted drug delivery, proton therapy, *in vitro* assays and other imaging applications. However, standardization of the process of chemical ligand modification is not an easy task from the toxicity point of view and the maintenance of the stability of the active ingredient. Thus nanoparticles require an interdisciplinary approach among different fields, including biopolymers, biopharmaceutics, materials science and tissue engineering to enable their potential applications in drug delivery. There are also a few challenges in commercializing nanotechnology, such as high processing costs, problems in the scalability of R&D for prototype and industrial production, the basic research orientation of the related sciences, concerns about the environment, health and safety including nanotoxicity, etc. However, utilizing nanotechnology, nanomedicine can eventually contribute towards cost-effectiveness and competitiveness and may provide important opportunities to revolutionize science, technology, and society. Designing the right size of nanoparticles, surface modification for cellular specific targeting; selecting a suitable route of administration, and optimum dosage can generate safe and effective nanoparticles for drug delivery, tissue engineering, sensing and imaging applications.