commentary

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Nucleic Acid Nanostructures for Advanced Applications

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Description

DNA nanotechnology facilitates the construction of rationally designed nucleic acid nanostructures for advanced applications. Since the pioneering work of Seeman in the 1980s, we have witnessed a rapid evolution of this field, particularly in the last two decades. From a Nano biotechnological perspective, DNAs are considered excellent materials for engineering nano-scaled structures because they possess many unparalleled advantages. In particular, the highly programmable and predictable Watson-Crick base pairing enables the design of virtually any DNA nanostructure. Thus far, a wide variety of one-, two-, and three-dimensional (1D, 2D, and 3D) structures, with definite size, exquisite geometry, and precise addressability at the nanometer scale, have been successfully developed through self-assembly. Meanwhile, DNA, as a naturally occurring bio macromolecule, can respond to a variety of biochemical events, such as hybridization, replication, elongation, and cleavage. With the advances of nucleic acid chemistry, diverse functional groups (e.g., amino, biotin, and carboxyl), of molecules (e.g., dyes, quenchers, and proteins) and nanomaterials can be site-specifically incorporated into DNA nanostructures. These unique features can endow the DNA nanostructures with tailorable functionalities, thereby enabling an increased applicability to many research fields, such as chemistry, biology, biomedicine, and materials science. In addition to functioning as exceptional building blocks for nanostructures, nucleic acids have attracted significant interest for their functionality, in particular aptamer molecules. DNA aptamers are single-stranded oligonucleotides screened by an *in vitro* method called systematic evolution of ligands by exponential enrichment, pioneered by the Gold and Szostak Labs in 1990. Considered "chemical antibodies," aptamers can bind to various targets, ranging from metal ions, small molecules, and proteins to whole cells, viruses, and bacteria with high specificity and affinity. Compared with antibodies, aptamers have several additional significant advantages, including relatively small molecular weight, high designability, convenient modification, and low immunogenicity. These unique properties make aptamers promising recognition probes for biological and biomedical research. Moreover, their integration with DNA nanotechnology can generate versatile and tailor-made nanosystems that possess both excellent recognition property and smart response toward an increasing list of bio targets, thereby offering promise in the fields of biology and biomedicine.17 Comprehensive reviews on either DNA nanotechnology or aptamers can be found elsewhere. In this review, we mainly focus on the convergence of these two emerging fields. We first present a brief overview of DNA nanotechnology and aptamers and then summarize recent progress in the applications of aptamer-integrated DNA nanostructure in bio sensing, bio imaging, targeted drug delivery, bio regulation, and bio mimicry.

Role of Sensors in Biomedical, Environmental, And Food Monitoring Applications

A current list of immediate 'basic human needs' emphasizes the necessity of good food, good health, and a healthy environment to live in. For a great time, various researches are being carried out to improve life. Biosensors are such a peculiar discovery of science which shows applicability in different fields and enhances the survival of mankind. Aided with nanotechnology, it opens the path for "Nano biosensors," which has refined the role of sensors in biomedical, environmental, and food monitoring applications. This concise and inclusive review is targeted towards the recent progress in these applicative spheres of nan biosensors. Colloidal particles in the nanometer size range (less than 1 μm in diameter) can be engineered to provide opportunities for the site-specific delivery of drugs after injection into the general circulation or lymphatic systems. Targets include the liver (both Kupffer cells and hepatocytes), endothelial cells, sites of inflammation and lymph nodes. The size and surface of the particle are crucial factors in targeting, and the attachment of cell-specific ligands can lead to increased selectivity. The applications of such particle engineering are discussed in relation to conventional drugs as well as the emerging area of gene therapy.With numerous recent advances, the field of therapeutic nucleic acid nanotechnology is now poised for clinical translation supported by several examples of FDA-approved nucleic acid Nanoformulations including two recent mRNA-based COVID-19 vaccines. Within this rapidly growing field, a new subclass of nucleic acid therapeutics called nucleic acid nanoparticles (NANPs) has emerged in recent years, which offers several unique properties distinguishing it from traditional therapeutic nucleic acids. Key unique aspects of NANPs include their well-defined 3D structure, their tunable multivalent

architectures, and their ability to incorporate conditional activations of therapeutic targeting and release functions that enable diagnosis and therapy of cancer, regulation of blood coagulation disorders, as well as the development of novel vaccines, immunotherapies, and gene therapies. However, non-consolidated research developments of this highly interdisciplinary field create crucial barriers that must be overcome in order to impact a broader range of clinical indications. Forming a consortium framework for nucleic acid nanotechnology would prioritize and consolidate translational efforts, offer several unifying solutions to expedite their transition from bench-to-bedside, and potentially decrease the socio-economic burden on patients for a range of conditions. Herein, we review the unique properties of NANPs in the context of therapeutic applications and discuss their associated translational challenges. Nanotechnology is becoming a popular approach in solving biomedical problems, including cancer therapeutics. As the demand for nanostructures rises, it will be important to ensure both the performance and sustainability of these products. Green synthesis therefore has become a great subject of interest, as it limits any hazards to people and the environment. Within this field, microbes can be a major source in the manufacture of nanoparticles (NPs), with their abundant availability and ease of growth aiding fast and potentially cost-effective production. The microbial-mediated synthesized NPs have shown excellent properties to combat different cancer cells. In this book chapter, we discussed not only the microbial approaches for NPs fabrication but also direct and indirect therapeutic mechanisms of anticancer activities of microbe-derived NPs against different cancers. Although many challenges should be addressed before the use of these NPs for clinical trials, these NPs may lead to a revolution in cancer therapeutics in the near future.

Advances in Nanotechnology in the Diagnosis of Cads

Cardiovascular diseases have become the major killers in today's world, among which coronary artery diseases (CADs) make the greatest contributions to morbidity and mortality. Although state-of-the-art technologies have increased our knowledge of the cardiovascular system, the current diagnosis and treatment modalities for CADs still have limitations. As an emerging cross-disciplinary approach, nanotechnology has shown great potential for clinical use. In this review, recent advances in nanotechnology in the diagnosis of CADs will first be elucidated. Both the sensitivity and specificity of biosensors for biomarker detection and molecular imaging strategies, such as magnetic resonance imaging, optical imaging, nuclear scintigraphy, and multimodal imaging strategies, have been greatly increased with the assistance of nanomaterials. Second, various nanomaterials, such as liposomes, polymers (PLGA), inorganic nanoparticles , natural nanoparticles (HDL, HA), and biomimetic nanoparticles will be discussed as engineered as drug (chemicals, proteins, peptides, and nucleic acids) carriers targeting pathological sites based on their optimal physicochemical properties and surface modification potential. Finally, some of these nanomaterials themselves are regarded as pharmaceuticals for the treatment of atherosclerosis because of their intrinsic antioxidative/anti-inflammatory and photoelectric/photothermal characteristics in a complex plaque microenvironment. In summary, novel nanotechnology-based research in the process of clinical transformation could continue to expand the horizon of nanoscale technologies in the diagnosis and therapy of CADs in the foreseeable future.