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EDITORIAL

The role of nanotechnology in the study of human DNA and delivery of drugs

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ABSTRACT

Increasingly, newer discoveries lead to innovative technologies that enable the study of existing phenomena as well as pave the way for advancement of other disciplines. One such field, that of Nanotechnology, offers unlimited promise and potential to enable researchers the ability to work at molecular or near-atomic levels. Medical applications are expected in vital areas of human health and disease, such as the structure and function of DNA, and the delivery of targeted drugs or other chemicals to areas of interest.

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INTRODUCTION

Nanotechnology is the branch of science that deals with the dimensions and tolerances of less than 100 nanometers, especially the manipulation of individual atoms and molecules. In simple words, it means the manipulation of materials on an atomic or molecular scale.[1]

The emerging trends of using nanotechnology in everyday life processes are all the concerns of today's researchers. It has revolutionized the field of technology and many industries including information technology, homeland security, food, environmental science, and even medicine. Nanotechnology is already broadening the medical tools, knowledge, and therapies currently available to clinicians.[2]

Some examples of recent advancements in the field of medicine are its use for diagnosis and treatment of atherosclerosis, drug delivery to cancer cells with nanoparticles to prevent cell damage to normal tissues. It is also studied for its use in regenerative medicine spanning several areas like bone marrow or neuronal tissues. Researchers are also looking at different ways of vaccine delivery to the body without the use of needles.[3]

Nanotechnology is being used for studying human DNA and gene sequences for information that it stores and codes for normal development of the system and its functions, and their impairments in different congenital or hereditary diseases like thalassemia or sickle cell anemia and acquired diseases like different types of cancers. The use of that information for the prevention and treatment of these diseases as the key feature of biology is not about knowing the information stored in the genes but about the use of that information for the benefits of human beings.[4]

DNA, the double-helical structure, is made up of four nucleotides and each nucleotide is made up of a nitrogen base bonded by sugar and phosphate groups. The order of these bases determines the genetic code. These nucleotides are grouped to make two long-standing spiral shape structure that creates double helix. Three different biological active forms of DNA, A-DNA, B-DNA and Z-DNA are found.

A and B DNA are more similar forms with the right-handed double-helical structures and major and minor grooves while the Z DNA is left-handed structure. Dehydration of DNA derives it in A form while B form is more common in nature found in fibers of 92 percent relative humidity.[5]

This long term self-assembly helps in normal functions of cellular processes like transcription, DNA replication and segregation of daughter chromosomes during cell division. Also, bringing DNA sites into proximity is required for DNA recombination, chromatin packaging and building architectural complexes that control transcription and replication.[6]

These aforementioned physical and chemical properties are used to create artificial DNA nanotechnology structures.

The term "Scaffolded DNA Origami" revolutionized the field of nanotechnology. This involves the folding of long strands into smaller staple strands and of desired shapes used to insert in predefined DNA nanostructures both in vitro and in vivo experiments which could be used to insert certain desired functions in DNA nanostructure. This process can be used for drug delivery in specific cells at specific sites which can be viewed by fluorescence-based assays. The different shapes of nanostructures named square, triangles and tubes were synthesized and used for drug delivery.[7]

This origami particularly triangle-shaped DNA origami showed enhanced optimal passive targeting accumulation and long-lasting properties when a known anticancer drug Doxorubicin was used in vivo.[8]

However change in the physiochemical properties greatly affect the size, shape, surface area, and binding capacity of these nanoparticles, which impart it toxicity due to the change in protein core.[9]

The drug delivery scientists are however working on the use of cellular components to be used for the active transport of medicine to the targeted sites by endocytosis and lysosomal pathways, and also on receptor internalization of the cell. This transport system greatly helped in the delivery of medicine to the targeted sites. Further studies on the cell organelles and their mechanism of function will further improve the approach of nano-medication.[10]

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