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Nanobiotecgnology: A Review

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ABSTRACT

The likelihood of engineered nanoparticles coming into contact with people and the environment is rising as nanotechnology develops quickly. Membranes, cells, DNA, and organelles that interact with proteins and nanoparticles provide a variety of nanoparticle/biological interfaces that rely on colloidal forces as well as dynamic biophysiochemical interactions. There is a tone of evidence that shows how revolutionary nano systems are for screening and protecting biological systems. The fascinating idea of nano-bio interfaces has been made possible by the rapid advancement of integrating biological entities with programmable nanomaterials. The use of nanomaterials in biomedicine has been hindered by a number of issues, including possible toxicity, immunogenicity, and diminished efficacy. Because of our incomplete understanding of the interconnections between nanomaterials, nanomedicines, and biology (nano-bio), the function and eventual efficacy of nanomedicines for clinical use remain unsatisfactory. Nanomaterials have the potential to be extremely effective diagnostic and therapeutic tools in a variety of highly promising nanomedicine applications. Utilizing inorganic nanoparticles' outstanding magnetic, optical, and photothermal properties as multifunctional molecular imaging probes for disease diagnosis and treatment requires engineering them with a biocompatible shell to enhance their physicochemical properties.

KEYWORDS: nanoparticles, nanobiotechnology, and nano-bio interactions.

I. INTRODUCTION

In recent years, DNA has assumed a variety of different roles, including those of a generic material for nanoscale engineering and the primary genetic molecule in biological systems.[1]

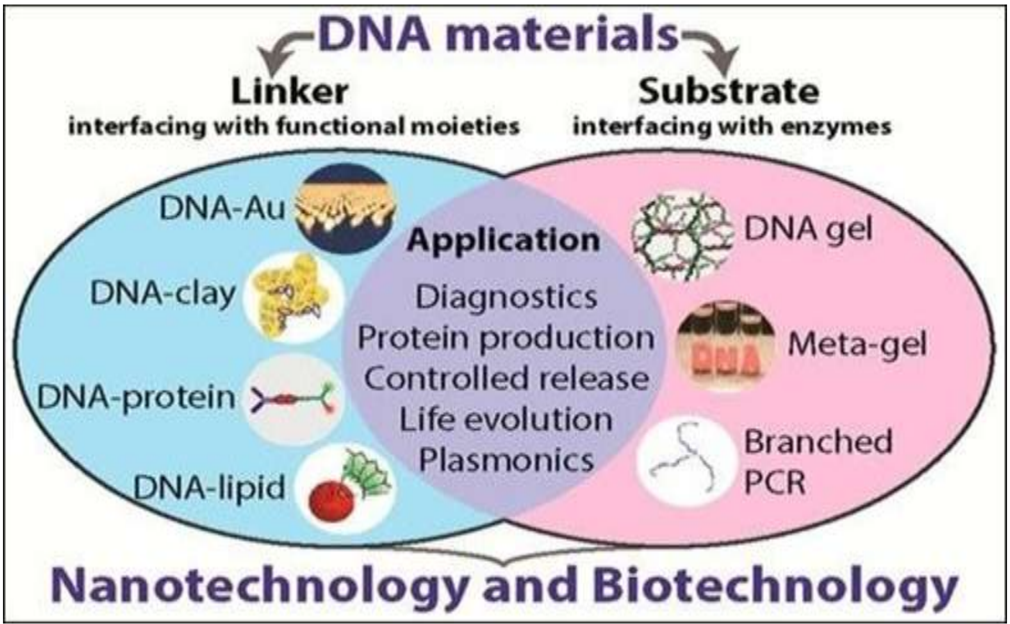

Fig.1 Nano-technology and Bio-technology [2]

The bench-to-bedside translation of biomedical nanomaterials is still difficult despite this rapid advancement.[3] Phase changes, free energy releases, reorganization, and dissolution at the surface of a nanomaterial can all be induced by biomolecules.[4] Only 0.7(median) of the injected dose of targeted nanoparticles (TNPs) for medication delivery, for instance, accumulates in the targeted solid tumor.[5]

The term "bio-nano things" refers to fundamental structural and functional components that can be uniquely identified and that function and interact in the biological environment. originating from living cells and made possible by nanotechnology and synthetic biology. In the IoT, Bio-Nano Things are anticipated to carry out operations and features like sensing, processing, actuation, and interactivity that are typical of embedded computing systems.[6]

- **Biological cells as Bio-Nano thing substrate**: A biological cell is the fundamental building block of life. It is made up of a membrane that encloses a combination of highly specialized molecules with a known chemical makeup and purpose. If we compare electron propagation in semiconductors to biological reactions, which are functionally comparable but far more complex, we can see a mapping between the elements of a typical IoT embedded computing device and the elements of a cell.[7]

- **Targeted nanoparticles, biochemical processes and medication delivery:** Due to its potential to minimize toxicity, avoid immune clearance and particle extravasation, and achieve tissue penetration and targeted cellular uptakes, targeted drug delivery and TNPs have been in the limelight for decades.[8] Determining the best physicochemical parameters that can simultaneously provide molecular targeting, NP trafficking, and controlled drug release, however, is a problem that hinders the clinical translation of TNPs. The development of clinically useful TNPs is hampered by the complex interdependence between their physicochemical properties (composition, morphology, surface properties, mechanics, etc.) and physiological trafficking (the sequential presentation of various biological barriers). Although there is a wealth of information available regarding individual factors that enhance the biological fate of TNPs. In order to find certain binding affinities through mediating multivalent binding to cell-surface receptors, Weissler et al. generated a library of 146 NPs coated with diverse small molecules in 2005.[9] Derivative NPs with high specificity to endothelial cells or pancreatic cancer cells and those capable of macrophage activation were found after screening against different cell lines or physiological conditions of one cell type. Later, for the treatment of prostate tumors, Reach et al. created preclinically efficient targeted polymeric NPs that contained docetaxel (DTXL), a chemotherapeutic drug.[10] Low transfection efficiency may jeopardies the promising use of NPs as non-viral carriers for genetic materials (such siRNA and p DNA). Through the radiometric combination of five molecular building blocks, Wang et al. produced a nano combinatorial library of 648 supramolecular NPs with a wide range of NP size, surface functionalization, and DNA loading capacities.[11] In order to provide DNA complexation, water solubility, structural stability, protective passivation, and cell-specificity, the five building blocks were chosen. A variety of fibroblast and cancer cell lines used for the validation of the nano combinatorial library revealed a highly effective gene-delivery formulation that performed better than commercial reagents. Similar to this, Siegwart et al. created a nano combinatorial library of 1536 chemically diverse core-shell nanoparticles (NPs) to determine the ideal conditions for siRNA delivery intracellularly. As a result, they identified advantageous design features like thin hydrophilic shells, a higher reactive block weight fraction, and stoichiometric equivalence between epoxides and amines.[12]Combinatorial probes based on nanostructured microelectrodes have been created as high-throughput electrochemical sensors to detect mutations of circulating tumor nucleic acids, such as the epidermal growth factor receptor [EFGR] gene, in addition to delivering genetic molecules. Das et al. discovered that the combinatorial method could precisely identify mutant sequences, and they were able to examine every one of the 40 clinically significant EFGR gene mutations in real-time in patient serum.[13]Additionally, the discipline of tissue engineering has been modifying the biophysiochemical interactions at the interface by programming the physicochemical features of nanomaterials.

The bio-nano interface gives nanomaterials a biological identity: Recently, [14,15] it has become clear how important the interaction of nanoparticles with biological molecules is for both nanomedicine and nanotoxicity. Nanoparticles are mobile solids, combining solid properties (such as fluorescence in the case of quantum dots where the constituent components are non-fluorescent) with the capacity to thermally diffuse (a property of molecules), according to a recent review of nanoparticles' interactions with biological systems.[16] It is evident that nanoparticles' interactions with biology greatly influence their biological behavior and effects. In 1990, the hypothesis that inhaled airborne particles would get coated with lung surfactant lipid was made. Considering the significance of the bio-nano interface and the possibility that it could be the key to the safe use of nanotechnologies and nanomedicine, attempts to characterize it have been disappointingly limited. [17]The fact that the OECD Sponsorship Programmer included characterization of nanoparticles in biofluids as one of their list of endpoints at the end of 2010 provides evidence for this widespread acceptance of the idea of the nanoparticle biomolecule corona and the significance of the bio-nano interface.[18] The study of the unfavorable interactions between artificial nanoparticles and cellular nanostructures or nanomachines might be seen as the core of the developing field of nanotoxicology[19].Before getting into the details of the state of the art and recommendations for moving The idea of airborne particulates becoming coated with lung surfactant lipid following inhalation was postulated in 1990.[20] The importance of the bio-nano interface, and the fact that it potentially holds the key to both safe implementation of nanotechnologies and nanomedicine, efforts to characterize it are surprisingly scarce. Evidence for this wide scale acceptance of the concept of the nanoparticle biomolecule corona and the importance of the bio-nano interface comes from the fact that the OECD Sponsorship Programmer has included characterization of nanoparticles in biofluids as part of their list of endpoints at the end of 2010. The emerging discipline of nanotoxicology may be viewed essentially as the study of the undesirable interference between man-made nanomaterials and cellular nanostructures or nanomachines.

Table 1: Adsorbed biomolecules as well as the surface and dispersion of nanoparticles are affected by interactions between nanoparticles and biomolecules and the creation of the bio-nano interface.

Sr.no	**Effect of absorption on Biomolecules**	**Effect of interaction of nano-particles**
1	Depletion of medium components which can results in indirect toxicity effect [21,22,23]	Masking targeting or other bio-functional elements? (possibly only temporarily) [24]
2	Oxidative effects-lesions post-transitional effects[25]	Reduce surface energy or reactivity[26]
3	Altered propensity for protein-protein interactions (e.g. Fibrillation) [27]	Altered surface characteristics and thereby stability and dispersibility [28]and potentially also dissolution potential (as per environmental macromolecules such as hemic acid) although limited literature [29]
4	Altered kinetics (distribution, half-life, degradation, etc.) [30,31]	Altered bioactivity[32,33]
5	Confirmation changes: blocked or enhanced presentation of active sites and subsequent functional changes. [34]	Conferring a biological identity: altered interaction or uptake and biodistribution. [35]

- **Bio-nanotechnology and medicine:** The ability to create, work with, and see matter at the nanoscale scale was first developed in the 1980s. We now have the unheard-of ability to directly target at the scale of biomolecular interactions, and the drive to develop clever nanostructures that could get around the obstacles impeding the efficacy of conventional pharmaceutical techniques, thanks to new abilities to reach the nanoscale.[36] Forty years later, the gradual blending of bio- and nanotechnologies is beginning to change how we identify, treat, and keep track of illnesses and unresolved medical issues. [37] Over the past 30 to 40 years, there has been a sharp increase in the synthesis of novel engineered materials, particularly nanomaterials. These materials have a wide range of applications in engineering, waste management, sports equipment, electronics, optics, clothing, food, and cosmetics, which covers almost all aspects of daily life.[38] This special issue integrates nano- and bio-technology to address a variety of innovative material uses in medicine. There are a variety of opportunities in the medical field due to the special properties of materials at the nanometer scale and the ability to manipulate and tailor their physiochemistry at the scale where biomolecular interactions occur, including the early detection of biomarkers, precise targeting of cells and tissues, advanced drug delivery systems, staging and assessing disease, and treatment of degenerative conditions.The chance to address difficult-to-treat medical diseases and learn about the underlying mechanisms is particularly intriguing. Engineered nanomaterials are those with at least one dimension less than 100 nm· In the field of medicine, this concept is open-ended and could, for instance, refer to a nanodrug with particles measuring 200 nm or larger. Additionally, the term "nanoparticle" is used broadly and can refer to both organic (such as lipids and biopolymers) and inorganic nanomaterials (such as metals, oxides, and carbon) that are not spherical and can take the form of cubes, stars, needles, spheroids, or artificial shapes with complex geometries (such as those used in DNA or protein nanotechnology) but are less than 100 nm aerodynamically. While some of the articles cover particle attributes in relation to the topic, some do not. The ability to work at the atomic, molecular, and supramolecular levels (on a scale of 1-o understand, develop, and employ material structures, devices, and systems with fundamentally novel features and functionalities deriving from their small structure) is known as nanotechnology. Cells are created through the nanoscale assembly of organic and inorganic matter, as are the human body's and the brain's most complex known systems. Understanding these mechanisms and advancing biological sciences and biotechnology both depend on nanotechnology. According to its definition, nanobiotechnology is a field that combines biological concepts and materials to develop novel nanoscale-integrated devices and systems as well as to comprehend and alter biological systems, whether they are living or not. In the upcoming decade, it is anticipated that the integration of nanotechnology with biotechnology, information technology, and cognitive science would accelerate. In order to study and alter biological processes, nanotechnology provides the tools and technological platforms, and biology supplies nanotechnology with inspiration models and bio-assembled parts**.**

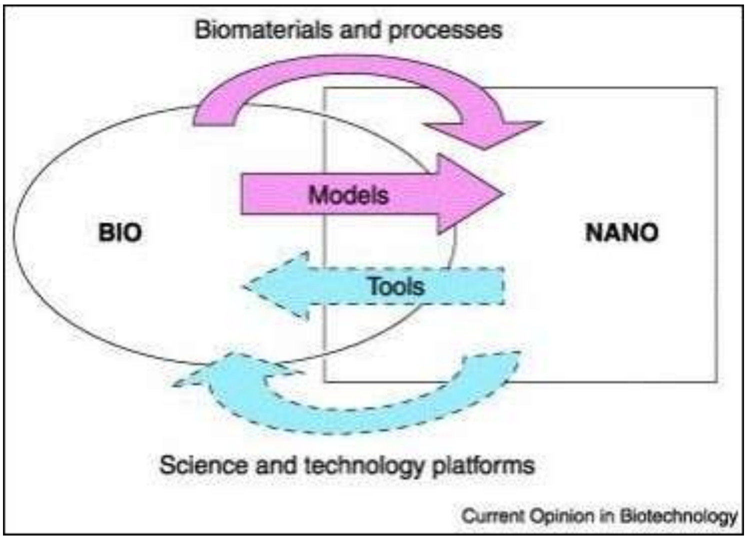

Fig2: key interaction between field of biology and nanotechnology [39]

• **Effective nanobiotechnology strategies for a sustainable future:** The process of creating a sustainable future typically entails techniques that simultaneously meet the needs of the present generation and future generations·[44] One of the most prominent topics in the early twenty-first century is the unification of various scientific domains, which is inspired by the unity of nature.

Nanotechnology, biotechnology, information technology, and cognitive sciences (NBIC), often referred to as "convergent technologies", have attracted a lot of attention in recent decades. Future stressors, such as climate change, must be anticipated in order to get a proper picture of prospective requirements. Non-renewable sources don't seem to be very effective at supplying the significant amounts of energy needed for different industrial technologies. Convergent technologies are thought to be a solution to this problem. For instance, a number of nano-based devices have been introducedthat use biologically sustainable energy sources. High stability, target selectivity, and plasticity are a few benefits of nanomaterials. In the creation of nanomaterials, a variety of biotic (such as the capsids of viruses and algae) and abiotic (such as carbon, silver, gold, and others) materials can be used. The field of "nanobiotechnology" combines the fields of nanotechnology with biotechnology. Nano-based strategies are being developed to enhance current biotechnological procedures and get beyond their drawbacks, like adverse effects from conventional medicines. According to numerous studies, nanobiotechnology has significantly increased the effectiveness of a number of procedures, such as medicine delivery, water and soil remediation, and enzymatic processes. Four main sectors are identified in this review as strategies that most profit from nano-biotechnological approaches: environmental, industrial, and medicinal.

•**The use of nanobiotechnology:** Agricultural uses, biofuel production, cancer immunotherapy, carbon capture, and biomarker detection using nano biochips, nanoelectrodes, or nano biosensors are just a few of the many uses for nanobiotechnology.

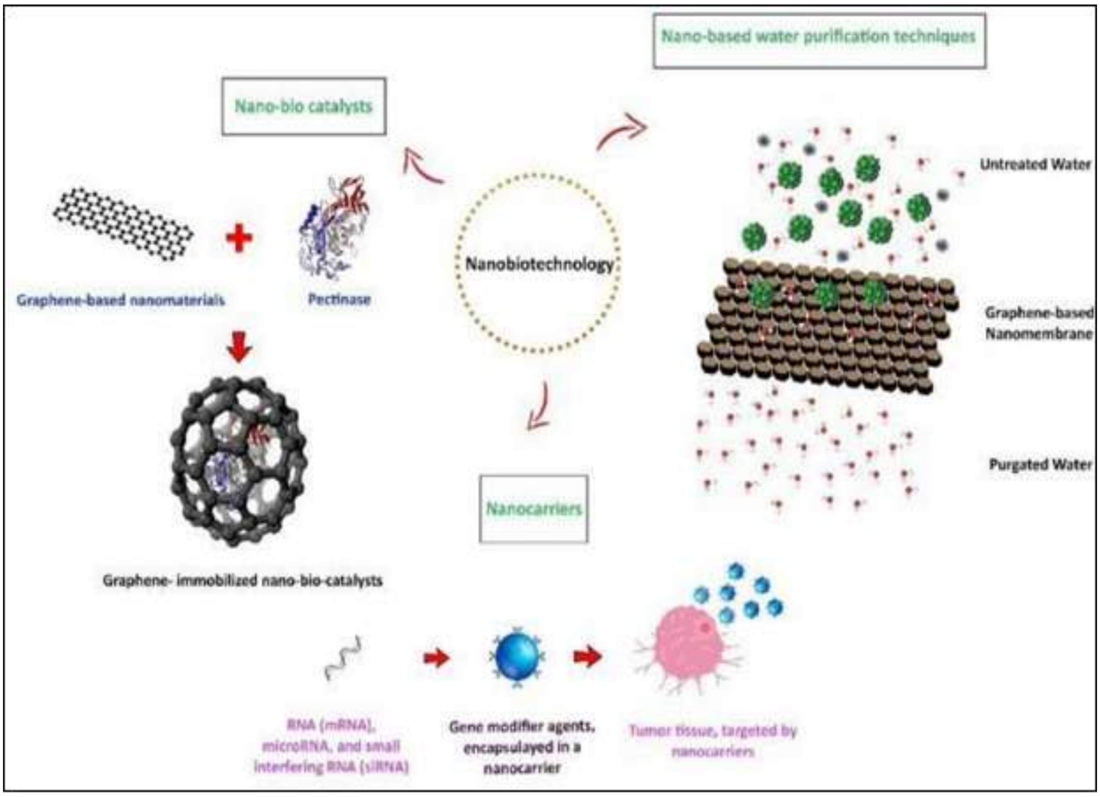

Fig 3: Diverse Applications of Nanobiotechnology: multiple techniques, including Drug delivery-based therapies, remediating processes,and industrial nano-biocatalysts benefit from nano-scaled particles.

Table2:Industrial applications of nanobiotechnology[40]

Sr. no	Nanomaterials.	Biotechnological application	Biological agent(Ifexisted)
1.	Nanomaterials synthesized from Carbon, Nitrogen, Graphite, and Silver/Graphene oxide (Ag-GO)	In the structure of nano- bio fuel cells: nanotube forests (NTFs), nanotube s (NTs),Nitrogen-doped hollow nanospheres with large pores (p NHCSs),and Ag-GO or graphite nanoparticles Nanofluids, Nano catalysts, and Nanomembranes in oil exploration/production, recoverin g the oil field, oil purification, and purification of gas and waste water produced in oil industry carbon nanotube carbon nanofibers, graphene oxide, and biochar in optimizing the bio-diesel production process	Glucose-oxidase/Glucose-oxidase, Laccase/Fructose dehydrogenase and laccase/Glucose-oxidase, laccase/NAH dehydrogenase
2	Lipid- based, polymeric-based, metal, micelles, hydrogels, dendrimers, TiO2, ZnO,silica, and carbon nanoparticles	Improve the supplementation of skin, hair or teeth with active cosmetic ingredients (ACIs) (Cosmetic industry).	-
3	MOF based nano-enzymes	biosensor s, biocatalystis, and biomedical imaging/ biosensors for evaluating the food safety in the food industry	Antibodies/aptamers/proteins/enzymes/Acetylcholinesterase/tyrosinase enzyme

II. CONCLUSION

Scientists can create faster, cheaper and more effective procedures by combining nanotechnology and biotechnology technologies. This nano-biotechnological technique has an impact on numerous industrial, agricultural, environmental, and therapeutic approaches. In this review, we looked at the present developments and constraints in biotechnology as well as the nano-based substitutes that nanotechnology has provided. In this study, we provide an overview of current developments in corona and redox-driven nano-bio interactions of nanomaterials. These developments will eventually lead to the application of nanomaterials in biomedicine.

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