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A Transformation in How Diseases are Treated and a Breakthrough Period for Medical Science

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ABSTRACT

Nanomedicine is a rapidly evolving field that uses nanoparticles for various purposes, such as DNA sequencing for diagnosis and screening, single-virus detection, and drug delivery systems. These applications have a significant impact on many medical specialties, such as molecular biology, biophysics, bioengineering, cardiology, oncology, and ophthalmology. The article also discusses how endocrinology and immunology can be used in different nano systems for cancer therapy. The article also examines how to improve the performance and security of nano systems and nanodevices for advancing human health. Soon, products utilizing nanotechnology in medical technology and medicine will be available in the market, with a hugely favorable impact on human health predicted for decades. Some of these topics are highlighted in this article, with a focus on DNA sequencing, viral vectors, and nanoparticles for drug delivery, screening, and diagnostic application identification, efficient treatment of a range of illnesses on specific building objects and materials by arranging atoms, molecules, or compounds into structures with unique characteristics and it's upcoming developments in the fields of medicine and pharmacy.
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KEYWORDS

Medication delivery nanoscale; diagnosis, DNA sequencing; treatment; nanotechnology and nanomedicine.

1. INTRODUCTION

The study of incredibly small, organized molecules (sizes ranging from 0.1nm to 100 nm) is known as nanotechnology. Nanomedicine includes everything from the use of biological and non-material devices. Nanoparticles, a fast-expanding multidisciplinary scientific topic. Since nanotechnology works with materials that range in size from 0.1nm to 100nm, it involves the study of incredibly small structures. Thus "Nano" in Greek means "dwarf." New nanotechnology products for medicine and medical technology are becoming available, with great promise to improve human health in the near future. Twentieth century has been altered by drugs, and their advancements will produce better, faster and less expensive products as a result of nanomedicine. To evaluate nanotechnology products in medicine, specific guidance documents should be created and the nanotoxicology aspects that need more investigation should be identified. Nanoscience requires labor by breaking down big buildings into their smallest forms (i.e., starting at the top), such as photonics applications in nanotechnology and nanoelectronics, the bottom up, converting individual molecules and atoms into nanostructures, and is more like biology and chemistry.
The following are some of the various domains where nanotechnology may find uses:

- ✓ Early detection and examination
- ✓ Energy and the surroundings
- ✓ Space travel

Several of these topics are covered in this article, with a focus on the use of nanoparticles in diagnostic of DNA sequencing, virus detection, medication, administration, screening and the safety treatment of different illnesses creating objects and materials with distinctive properties by using atoms, molecules, or compounds as the basic units and their upcoming advances in the field of medicine and pharmacy[1].

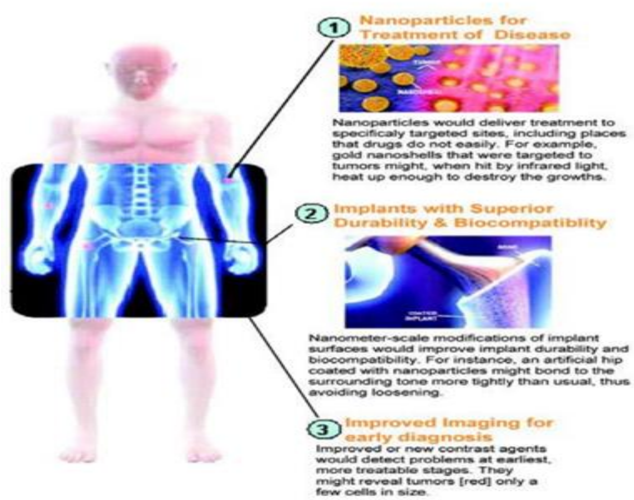

Fig. 1 Nanoparticles for disease therapy, 1) Biocompatible and durable implants, 2) Enhanced imaging for early detection

A. Nanoparticles for detecting and screening diseases: -

Nanomedicine's main and initial use is to enhance fluorescent markers for detecting and screening diseases. Traditional fluorescent markers need lasers with matching colors, which lose their fluorescence after one use and cannot distinguish well because of dye leakage. These issues could be resolved by fluorescent nanoparticles, like quantum dots, PEBBLES (probes encapsulated by biologically localized embedding), and fluorocarbon particles[2].

Example: It could be injected into the body to get to the lymph nodes, liver, and spleen. Polymeric nanospheres have the ability to scan particular tissues.

B. The Role of Nanoscale and Nanostructure in Diagnosis:-

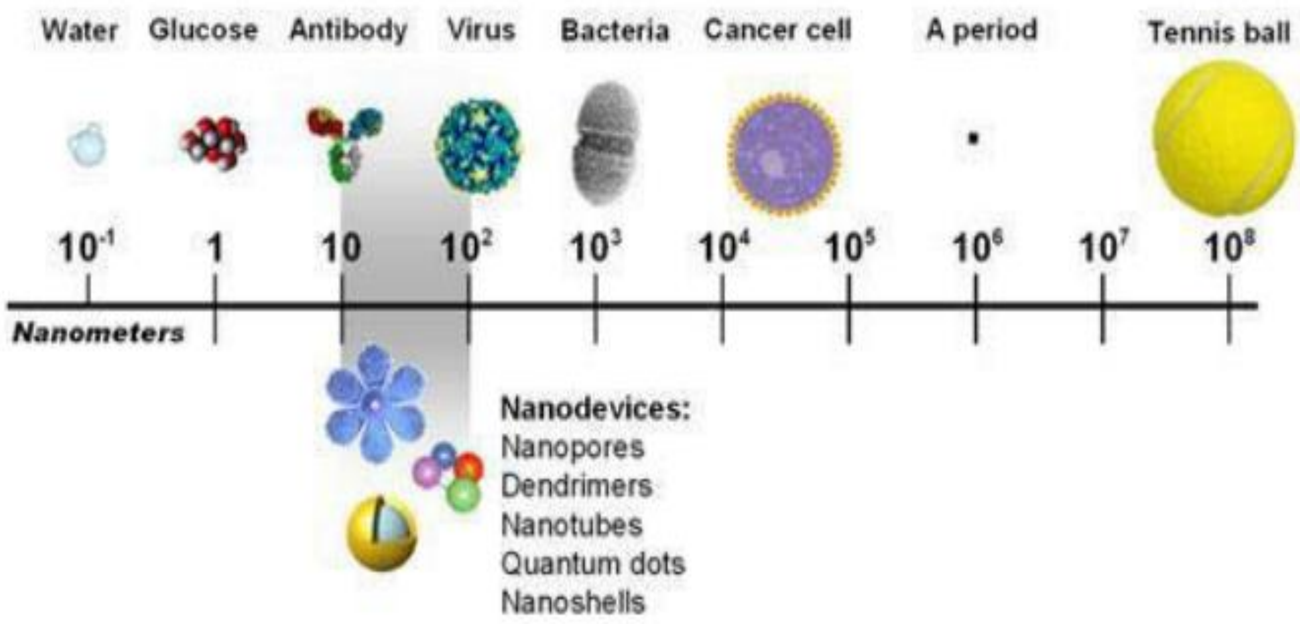

Fig. 2 Nanometer scale and structure

Above fig shows the scale of an atom, the nanoscale where the majority of common object's qualities are found. At least one dimension (height, length, or depth) of an object in the nanoscale ranges from 1 to 999 nm (1–999 nm). Here is a quick rundown of the pharmaceutical nano system.

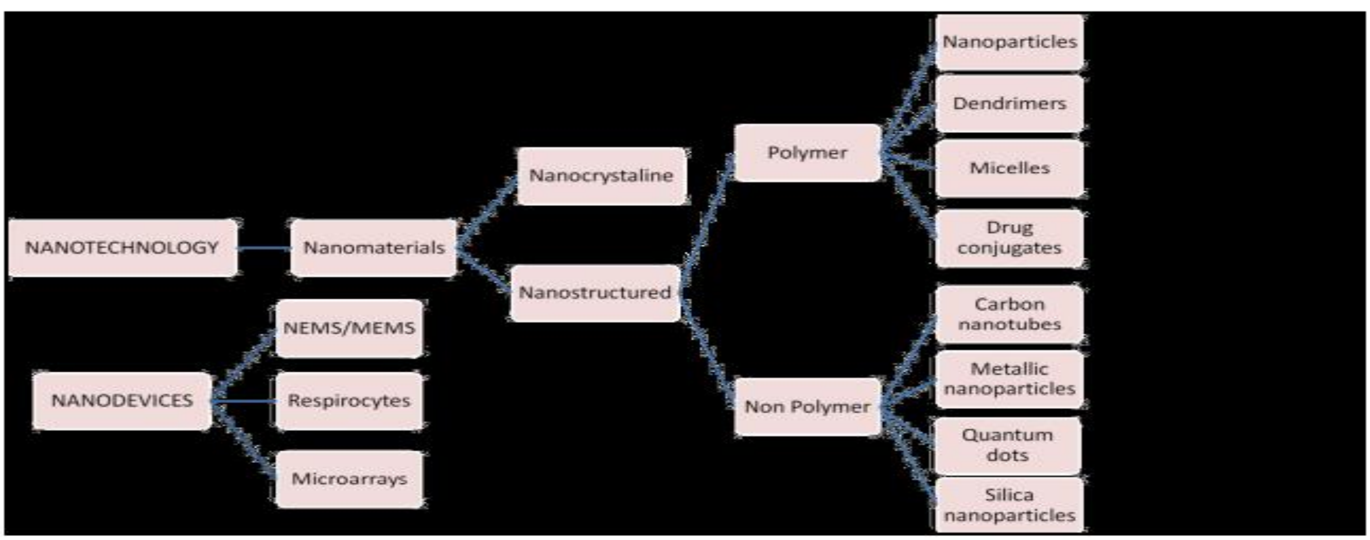

Fig. 3 Pharmaceutical purposes of nanoscale system

- Tube-Shaped Carbon Molecules: These are small macromolecules that have a cylindrical shape with distinct physical characteristics. Because of their distinct physical characteristics, nanotubes have certain benefits compared to other methods of delivering and diagnosing drugs (Fig.3).

- Metallic nanoparticles: These particles have been used in medication delivery and biosensors, especially in the treatment of cancer. Silver and gold nanoparticles rank first among different metals.

- Quantum Dot: These nanocrystals are made to a diameter of several nano meters and come in an almost infinite variety of vividly defined colors. White light is used to excite these particles, which can then be connected to biomolecules to create long-lasting, sensitive probes.

C. Ultra-Fast DNA Sequencing Using Nanopores: -

Nanopores for Ultra-Fast DNA Sequencing, Very quick genome sequencing is made possible by the ability of DNA to distinguish between low copy numbers through the passage of DNA through nanopores. A variety of 1.6 nano meter-diameter inner-diameter cylindrical gold nanotubules were taken into consideration. In this case,

The transportation of positive ions is done through the membrane and excluded from the tubules when they were positively charged, while only positive ions passed through the membrane when it was negatively charged. This technique has even been applied to force DNA and RNA using electric fields, polymers are pushed through the canter nanopore of an α-haemolysin protein channel embedded in a lipid bilayer[3].

Advantages:- Improving these resources could result in,

- low-cost
- simple and precise detection and high-throughput technique for polynucleotide analysis in DNA.
- Potential nanodevices could potentially integrate voltage gating with pore dimensions form and charge.
- limitations to accomplish accurate ion transport control with substantial molecular precision.

2. SINGLE-VIRUS DETECTION

Early identification of various kinds of viruses would help the individuals to overcome different diseases at very early stages so it prevents them from being affected to those deadly diseases. It has been recently confirmed that nanowire field-effect transistors can detect single virus particles with high accuracy by measuring the conductance changes that occur when they bind and unbind to nanowire-arrays coated with viral anti bodies . The arrays could identify and distinguish between influenza-A viruses, paramyxoviruses and adenoviruses based on the receptors they used to attach and the time they stayed bound. This method could enable nanowire devices to detect many different viruses at the same time at the single-particle level, if it can be applied in clinical settings.

A Nanotechnology as a tool for Health And Medicine:-

Numerous significant and debilitating diseases still exist today, such as diabetes, cancer, Parkinson's disease, Alzheimer's disease, cardiovascular disease, multiple sclerosis, and various chronic inflammatory or viral disorders (including HIV). complicated illnesses that are becoming a big issue for humanity. An application of nanotechnology to the medical and health domains is known as nanomedicine. Nanomaterials and nanoelectronics biosensors are used in nanomedicine. Eventually, nano Molecular nanotechnology will be beneficial to medicine. The field of nanoscience in medicine The application is potentially beneficial to all human races and has several expected benefits. Nanomedicine makes it possible for better diagnosis, early detection and prevention, targeted treatment, and post-illness follow-up. Particular nanoparticles are used as labels. And labelling biological testing may be completed swiftly testing has grown increasingly sensitive and more adaptable. The development of nanotechnologies has increased the efficiency of gene sequencing When these gold particles are tagged with brief DNA sequences, they can be used as gold nanoparticles. Utilized to identify the genetic sequence present in a sample. It is possible to replicate or mend damaged tissue with the use of nanotechnology.It is possible to create cutting-edge biosensors with unique properties with

B. The impact of Nanotechnology in stem cell research: -

- Isolating and dividing stem cells has been effectively accomplished with magnetic nanoparticles (MNPs).
- The use of quantum dots in molecular imaging, stem cell tracing, and medication delivery to stem cells.
- Specialized nanostructures were created to regulate proliferation in a controlled manner.
- The process of stem cell differentiation involves the creation of distinct nanostructures.
- Using nanotechnology, we can monitor and image stem cells, guide their transformation into specific types of cells and learn more about their biology. This could help us develop stem cell-based treatments for preventing, diagnosing and curing human diseases.[4]

Recent advances in stem cell research using nanotechnology may open up new avenues for regenerative medicine. One useful tool for tracking and imaging stem cells, as well as for accelerating their differentiation into a particular cell lineage and eventually comprehending their illogical makeup, That will ideally result in stem cell-based therapies for human disease prevention, diagnosis, and treatment. Nanotechnology can be used to track and image stem cells in research. It possesses applications in both translational medicine and basic science. Stem cells are molecules with nanocarriers. Nanotechnology can be applied to intracellular access as well as for biomolecule sensing and intelligent delivery.

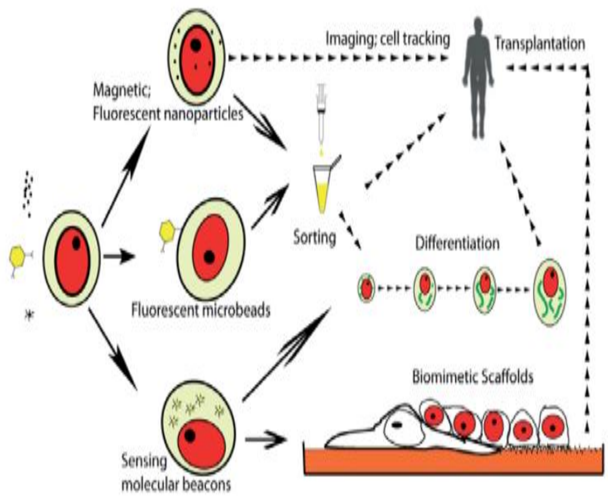

Fig. 4 Nanotechnology as a tool for stem cells

C. Nanotechnology as a tool for Drug Delivery: -

Nanotechnology uses nanoparticles to deliver drugs to specific sites. This method uses the required dosage of the medication and greatly reduces side effects because the active ingredient is only deposited in the morbid region. This extremely focused method can lessen expenses and suffering for sick people. Consequently, a range of nanoparticles, including dendrimers and nanoporous materials, search for a form. To encapsulate drugs, block co-polymer-derived micellar systems are employed. They carry tiny drug molecules to the intended site. Likewise, nano pharmaceuticals with active release are administered via electromechanical systems. Nanoparticles of iron or a significant use of gold shells is in the treatment of cancer. A specific medication lowers drug use and treatment costs, resulting in lower patient treatment costs and nanotechnology gadgets like nanorobots. The drugs are delivered with cellular precision, and the molecules are targeted.

Lipid and polymer-based nanoparticles enable the construction of drug delivery systems that enhance the pharmacological and therapeutic qualities of pharmaceuticals. Using MRI and ultrasound images of nanoparticles as a contrast, nanoparticles are employed. The third method of drug delivery discussed here makes use of "nano shells" or dielectric-metal (gold-coated nanospheres of silica). An intriguing potential application for nano shells is the delivery of chemotherapy for malignancies. These materials with nanoengineered structures are being created to efficiently manage ailments and conditions such as cancer with the development of nanotechnology, biocompatible, self-assembling nanodevices can be made that will detect malignant cells, automatically assess the condition, heal, and use the technology of delivery.

D. Proteins and Peptide delivery using nanotechnology: -

Proteins and peptides are examples of macromolecules that are biopharmaceuticals. These have been found to have numerous biological effects, making them suitable for treating a wide range of illnesses and conditions. Nanoparticles and dendrimers are examples of nanomaterials. Biopharmaceuticals are administered in a controlled or targeted manner.

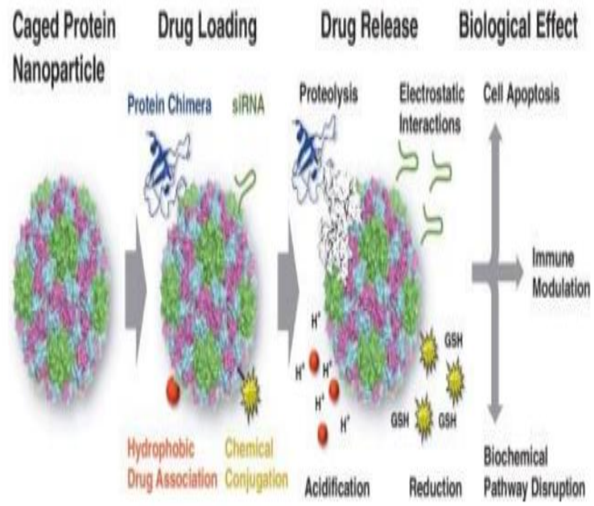

Fig. 5 protein and peptide delivery.

E. Application of nanotechnology to cancer:

Nanoparticles, small size makes them very useful in oncology, especially for imaging. When combined with magnetic resonance imaging, nanoparticles having quantum confinement characteristics, such as size-tenable light emission, can create remarkable images of tumor sites. Examples of these particles are quantum dots compared to organic dyes, nanoparticles are much brighter and can be excited by a single light source[7]. Therefore, using fluorescent quantum dots instead of organic dyes as contrast media could result in an image with more contrast and at a lower cost. However, hazardous materials are typically used to make quantum dots. Because of their unique high surface area-to-volume ratio, nanoparticles may accommodate a variety of functional Using only a few drops of a patient's blood, sensor test chips that can identify proteins and other indicators left by cancer cells are created using nanowires. This allows for the early detection and diagnosis of cancer. Multifunctional nanoparticles can be created which would help to identify, image and then identify a tumor in upcoming cancer treatment [9].

The basis for drug delivery based on nanotechnology consists of three facts: -

- Effective drug encapsulation
- Successful drug delivery to the intended site of the body
- Successful drug release from the targeted site of the body.

Professor Jennifer of Rice University used gold-coated nano shells with a diameter of 120 nm to eradicate cancerous tumours in mice. These nano shells are designed to adhere to cancerous cells by conjugating antibodies or peptides to their surface. When using nanoparticles for cancer photodynamic therapy, the particle is placed within the body's tumor and exposed to external photo light. When a particle absorbs light, the energy from the light causes it to heat up if it is made of metal. Light causes the production of high-energy oxygen molecules, which interact chemically with tumor cells to cause their destruction. without causing other bodily cells to react. The use of photodynamic therapy as a non-invasive tumor treatment method has grown in popularity.

F. Using nanotechnology to treat neurodegenerative diseases: -

One of the most important applications of nanotechnology is the treatment of neurodegenerative illnesses. [10]. Numerous nanocarriers, including polymeric nanoparticles, solid lipid nanoparticles, liposomes, nanogels, nano emulsions, and dendrimers, have been investigated for the delivery of CNS medicines[10]. Through endocytosis and/or transcytosis, these nanomedicines have been shown to be transported across a range of in vitro and in vivo BBB models. This suggests that early preclinical success for the treatment of the many CNS disorders listed below may be achievable.

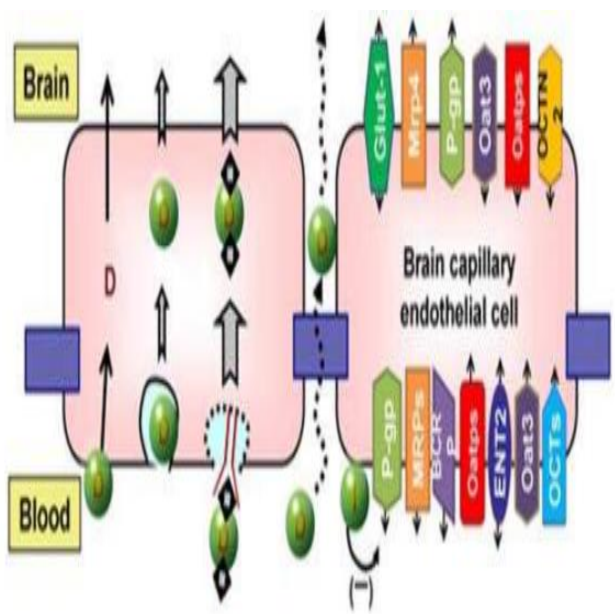

Fig. 6 Delivery of nanomedicine via the blood-brain barrier to the central nervous system.

3. PARKINSON'S DISEASE

One in every 100 people over 65 those who suffer from Parkinson's disease (PD), which is the second most prevalent neurological illness after Alzheimer's has a central nervous system component that causes neuro-inflammatory responses and causes significant difficulties with movement. Modern treatments try to prolong the patient's functional ability, but they are unable to stop the neurodegenerative process from progressing. The goal of applied nanotechnology is to regenerate and protect the central nervous system (CNS), and basic nanotechnology research carried out in tandem with developments in neuropathology, neurophysiology, and cell biology would be extremely beneficial. The central nervous system (CNS) is being developed with the aim of protecting and regenerating it using applied nanotechnology. Basic nanotechnology research conducted in conjunction with advancements in neuropathology, neurophysiology, and cell biology will be highly advantageous. In order to provide neuroprotection, a permissive environment, and/or active signalling cues for guided axon growth, efforts are made to develop novel technologies. The aim of the research is to develop, test, and improve an implantable device that uses nanotechnology to deliver dopamine to the brain in a targeted way. This could be a way to reduce the unwanted effects of conventional treatments for Parkinson’s disease. The latest tools for treating a variety of CNS disorders are peptides and peptidyl nanoparticles[14].

The creation of novel diagnostic and therapeutic instruments will be greatly aided by nanotechnology[17]. Devices using nanotechnology may be able to prevent and treat neuropathological disease states, support and encourage the functional regeneration of injured neurons, offer neuroprotection, and make it easier to get medications and small molecules through the blood-brain barrier.

Numerous nanocarriers, including dendrimers, polymeric nanoparticles, solid lipid nanoparticles, nanogels, nano emulsions, liposomes, and nanosuspensions, have been investigated for the delivery of CNS therapeutics. In numerous in vitro and in vivo blood-brain barrier models, the transportation of these nanomedicines has been accomplished by endocytosis and/or transcytosis[15]. As a result, early preclinical success for the treatment of CNS disorders such as Alzheimer's disease, brain tumours, HIV encephalopathy, and acute ischemic stroke has become possible .The goal of CNS nanomedicine development going forward must be to improve drug trafficking efficacy and brain tissue specificity through the use of innovative.

4. ALZHEIMER'S DISEASE

Alzheimer's disease (AD), the most common type of dementia, affects more than 35 million individuals worldwide. Neurology benefits greatly from the use of nanotechnology[6]. These methods are predicated on the idea that the creation and engineering of numerous nanoparticulate entities with high specificity for brain capillary endothelial cells allows for the early diagnosis and treatment of AD [18]. Because of their strong affinity for the circulating forms of amyloid-β (Aβ), nanoparticles (NPs) may create a "sink effect" and ameliorate the condition of AD [21]. Thanks to the development of ultrasensitive NP-based bio-barcodes, immune sensors, and scanning tunnelling microscopy techniques that can identify A1–40 and A1–42, in vitro diagnostics for AD have advanced.

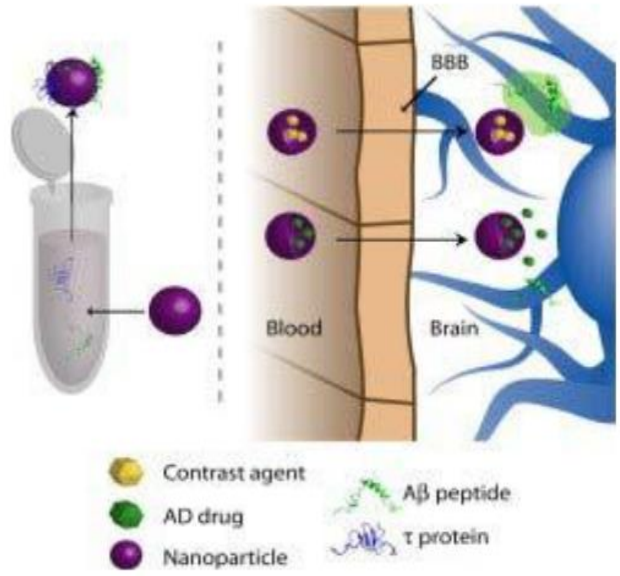

Fig. 7 Nanotechnology in Alzheimer's disease.

TUBERCULOSIS TREATMENT

TB is a deadly disease that spreads through infection. The treatment takes a long time and involves many pills, which can affect the patient's quality of life and lead to the emergence of strains that resist multiple drugs (MDR). TB is also a major problem for children, who do not have access to the first-line drugs in a suitable form. New antibiotics are needed to overcome drug resistance, shorten the treatment duration and reduce drug interactions with treatments for HIV. Nanotechnology is a promising way to develop better and more convenient medicines. By using nano-based systems to encapsulate and release anti-TB drugs, we can improve the effectiveness and affordability of TB therapy [25].

A. Nanotechnology's practical application in operational dentistry: -

Nanofillers are spherical silicon dioxide (SiO_2) particles that are typically 5–40 nm in size and are used in surgical dentistry. The ability to increase the inorganic phase load is the true innovation of nanofillers. Numerous studies have documented the impact of this high filler load on mechanical characteristics[20]. The best option for practical use is micro hybrid composites with an additional load of nanofillers.

Nano Products Corporation has successfully produced nanoparticles that are uniformly distributed in resins or coatings to create nanocomposites. The aluminosilicate powder utilized as a nanofiller has a refractive index of 1.508, a mean particle size of 80, and an alumina to silica ratio of 1:4 M. These nanocomposites have a refractive index of 1.508, an alumina to silica ratio of 1:4 M, and outstanding handling qualities [23]. Additionally, they have a lower polymerization shrinkage and better flexural strength, modulus of elasticity, and hardness.

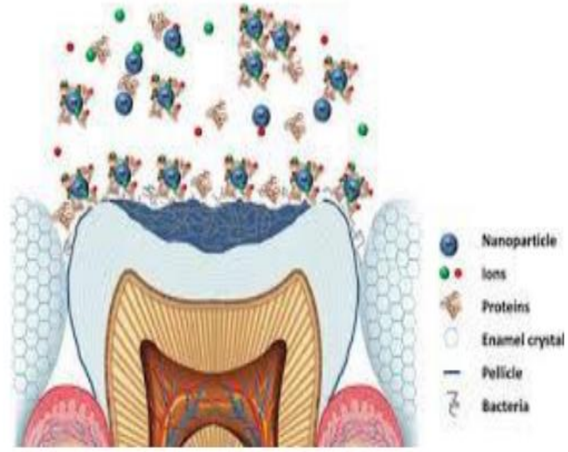

Fig. 8 Nanotechnology in dentistry

B. Applications in Ophthalmology: -

Nanotechnology has many applications in ophthalmology, such as treating oxidative stress, measuring intraocular pressure, diagnosing eye diseases, using nanoparticles to heal abnormal blood vessels in the choroid, preventing scar formation after glaucoma surgery, and treating retinal degeneration with gene therapy, prosthetics and regenerative nanomedicine[28].

5. CONCLUSION

Nanomaterials have more surface area and special effects at the nanoscale, so they are helpful for improving the drug delivery and genes, the imaging and detection of drugs and genes, the imaging and detection of biological systems. The characteristics of Depending on their size and shape, nanomaterials can alter. Because of their larger surface area and ability to produce effects at the nanoscale, nanomaterials hold great promise for the development of therapeutic and gene delivery, biomedical imaging, and diagnostic biosensors. The unique characteristics of nanomaterials, such as their size, shape, chemical composition, surface structure, charge, solubility, and agglomeration, can significantly impact how they interact with biological molecules and cells. Nanotechnology has a very bright future since it will combine with other technologies to create sophisticated and creative hybrid technologies. Nanotechnology and biology are interwoven; genetic material is being manipulated by nanotechnology, and biological components are already employed to create nanomaterials.

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