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Nanotechnology in Medicine: Technology Trends

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Abstract

The field of study known as nanotechnology is concerned with the conceptualization, synthesis, characterization, and application of materials and technologies that have the smallest possible functional organisation on the nanoscale scale (one billionth of a metre). Without initially addressing the molecular and molecule-group interactions that occur at these length scales, it is impossible to influence the chemical and physical characteristics of a material or device at the macroscopic scale. The next paragraphs will go through some of the possible medicinal uses of nanotechnology. The unknown has always had a special allure for humans and served as a source of creative motivation for them. Inquisitive minds from all over the globe have been devoting significant amounts of their time and energy to scientific research and the scientific method. The field of research known as nanotechnology has seen meteoric expansion during the last few years. The medical and dental communities are now able to detect, diagnose, and treat sickness more effectively because to the utilisation of nanotechnology. The growing interest in the potential medical uses of nanotechnology in the future is driving the development of a new discipline known as nanomedicine. Nanomedicine has to overcome obstacles to deployment if it is going to help us better understand the pathophysiological foundation of disease, bring about more refined diagnostic capabilities, and give more effective therapeutics and preventative properties. The widespread availability of medical robots to medical professionals has the potential to result in a number of beneficial outcomes, including the accelerated treatment of the majority of known diseases that cripple and kill people today, the accelerated healing of the majority of physical harm that our bodies may experience, and a significantly increased health span for humans. The field of dentistry and modern healthcare are quickly becoming more reliant on molecular technology as an essential component. In this piece, we have made an effort to get a glimpse of the potential future repercussions that the use of nanotechnology may have in the fields of dentistry and medicine.

Keywords:Nanotechnology , Medicine, Technology, Healthcare,Nanomaterials, Imaging Diagnosis

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Introduction

Nanoscience is the study of the unique properties that materials with dimensions between one and one hundred nanometers possess, and nanotechnology is the application of this knowledge to the manufacturing of new things or the modification of existing ones. The capacity to make changes to structures on an atomic scale opens the door for the development of nanomaterials (1-3). Nanomaterials may be recognised by the unique optical, electrical, and/or magnetic properties that they display at the nanoscale. These properties can also be combined. These characteristics have the potential to be used in a wide range of fields, some of which include the fields of medicine and electronics, to mention just a few examples of the many possible applications. Nanomaterials are in a category all by itself due to the very high surface area to volume ratio that they give. Nanomaterials, in contrast to larger-scale manufactured items and systems, are governed by the laws of quantum mechanics rather than the standard principles of physics and chemistry. This is because quantum mechanics governs the behaviour of subatomic particles. This is due to the fact that quantum mechanics is responsible for governing how subatomic particles behave. This is because they provide products that are of a better quality in terms of structure, as well as safety and cleanliness, durability, and intelligence. In addition, they are intelligent. When it comes to the use of nanoparticles in items that are often bought by customers, there are basically two areas that may be taken into consideration: the first is the safety of the nanoparticles; the second is the effectiveness of their usage.. (Salta , 2004)

To begin, nanoparticles have the potential to be combined with or added to an existing product in order to improve the overall performance of the composite products by contributing some of the one-of-a-kind properties that nanomaterials possess. This can be done either by combining the two products or by adding the nanoparticles to the existing product. In any other scenario, nanomaterials such as nanocrystals and nanoparticles may be utilised directly to construct complex and powerful technologies as a consequence of the special features that they contain. The benefits that nanoparticles have to offer have the potential to affect the future of practically every sector of business. Sunscreens, cosmetics, sporting goods, tyres, electronics, and a number of other mundane objects all make use of nanoparticles in ways that are advantageous to the products. In addition, nanotechnologies

have been a game-changer for medical developments, namely in the areas of imaging, medicine administration, and diagnostic procedures. This has been the case in a number of different domains. (Caruthers, SA, & Lanza , 2007)

Nanotechnology In Medicine And Healthcare

The use of nanotechnologies in medical and healthcare contexts is referred to as "nanomedicine," and the term "nanomedicine" is used to describe the many uses of these technologies. In specifically, nanomedicine refers to the practise of preventing, diagnosing, monitoring, and treating diseases via the use of technologies that operate on the nanoscale and approaches made possible by nanotechnology. The area of medicine is one in which nanotechnologies have a substantial amount of potential applications. Some of these applications include imaging methods and diagnostic tools, drug delivery systems, tissue-engineered constructions, implants, and pharmacological treatments. In addition, treatments for a variety of diseases, such as diabetes, cardiovascular disease, cancer, conditions affecting the musculoskeletal system, psychiatric and neurodegenerative diseases, infectious diseases caused by bacteria and viruses, and musculoskeletal conditions, have been advanced thanks to the development of nanotechnologies. (Silva, 2004)

Imaging And Diagnosis Facilitated By Nanotechnology

Correctly diagnosing a patient's condition in order to provide the most effective treatment is one of the most important aspects in the process of providing medical care to a patient. If one wishes to reduce the number of instances of a phenomena that is known as a "false negative," it is essential that all diagnostic procedures be carried out in a timely manner while maintaining their accuracy and specificity. In vivo imaging is a method that does not need the use of any invasive procedures and may detect any indications or symptoms that may be present within the living tissues of a patient. This method was developed in the 1980s. Because of this, the patient won't need to have any surgical operations done to them. (Medina, Santos-Martinez, MJ, Radomski , & Corrigan, 2007)One of the first advancements that has been made to diagnostic imaging processes is the use of biological markers that are able to detect changes in the tissues at the cellular level. This is one of the earlier advances that has been produced. When used as a technique for early detection, the use of a biological

marker has as its main objective the diagnosis of illness or the identification of symptoms. (Ratner & Bryant , 2004)It is vital to emphasise that some of these molecular imaging agents have been made with excellent precision thanks to the aid of nanotechnologies. This is something that must be emphasised. Imaging is essential not only for the purpose of diagnosis, but also for the study of controlled drug release, the assessment of drug distribution throughout the body, and the careful monitoring of the development of a treatment. Imaging can be used to study controlled drug release, drug distribution throughout the body, and careful monitoring of the development of a treatment. Imaging is a useful tool for researching controlled drug release, determining how drugs are distributed throughout the body, and keeping close tabs on the progress of therapy development. Imaging plays a vital role in each of these distinct disciplines. The capability of monitoring the distribution of medications throughout the body as well as the capability of releasing the drug at the proper moment both contribute to the possibility of minimising the potential toxicity of pharmaceuticals.. (Sakiyama-Elbert & Hubbell , 2001)

Nanotechnology in drug delivery

Drugs are often administered topically during treatment. Surgical treatments and radiation therapy are examples of external therapeutic approaches used when an internal route for medication administration is not possible. In the fight against illness, these strategies are often combined or employed interchangeably. To effectively treat a patient, tumours or other disease-causing factors must be surgically removed. (Yan, Bin, & Deng , 2005)Nanotechnologies are making a significant contribution to this field through the development of novel modes for the delivery of drugs; some of these methods have been demonstrated to be effective in a clinical environment and are currently being utilised in clinical practice. (Ochekpe , Olorunfemi , & Ngwuluka , 2009)The improved in vivo distribution, pharmacokinetic properties that are favorable, and evasion of the reticuloendothelial system are all factors that have contributed to the success of nanotechnologies in the field of drug delivery. (Ochekpe , Olorunfemi , & Ngwuluka , 2009)Control over the drug release and the ability to precisely target the drug's destination are both essential components of the ideal drug delivery system. By selectively targeting and destroying cancerous or harmful cells, it is possible to significantly reduce the severity of side

effects while also ensuring the efficacy of the drug. In addition to this, controlled drug release is an effective method for minimising the negative effects of drug use. (Zalipsky , 1995.)

The Use Of Nanotechnology In The Treatment Of Cancer

The staggering incidence of cancer that can be found all over the world highlights the need for improved cancer screening methods in addition to the development of innovative medication delivery systems that are better able to target specific areas of the body, are more efficient, and produce fewer negative side effects (41). It is often accepted that cancer treatments are of a better grade if the therapeutic substance can effectively reach the designated target place without generating any detrimental effects along the way. It is feasible that the required targeted delivery may be improved by altering the surface chemistry of the nanoparticle carriers using chemicals. The incorporation of PEG, which is sometimes referred to as polyethylene oxide, is one of the most noteworthy examples of adjustments that have been made to the exterior of nanoparticles. As a consequence of these modifications, not only is there an increase in the selectivity of medicine absorption, but there is also an increase in the capability to target tumours. The incorporation of PEG into the nanoparticles inhibits the body's immune system from recognising them as foreign bodies and attacking them accordingly. Because of this, the nanoparticles are able to keep travelling through the circulation all the way up to the point when they reach the tumour. In addition, the utilisation of hydrogel in the therapy of breast cancer is a fantastic example of this cutting-edge therapeutic method. Herceptin is a monoclonal antibody that is directed at the human epidermal growth factor receptor 2 (HER2) that is located on the surface of cancer cells. It is administered to patients as part of their therapy for breast cancer. As a result of this, a hydrogel that is derived from vitamin E has been developed. This hydrogel has the capacity to transport Herceptin to the area of interest with just a single dose, but it can do so for a considerable amount of time. The hydrogel-based drug administration is more effective than the standard subcutaneous and intravenous delivery routes of medication because it increases the amount of Herceptin that is retained inside the tumour. This makes the hydrogel-based drug administration more effective than the standard delivery routes. As a consequence of this, it is a more efficient method of treating cancer. (Biswas, Islam, Choudhury, & Mostafa , 2004)

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Utilizing Nanotechnologies to Treat Cardiovascular Diseases

Another field that might stand to gain from making use of the capabilities of nanoparticles is that of cardiovascular diseases. As a result of an increase in the number of individuals leading sedentary lifestyles, cardiovascular diseases have emerged as the leading cause of death around the globe. The occurrence of these illnesses is likewise on the rise at a startlingly rapid rate. A stroke, high blood pressure, and situations in which blood flow is limited or obstructed in a specific place are all examples of common cardiovascular problems that may affect several individuals at the same time. These conditions are the most common contributors to lengthy periods of disability as well as death, and they are also among the most preventable. Through the use of nanotechnologies, there is a possibility that novel possible therapeutic and diagnostic techniques for the treatment of cardiovascular diseases may become available **(McGill , McMahan, & Gidding , 2008)**

A disease process known as the deposition of atherosclerotic plaque in the lining of the coronary arteries is what is referred to as coronary artery disease (CAD), which is an abbreviation for the phrase coronary artery disease. This causes the lumen of the artery to become more constricted, the vessel wall to become less flexible, and the blood supply to a region of the myocardium to get cut off gradually or abruptly, depending on the severity of the condition. It is possible for a disease known as angina, often known as chest discomfort, to develop when there is a considerable decrease in the volume of blood that is given to the muscle of the heart. This unease may surface either after the individual has engaged in some kind of physical exercise or when they are at rest. It is possible for a coronary thrombosis to bring on a heart attack or a myocardial infarction if it suddenly obstructs the flow of blood to the heart. Another important problem that can arise is the one discussed here. The rupture of an atherosclerotic plaque that was previously present in a coronary artery is the cause of this kind of sudden thrombosis more often than any other explanation. Plaques are said to be "susceptible" when they have certain characteristics that make them more likely to rupture than other plaques. These characteristics include: These characteristics include the presence of a thin collagen cap, a lipid-rich interior, a high metabolic rate, many activated macrophages, a high degree of inflammation, a necrotic core resulting from macrophage apoptosis, and a content rich in tissue factor that precipitates the actual thrombosis. Other

characteristics include a high degree of inflammation and a high degree of necrosis in the core. A high level of inflammation and the presence of a necrotic core, which is caused by the apoptosis of macrophages, are two further features of this condition. In light of more recent studies, the concept of being susceptible to having a heart attack has been broadened to include blood that is sensitive to thrombosis in addition to myocardial that is vulnerable to being damaged (prone to fatal arrhythmia). As a consequence of this, the term "vulnerable patient" would be a more appropriate option to characterise the high risk of experiencing cardiac events in the very near future. **(Badimon & Vilahur, 2014)**

Potential Risks of Nanotechnologies

Because of nanotechnologies, there has been a great deal of debate over whether or not they are safe to use and whether or not there are any related health hazards. In spite of the fact that the expanding area of nanotechnology has grabbed the curiosity of the general population as a whole, considerable disputes have also been sparked by nanotechnologies. When nanoparticles are utilised, additional challenges arise, most notably in terms of predicting, understanding, and regulating any potential harmful impacts on human health. These challenges are brought about by the usage of nanoparticles. When examined on a mass-for-mass basis, the results of recent research indicate that nanoparticles with restricted solubility are much more hazardous and deadly than larger particles. The presence of nanoparticles raises a wide variety of potential safety issues, many of which are associated with the increased risk of catalytic reactions and explosions. It is essential to keep in mind that the only nanomaterials thought to be capable of causing damage are specific types of nanomaterials, specifically those having significant degrees of reactivity as well as mobility. It is also essential to keep in mind that the only nanomaterials thought to be capable of causing damage are specific types of nanomaterials. This fact will not change until more research demonstrates that nanomaterials do, in fact, have negative effects, and the mere presence of nanomaterials in a laboratory does not, on its own, pose a threat to human health or the natural environment. The mere existence of nanomaterials in a laboratory does not, in and of itself, pose a threat to either the health of humans or the natural environment.

(Sahaym & Norton, 2008)

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Applications In Medicine

Machines of the micrometre scale, built from nanoscale components, are expected to be possible over the next ten to twenty years. Useful robotic components like 100 nm manipulater arms, 10 nm sorting rotors for molecule-by-molecule reagent purification, and smooth ultra hard surfaces created of automatically perfect diamond may be included into subassemblies of such systems. To activate, regulate, and deactivate such nanomechanical devices would become the primary task of nanocomputers. To guarantee the proper operation of nanomechanical devices, nanocomputers would be charged with storing and executing mission plans, receiving and processing external signals and stimuli, connecting with other nanocomputers or external control and monitoring devices, and having contextual knowledge. Both medical and dental treatment stand to benefit greatly from this technological advancement. (Frietas , 2005)

Most bacteria and viruses that cause illness are very small, often being just a few nanometers in size. It's probable that nanotechnology will provide us safeguards against this. In ancient Greece, silver was utilised for both healing and illness prevention, but this practise has since died out due to the widespread availability of antibiotics. Nycryst Pharmaceuticals of Canada has resurrected an ancient treatment by applying nanoscale silver particles to a burn and wound bandage, which are more reactive than the bulk form of metal. They absorb deeply into the skin and consistently provide the advertised results. Bandages on burn sufferers only need to be changed once a week. The molecular causes of a wide variety of illnesses are being quickly elucidated through genomic and proteomic research. There is now a better chance to create accurate diagnostic methods for locating hereditary illness propensities. Point-of-care diagnosis is expected to become commonplace in the near future for many reasons, including determining who needs preventative medicine, choosing the best medication for each patient, and keeping tabs on their recovery. **(Freitas , 2000)**

Nanotechnology is crucial to the development of easily accessible diagnostic instruments. A new mobile lab is being designed by Chris Backous. The DNA of individual cells is examined using a chip, with the findings being sent promptly to the attending clinician. The research and development of this chip is meant to aid in the diagnosis of cancer and the

tracking of infectious diseases. Technological advancements have made possible the rapid and accurate sequencing of minuscule quantities of biological fluids or tissues like blood, bone marrow, or cancer. The BK virus is an early warning indication of complications in kidney transplant patients; the device may be able to detect this virus as well. Pilarski predicts that in the not-too-distant future, we'll be able to tell which strain of influenza someone has just by looking at their chip, as well as if they have SARS or HIV. One possible use of nanotechnology is the development of nanocoatings that might delay the onset of asthma relief from inhalants. Therefore, the pharmaceutical industry is looking to nanotechnology to create longer-lasting medication particles. **(Fahy , 1993)**

NanoroboticMicrobivores

Microbivores are artificial phagocytes that have the ability to patrol the circulation, hunting for and digesting unwanted organisms such as bacteria, viruses, or fungi. Microbivores are often referred to as "phagocytes." In a couple of hours or less, microbivorous organisms may be able to totally eliminate even the most acute septicemic infections. The risk of developing sepsis or septic shock is not enhanced by the nanorobots since the pathogens are completely digested into innocuous sugars, amino acids, and other substances. Only these substances may be considered to be considered to be effluents that are created by the nanorobot. (Logothetidis , 2006)

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Surgical Nanorobotics

A surgical nanorobot that is capable of being programmed or guided by a human surgeon could function as a semiautonomous on-site surgeon once it has been introduced into the body through the vascular system or cavities. This would allow the nanorobot to perform surgical procedures inside the human body. This would make it possible for the robot to carry out surgical procedures without the assistance of a human. A device similar to this one is capable of performing a wide range of functions, including looking for disease, identifying defects, and then fixing them by using nanomanipulation. An onboard computer would be responsible for coordinating all of these different duties, and the device would maintain communication with the supervising surgeon via the use of ultrasonic transmissions that are encrypted. **(Freitas R. , 2005)**

Nanogenerators

A new class of self-powered implanted medical devices, sensors, and portable electronics might be developed by converting kinetic energy from activities like movement, muscle stretching, or water flow into electrical energy. Nanogenerators work by deforming and releasing nanowires made of piezoelectric and semiconducting zinc oxide. Given that nanowires can be produced on polymer-based films, flexible polymer substrates might one day allow users to create energy for their own portable electronics by simple motion. Professor Wang of China's Peking University and the National Center for Nanoscience and Technology said that the nanogenerators are useful because "our bodies are adept at transforming chemical energy from glucose into the mechanical energy of our muscles." The prospective uses of self-sustaining medical implants might be substantially widened as a result of this. **(Konig , Riemann, Fischer , & Halbhuber , 1999)**

Conclusion

Nanotechnologies have without a doubt made a contribution to an increase in the quality of life of patients. This is due to the fact that they serve as a basis for breakthroughs in the biotechnology, medical, and pharmaceutical industries. Additionally, they have made the procedures that are involved in healthcare more manageable, beginning with diagnosis and continuing through therapeutic treatments and the monitoring of follow-up care. There is a continuous effort being made to generate and develop innovative nanomaterials with the intention of enhancing illness diagnostics and treatments in a way that is more specific, accurate, powerful, and long-lasting. The end objective of this work is to produce medical practises that are more tailored to the patient's specific needs, as well as those that are more reasonably priced and secure (57,58). In order to fully realise the promise of nanotechnology, it is necessary to make use of the proper nanomaterials while at the same time taking precautions to reduce the possibility of any unintended repercussions. Before they may be utilised in clinical or commercial settings, newly developed products based on nanotechnology are required to first be subjected to risk assessments. This is standard procedure for the approval of any product. This is done with the intention of lowering the total number of potential threats to not just human health but also the health of the natural environment. In order to establish the practicability and safety of their use throughout the course of a longer period of time in a more accurate manner, it is required to carry out an exhaustive life cycle study. It is anticipated that nanoparticles and nanotubes, as well as their derivatives such as hollow nanospheres, core shell structures, nanocomposites, nanoporous materials, and nanomembranes, would play an increasingly essential role in dental materials research and development. The dream of every doctor, healer, and medicine man throughout history will come true when nanomechanics is made available to the masses. The development of microscale robots constructed from nanoscale components built to nanometer precision will pave the way for reconstructive and curative surgery to be performed at the cellular and molecular levels of the human body. In the 21st century, nanomedical practitioners will continue to make good use of the body's own healing powers and homeostatic mechanisms since, all else being equal, those therapies are best which interfere least.

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