Section A-Research paper
ISSN 2063-5346

A Future Perspectives of Nanorobots in health care diagnosis & Treatment

[1]Uri Adrian Prync Flato, [2]Dr. Anurag Rawat, Prof.Cardiology. [3]Madhu S Mallisetty, [4]Dr.Vijaya Krishna Prasad Vudathaneni, [5]Dr. Shamika Kamath, [6]Mohammad Mobarak Hossain, [7]Dr. Sanghmitra Sharma, [8]Prof.Susmita Srivastav

[1]Researcher, Physician, Hospital Israelita Albert Einstein, Av. Albert Einstein, 627/701 - Morumbi, São Paulo - SP, ZIP CODE 05652-900, Brazil, Email- uriflato@gmail.com

[2]Himalayan Institute of medical science. Jolly Grant. Dehradun. Email- anuragrwt@gmail.com

[3]Software Developer, Charlotte, NC - 28217, USA. Email- mmallisettysoftwaredev@gmail.com

[4]Attending Physician, North Central Bronx Hospital 3424 Kossuth Ave, Bronx, New York, Zip code-10467, United States of America. Email- vvkinternalmedicine@gmail.com

[5]Associate Professor, Dept. of Dentistry, NAMO Medical Education & Research Institute, Silvassa, 396230. Email- shamikakamath@gmail.com

[6]Lecturer, Department of Textile Engineering, Jashore University of Science and Technology, Jashore, Bangladesh. Email- mobaraknits89@gmail.com

[7]Assistant professor, IIMT UNIVERSITY, O pocket, Ganga Nagar Meerut, Uttar Pradesh 250001. Email- sanghmitrasharma92655@gmail.com

[8]Professor and Head, Department of Zoology, Shivharsh Kisan P.G.College Basti, Pincode-272001. Email- susmita.sus74@gmail.com

DOI: 10.48047/ecb/2023.12.si4.1588

Abstract

Nanorobotics-related equipment is used in the research of biological sciences. It has become a frontier of increasing relevance for several important industries, most notably healthcare in both diagnostic and therapeutic applications. The potential for nanorobots to progress biological research and improve global healthcare is enormous. New nanoparticles and nanodevices are expected to be used shortly with favorable effects on human health. The use of nanotechnology in the study of health is still in its infancy. For the biological sciences to use nanotechnology, processes, and instruments must be created that are accurate and powerful enough to interact at the cellular and subcellular level. With few to no side effects, tissue/cell-specific targeted treatments and/or therapies may be able to achieve significant therapeutic success. More accidental trials and in-depth research are required to properly transform nanorobots into humane models. The limitations, guiding principles, challenges, and possible future applications of nanotechnology in the area of health science for diagnostic and therapeutic applications of nanorobots are covered in this article.

Keywords: Nanorobots, Nanorobots; applications; diagnostics; therapeutics; biomedical

Introduction

To modify a material's physicochemical properties at the molecular level, nanotechnology requires materials and specialist equipment. Biotechnology modifies cellular, molecular, and genetic processes using scientific methods and biological knowledge to provide useful services and goods for a range of sectors, from agriculture to health. Nanorobots are viewed as a creative means of effectively fusing conventional microtechnology with a molecular approach. This technology permits the construction of molecular or even atomic-grade machines by integrating or reproducing biological processes, or by synthesizing tiny tools to modify a variety of molecular properties of living systems. Therefore, by combining cutting-edge applications of nanotechnology and information technology with current biological issues, nanorobots may enable several methodologies in the life sciences. This cutting-edge technology has the potential to broaden our understanding and ideas while blurring some of the boundaries between physics, chemistry, and biology. As a result, the widespread use of nanorobots in research and diagnostics may present several brand-new challenges and opportunities in the future (Qamar, Asgher, Khalid, & Sadaf, 2019).

Nanorobots

Nanoid robotics is a relatively young branch of technology that develops machines or robots with parts that are at or very close to the nanoscale. Nanorobotics, nanorobotics, or nanorobots are other names for it. More specifically, the term "nanorobotics" designates the area of nanotechnology that is concerned with creating nanorobots having parts that are molecular or nanoscale in origin and range in size from 0.1 to 10 micrometers. These presently being researched and developed gadgets are also known as nanobots, nanoids, nanites, nanomachines, and nanometers. Most nanomachines, however, are still in the research and development phase. Nanomotors and molecular machinery have been put to the test. A sensor with a switch that counts particular molecules in a chemical sample is one example. The field of nanomedicine may contain the first uses for nanomachines. As an illustration, biological equipment could be able to recognize and eliminate cancer cells. Identification of hazardous substances and assessment of their environmental concentrations are two further possible uses. A chemically synthesized single-molecule automobile with wheels made of Buckminsterfullerene was on exhibit at Rice University. By placing the tip of a scanning tunneling microscope there and adjusting the surrounding temperature, it may be made active. A robot that enables accurate interactions with objects at the nanoscale or can manipulate them at the nanoscale is another description. As opposed to molecular machines, these devices are more closely connected to microscopy or scanning probe microscopy. Even a piece of large equipment, such as an atomic force microscope, might be classed as a nanorobotic instrument under the microscopy requirements when it is intended to do nanomanipulation. According to this definition, nanorobots are also macroscale or microrobots with accurate nanoscale movement (Li, Esteban-Fernández de Ávila, Gao, Zhang, & Wang, 2017).

Applications of Nanorobots in Health Sciences

The study of cell and gene therapy, targeted drug delivery, disease diagnostics, molecular imaging, nanomedicines, and nanoarrays all make use of nanorobots. A variety of in vitro and in vivo environments are also being used to study several novel nanostructures. Advanced nanorobot applications to living systems will undoubtedly alter future preventative, disease diagnostic, and treatment approaches. A detailed explanation of these uses may be found below:

Diagnostics

Before a healthcare professional concludes that a certain patient has a specific type of disease, existing diagnostic techniques for a wide range of diseases rely on the presence of visual indications and symptoms. Several electrochemical and enzymatic biosensors have been developed, mostly in the healthcare and agricultural industries, for the aim of identifying illnesses. Since these symptoms are now apparent, the therapy may not be effective. Therefore, a disease's early detection increases the likelihood that a cure will be found. Finding the problem and fixing it before the patient experiences any symptoms is the best course of action. It will be essential to use nucleic acids (DNA and RNA) to detect various disorders, as doing so will enable the early identification of sick cells and effective treatment. Current technologies like polymerase chain reaction (PCR) made it possible for these devices, but Nanorobots are expanding on the possibilities that were already practical, which certainly will increase economy and efficiency (Ali et al., 2021).

Quantum Dots

By detecting certain antibodies connected to a given condition, some regularly used/conventional healthcare tests show the frequency of a chemical, pathogenic organism, or microbe. In the past, imaging techniques like fluorescence or electron microscopy have been utilized to explore the material utilizing inorganic/organic dyes that have been coupled with the antibodies. However, synthetic dyes frequently lessen the value and accuracy of a diagnosis. Nanocrystals sometimes referred to as "quantum dots" are suggested by nanorobots as a viable treatment. It's fun to consider several ways to depict a single-color detection and binding event that necessitates complex tagging of unknown objects (Karimi et al., 2016).

Microarray

Proteins are important in determining a person's phenotype, whether they are healthy or ill, as well as acting as functional symptoms. Since medications are created to modify signaling pathways, proteomics is crucial for diagnostics and pharmaceutics. Protein chips can be treated using chemical groups and minute-integrated protein components. It could intercalate with a certain biochemical structure or kind of unique protein. Gold nanoparticles tagged on protein chip microarrays were optically detected using surface plasmon resonance with rolling circle amplification and selective molecule binding. Proteins are commonly immobilized on a micro slide by routine or exceptional contact to produce protein chips (Prasad et al., 2018).

Nanotubes

Medical professionals will continue to favor calorimetric and optical detection over rival detection techniques like magnetic detection. Thanks to methods developed by Nanosphere Inc., the medical world can now clearly discern the genetic makeup of living material. The foundation for determining if a certain genetic sequence is present is the analysis of short DNA segments tagged with gold nanoparticles. The target probes generation approach effectively enables pathogen identification if the sequence of interest present in the sample binds to the cDNA nanocarrier and forms a dense network of gold balls. With far better sensitivity than currently used test techniques, this strategy showed fascinating results in the in situ detection of breast cancer cells, prostate cancer cells, and anthrax (Rashidzadeh et al., 2021).

Chromophores and Quantum Dots

Utilizing tagged probes that may be seen noninvasively, in vivo physiological changes are evaluated utilizing molecular imaging technology. Over the past few decades, the discipline of nanoimaging has made rapid advancements. Target molecules that have been marked with synthetic chromophores or quantum dots have made intercellular imaging conceivable. Such fluorescent proteins enable optical molecular methods, such as correlation imaging or confocal fluorescence microscopy, to directly see intracellular signaling. Nanotechnologists are working hard to create nanomaterial that could help study the biological processes linked to human disease and monitor changes following a particular drug. With the creation of various cutting-edge nanoparticles, including quantum dots, the adaptability of molecular imaging techniques has significantly increased. Biological activity such as ion-channel activity, enzyme activity, gene expression, or protein-protein interaction can be studied using imaging probes. Real-time monitoring of receptor density may benefit from nanoparticles that bind to certain receptors with high affinity (Anjum et al., 2021).

Spares Cell Detection

In usual physiological settings, sparse cells are distinct from neighboring cells, including lymphocytes, cancer cells, HIV-infected T-cells, and fetal cells. These are essential in locating many genetic diseases. Even so, it might be challenging to separate and recognize these few cells. Thus, nanorobots provide fresh chances for advancement in this area. Nanotechnologies that can discriminate between sparse cell populations and healthy tissues and blood have been successfully developed by researchers. Nanorobots exhibit novel surface charge shifts, deformation, and affinities of specific ligands and/or receptors. For example, by implanting electrodes into microchannels, accurate separation may be achieved on sparse cells. Using microscopic nanopores on biocompatible surfaces is an additional technique for categorizing sparse cells (Narang & Narang, 2015).

Therapeutic

New, safer pharmaceutical formulations can be made with the help of nanorobots. Over the past few decades, drugs based on nanoparticles have grown more prevalent as generally accessible therapeutic therapies. According to a study by the European Science and Technology Observatory 1, more than 150 companies throughout the globe are now creating drugs based on nanoparticles.

Nanocarriers Mediated Drug Delivery

One of the key challenges in the treatment of many diseases is getting therapeutic medications to the desired site. By controlling medication distribution, these issues and limitations can be solved. Conventional applications of a select few medications are characterized by poor biodistribution, constrained effectiveness, and a lack of selectivity. By using a controlled drug delivery system (DDS), drugs can be delivered to the area of action with fewer adverse effects on essential tissues. The method of medication administration boosts the treatment's concentration in the target tissues and protects it against quick breakdown or evacuation. Particularly in situations when there is a discrepancy between medication concentration and therapeutic benefits, this modified type of treatment has grown in relevance. Cell-specific targeting may be made possible by affixing a particular medication to an independently created carrier. The word "theranostics" is important in describing focused diagnosis with an emphasis on patient care. Many theranostic methods have been created and used in *in vivo* situations. Doxorubicin-Ce6 conjugated nanoparticles were created by a researcher (Patra et al., 2018).

Nanosized Gene Carriers

Many human genetic diseases, such as Parkinson's disease, cancer, Parkinson's disease, and cystic fibrosis, have been successfully treated by gene therapy. Current gene therapy techniques face difficulties in the design and processing of effective pharmaceuticals as well as the possibility of a mutant going back to its original kind. Another issue is the potential immunological response to the viral vector being employed for gene delivery. Nanotechnology enables contemporary therapeutic strategies for human gene delivery, such as nanocarrier-based non-viral gene therapy (Hill & Li, 2017).

Liposomes

A liposome's lipid bilayer shape allows for the delivery of genes and/or medicines. This is so that a liposome, which is lipophilic and can cross target cells' and tissues' cell membranes, can function. When lipids are disseminated in aqueous environments by sonication, which is how such liposomes are created, spherical-shaped vesicles consisting of steroids, phospholipids, or other surfactants naturally emerge. The therapeutic index of chemotherapeutic medications, the reduction of undesirable side effects, the speed of metabolism, and the augmentation of in vivo and in vitro anticancer activity have all been explored utilizing liposomes to improve the solubility and pharmacokinetic features of drugs (Aziz, Aziz, & Akbarzadeh, 2017).

Nano based Biopharmaceuticals

Nanorobots can also be employed in the development of nano-based therapeutics to effectively cure illnesses that cannot be appropriately addressed with conventional drugs. The pharmaceutical business has traditionally focused on developing drugs to treat a certain set of diseases. The failure of 70–80% of drug development programs is often discovered after millions of dollars have been lost in research and development. Nanoscale drug development would be helpful since pharmaceutical corporations cannot afford to pay organic chemists hundreds of dollars to synthesize and evaluate thousands of novel chemicals (Kumar et al., 2020).

Nanoscale Biomolecular Engineering

The amount of physiologically active molecules is constrained due to the time and money required for classical biomolecular engineering. The use of nanoscale synthesis and assembly instead of conventional methods is fantastic. Nanoparticles can be used for immobilization, controlled synthesis of hybrid biomaterials with enhanced biocompatibility, and the production of nanostructures and nanomaterials. Instead of employing more traditional solution-based methods, development can be achieved by conducting biological and chemical interactions on solid substrates. The use of a solid matrix typically results in less waste and biomolecular manipulation that is much more exact. Through molecular linkers, biomolecules are joined to the surface of solid matrixes. Numerous biomolecules may be immobilized on solid surfaces like nanocarriers, including bioactive peptides, enzymes, and antibodies (Joshi, Choudhary, & Mundra, 2019).

Nanosurfaces

Instead of employing more traditional solution-based methods, development can be achieved by conducting biological and chemical interactions on solid substrates. The use of a solid matrix typically results in less waste and biomolecular manipulation that is much more exact. Through molecular linkers, biomolecules are joined to the surface of solid matrixes. Numerous biomolecules may be immobilized on solid surfaces like nanocarriers, including bioactive peptides, enzymes, and antibodies. Hybrid nanomaterials can be employed for implants and medical devices, as well as for medication evaluation. According to research, PLGA (polylactic-co-glycolic acid) nanoparticles were functionalized by adding surface enhancers such as folate, a polymer, and a peptide. The interactions between nanoparticles with altered surfaces were beneficial since there was no longer any cytotoxicity or dopamine bioactivity (Ahmad et al., 2017).

Nanorobots for Dental Therapy

The future of nanorobots in dentistry is quite promising. Through the use of biotechnology, nanomaterials, and nanorobotics, nano dentistry will enhance oral health. These amazing advancements in dental care research will assist millions of people who now have poor oral health. Furthermore, significant tooth healing using nano dentistry may emerge. Nanorobotics in dental treatment may quickly and precisely occlude teeth if specific parameters are met. Nanodentistry's capacity to retain natural teeth might lead to yet another important development. To improve the strength and attractiveness of teeth, sapphire, ceramic, or zirconia replacement dental enamel layers may be used.

Nanoparticles with a size range of 1 to 100 nanometers, generated from nanoscale mineral and organic phases, play a significant and ground-breaking function in the formation of bones. Nanomaterials including carbon nanofibers, nanotubes, nano polymers, and ceramic nanocomposites are a few examples. These materials may increase the effectiveness with which calcium-rich minerals are deposited. Based on these findings and supporting information, nanoscale materials have a unique niche in research and development because they could improve the interaction between bone cells, which might improve bone tissue's capacity to attach to implants. Without a doubt, this technology will support nanoscale biomolecular engineering in increasing implant effectiveness while significantly lowering the issues with patient compliance (Omanović-Mikličanin, Maksimović, & Vujović, 2015).

Nanorobots in Cardiac Therapy

To better understand the cellular frontiers of cardiovascular sciences and cure CVDs, nanorobots are making potential advancements in cardiovascular medicine. Imaging, detection, and tissue engineering can all be improved with nanotherapeutic methods. Nanobarcodes, nanocrystals, and quantum dots are examples of nano-sensors that can recognize and track complicated immunological signaling that results from inflammatory cardiovascular events. Nanorobots can also help with diagnostics by defining clinically applicable cardiac disease-related pathways. Building molecularly integrable nanomachines for application in biological systems also depends on it. Several notions and ideas concerning the management of severe CVD may be altered by these nanostructured devices. Furthermore, the management of issues like unstable plaques and valvular clarity may be significantly impacted by nanotechnology. In the quest for prolonged and focused cardiac therapy for the treatment of CVDs, this nanotechnology strategy may represent a significant advancement (Bregoli et al., 2016).

Challenges for Nanorobots

A single individual or a group of ideas cannot resolve the problems that Nanorobots present. Making equipment that is so precise at assessing the exposure of nanomaterials to water and air is one of the biggest challenges. To avoid negative effects, it is essential to monitor both human and animal exposure to air and water contaminated with nanomaterials. When we discuss the possibility of nanomaterial contamination of goods like food, this truth has a more ominous tone. The next difficulty would be the development of appropriate procedures to assess the toxicity of nanomaterials, which would take another 10 to 15 years. However, it would be challenging to assess the impact of these nanomaterials on the environment and human health without doing in vivo research utilizing animal models. The creation of a method for studying the exact effects of nanomaterials throughout a person's life and/or the life of his surroundings would be another difficulty. The commercialization of nanorobots would be the largest obstacle and require good scalability, patience, finance, innovation, restricted resources, etc. Numerous businesses highlight the enormous potential of nanorobots for enhancing and creating new goods. Nanorobots raise important issues with new legislation. To progress with this emerging technology, authorities should assess any potential risks posed by nanoparticles and choose the best course of action in terms of regulation (Aeran, Kumar, Uniyal, & Tanwer, 2015).

Conclusion

The field of nanorobotics is continually evolving. It is improving the technology that supports absurdly compact gadgets. At some point, these developments will likely be so significant that they will influence every field of science and technology. Nanoscale-based biotechnology has several potential uses in medicine. The base for the start of something spectacular is innovation, such as the creation of gene delivery systems or tailored drugs. Future medical innovations on the nanoscale may be able to successfully treat several serious conditions for which there is now no treatment. Despite the great expectations and various potential advantages, the safety of nanomedibots and nanomedicines has not yet been thoroughly investigated. It is necessary to do a complete review of how nanobiotechnology is being used in medical diagnosis and therapy. Although in vivo studies should be done to assess the safety level, scientists who are opposed to deploying nanotechnology in biological systems claim that nanorobots should advance regularly since they are offering enormous advantages. In the future, nanomedicines may be crucial for treating human illnesses and maintaining healthy human physiology. If nanotechnology keeps progressing in this direction, it will soon be a need in daily life and contribute to the saving of many lives.

References

- Aeran, H., Kumar, V., Uniyal, S., & Tanwer, P. (2015). Nanodentistry: Is just a fiction or future. *Journal of Oral Biology and Craniofacial Research, 5*(3), 207-211.
- Ahmad, J., Akhter, S., Rizwanullah, M., Ahmed Khan, M., Pigeon, L., T Addo, R., . . . Amjad Kamal, M. (2017). Nanotechnology based theranostic approaches in Alzheimer's disease management: current status and future perspective. *Current Alzheimer Research, 14*(11), 1164-1181.
- Ali, E. S., Sharker, S. M., Islam, M. T., Khan, I. N., Shaw, S., Rahman, M. A., . . . Das, N. (2021). *Targeting cancer cells with nanotherapeutics and nanodiagnostics: Current status and future perspectives.* Paper presented at the Seminars in cancer biology.
- Anjum, S., Ishaque, S., Fatima, H., Farooq, W., Hano, C., Abbasi, B. H., & Anjum, I. (2021). Emerging applications of nanotechnology in healthcare systems: Grand challenges and perspectives. *Pharmaceuticals, 14*(8), 707.
- Aziz, S. G.-G., Aziz, S. G.-G., & Akbarzadeh, A. (2017). Advances in silver nanotechnology: An update on biomedical applications and future perspectives. *Drug Research, 67*(04), 198-203.
- Bregoli, L., Movia, D., Gavigan-Imedio, J. D., Lysaght, J., Reynolds, J., & Prina-Mello, A. (2016). Nanomedicine applied to translational oncology: A future perspective on cancer treatment. *Nanomedicine: Nanotechnology, Biology and Medicine, 12*(1), 81-103.
- Hill, E. K., & Li, J. (2017). Current and future prospects for nanotechnology in animal production. *Journal of animal science and biotechnology, 8*(1), 1-13.
- Joshi, H., Choudhary, P., & Mundra, S. (2019). Future prospects of nanotechnology in agriculture. *Int. J. Chem. Stud, 7*(2), 957-963.
- Karimi, M., Zare, H., Bakhshian Nik, A., Yazdani, N., Hamrang, M., Mohamed, E., . . . Hamblin, M. R. (2016). Nanotechnology in diagnosis and treatment of coronary artery disease. *Nanomedicine, 11*(5), 513-530.
- Kumar, S., Nehra, M., Kedia, D., Dilbaghi, N., Tankeshwar, K., & Kim, K.-H. (2020). Nanotechnology-based biomaterials for orthopaedic applications: Recent advances and future prospects. *Materials science and engineering: C, 106*, 110154.

- Li, J., Esteban-Fernández de Ávila, B., Gao, W., Zhang, L., & Wang, J. (2017). Micro/nanorobots for biomedicine: Delivery, surgery, sensing, and detoxification. *Science robotics*, *2*(4), eaam6431.
- Narang, R. S., & Narang, J. K. (2015). Nanomedicines for dental applications-scope and future perspective. *International Journal of Pharmaceutical Investigation, 5*(3), 121.
- Omanović-Mikličanin, E., Maksimović, M., & Vujović, V. (2015). The future of healthcare: nanomedicine and internet of nano things. *Folia Medica Facultatis Medicinae Universitatis Saraeviensis, 50*(1), 23-28.
- Patra, J. K., Das, G., Fraceto, L. F., Campos, E. V. R., Rodriguez-Torres, M. d. P., Acosta-Torres, L. S., . . . Sharma, S. (2018). Nano based drug delivery systems: recent developments and future prospects. *Journal of nanobiotechnology, 16*(1), 1-33.
- Prasad, M., Lambe, U. P., Brar, B., Shah, I., Manimegalai, J., Ranjan, K., . . . Khurana, S. K. (2018). Nanotherapeutics: An insight into healthcare and multi-dimensional applications in medical sector of the modern world. *Biomedicine & Pharmacotherapy, 97*, 1521-1537.
- Qamar, S. A., Asgher, M., Khalid, N., & Sadaf, M. (2019). Nanobiotechnology in health sciences: Current applications and future perspectives. *Biocatalysis and Agricultural Biotechnology, 22*, 101388.
- Rashidzadeh, H., Danafar, H., Rahimi, H., Mozafari, F., Salehiabar, M., Rahmati, M. A., . . . Ertas, Y. N. (2021). Nanotechnology against the novel coronavirus (severe acute respiratory syndrome coronavirus 2): Diagnosis, treatment, therapy and future perspectives. *Nanomedicine*, *16*(6), 497-516.