Review Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2023.49.007774

Disease Fighting Machines Inside the Body: A Review

Girum Tefera Belachew*

Department of Biotechnology, College of Natural and Computational Sciences, Debre Birhan University, Ethiopia

***Corresponding author:** Girum Tefera Belachew, Department of Biotechnology, College of Natural and Computational Sciences, Debre Birhan University, P.O. Box 445, Debre Birhan, Ethiopia

ARTICLE INFO

Received: March 02, 2023

Published: March 14, 2023

Citation: Girum Tefera Belachew. Disease Fighting Machines Inside the Body: A Review. Biomed J Sci & Tech Res 49(2)-2023. BJSTR. MS.ID.007774.

ABSTRACT

Background: Nanotechnology will bring about a revolution in the globe. The National Nanotechnology Initiative (NNI) defines nanotechnology as the study of all particles with a dimension of 100 nanometers or less. One of the main advantages of smaller particles is the rise in the ratio of surface atoms or molecules to total number. Due to their large surface area, which enhances surface activity and alters their biological and physical features, they have many surfaces. Drugs having nanoscalesized active ingredients are referred to as nanotechnology applications in the pharmaceutical sector. They can repair damaged tissue at the cellular level, are helpful in detecting, diagnosing, and treating illness, and are beneficial in treating severe diseases like HIV, cancer, and others. Drugs can now be injected into previously inaccessible areas of the body thanks to smaller drug delivery systems, which are also essential for the treatment and early diagnosis of specific diseases like cancer. Target treatment, a recent development in pharmaceutical administration, improves medical equipment and diagnostic techniques.

Keywords: Nanorobots; Medical Diagnosis; Disease Treatment

Introduction

Modern biomedical advances has placed a high priority on precision medicine, which is being advanced thanks to the development of micro- and nanorobots. Micro/nanorobots are functional objects that are propelled by electromagnetic fields like light, sound, and magnetic fields that can move at the micron and nanoscale [1]. Richard Phillips Feynman was the first to suggest deploying micro/nanorobots in biomedical applications, and he also predicted that the machines will be able to do minuscule operations [2]. Professor Toshio Fukuda, the pioneer of micro/nanorobots, created the first nanorobot operating system for single-cell research and manipulation in the early 2000s [3]. However manufacturing micro/nanomaterials with complex structures and a range of physical properties is challenging, making the development of micro/nanorobots highly challenging. Artificially produced micro- and nanorobots have developed from centimeter-scale to micro- and nanoscale in recent years utilizing both top-down and bottom-up techniques. Also, they have created micro/nanorobots with a range of shapes and materials, such as tubular, linear, rod, yinyang spherical, spiral, peanut, and sea urchin micro/nanorobots. Micro/nanorobots have been widely used in a variety of industries, including drug targeting delivery, cell capture and separation, minimally invasive surgery, analysis and detection, environmental purification, and nano printing [4,5].

This is due to their small size and controlled navigation capabilities. The development of motion control techniques for micro- and nanorobots coincides with the intensification of research. Micro/nanorobots, for instance, can carry out their navigation motion using an electric field, magnetic field, ultrasonic field, and light field. As a result of the ongoing developments in micro-nanomaterial synthesis technology, many micro/nanorobots have been completely created and have a wide range of potential applications, particularly in the biomedical field [6,7]. The two main facets of biomedicine are therapy and diagnosis. From an engineering standpoint, diagnosis is the measurement of a variety of anomalous events in the human body, and treatment is the modification of the current state of the human cells. Diagnostic techniques must be scaled down to the micron and nanoscale as medicine develops at the cellular and molecular levels, enabling cellular and molecular sensing and offering novel diagnostic methodologies [8]. The treatment procedure, which starts at the genetic and cellular levels, is the same. Because DNA molecules are the fundamental building blocks of cells and cells are the fundamental building blocks of organ tissue, solving the problems relating to human disease at these levels will have a more profound effect [9]. Hence, in order to diagnose and treat patients, finer sizes of sensing and manipulation techniques are needed. Modern biomedical treatments have advanced thanks to the advent of robotics, which offers new ideas on how to enter the human body as little-disturbingly as possible [10]. This technology cannot be delivered by conventional medical technology. Over the past ten years, medical micro/nanobots have made some progress, but their widespread clinical use has been limited by immature technology requirements, such as the drive and cluster control of microrobots, while operating a large number of micro/nanobots frequently requires complicated procedures and sophisticated equipment [11]. This article briefly describes the most recent advancements in the field, covers the dynamic foundation of micro/nanorobots, and focuses on their use in disease diagnosis and treatment (Figure 1).

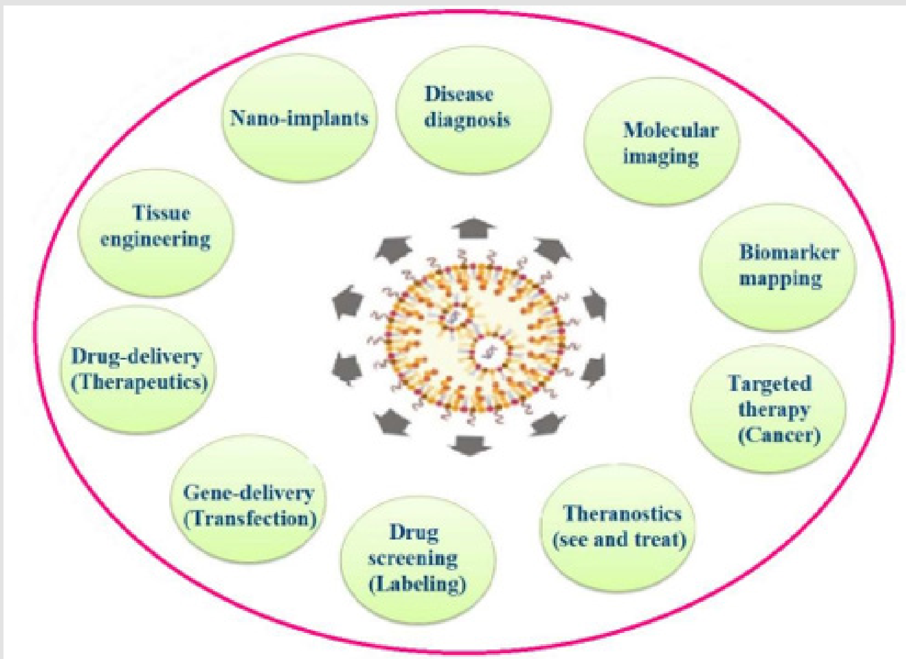

Figure 1: Medical uses of nanotechnology.

Nanorobots and their Types

Nanorobots have proved their utility in lowering infertility problems by working as an engine and enhancing sperm motility when attached to them, in addition to having uses in business, medicine, and other fields including the development of nanomotors used for energy conservation. Nanorobots are extremely small machines that are capable of doing tasks that are on par with those now performed by other machines [12]. The two types of nanorobots that are most frequently examined are organic and inorganic. By fusing DNA cells from bacteria and viruses, organic nanorobots, also referred to as bio nanorobots, are produced. The risk to the organism is lower with this particular form of nanorobot. In comparison to biological nanobots, inorganic nanobots are more dangerous because they are made of materials like synthetic proteins, diamond structures, and other things. Researchers have created a method of encapsulating the robot to get around this toxicity barrier and minimize the risk of the robot being destroyed by the body's defensive processe [13,14]. Understanding the biological drivers of live cells will help scientists develop reactive mechanisms to power micro- and nanoscale devices [15]. The Chemical Institute of the Federal Fluminense University created a nano valve. It is made out of a tank with a shutter covering it, from which dye molecules can escape when the lid is evenly opened. This device, which is natural and made of beta-cyclodextrins, organometallic compounds, and silica ($SiO2$), will be employed for therapeutic applications [16].

In some research, proteins are utilized to power nanomotors that can move massive objects, and they are also used to build nanorobots using DNA hybridization and antibody proteins. DNA hybridization is the process by which two single-stranded molecules of complementary DNA or RNA combine to generate a double-

DOI: 10.26717/BJSTR.2023.49.007774

stranded molecule. Nanorobots can be functionalized using a variety of chemical compounds [17]. It has been investigated in DDS, a field of nanomedicine that deals with certain cells found in the human body. Researchers are working on creating devices that could deliver medications to particular areas while also adjusting the dose and pace of release. It is possible to use this DDS with nanorobots to cure conditions including hepatitis, diabetes, cancer, joint problems, and more [12,18-21].This method reduces the likelihood of unpleasant results and can diagnose and treat diseases with little to no negative effects on healthy tissues while also focusing healing and remodeling therapy at the cellular and sub-cellular levels [22,23] (Figure 2).

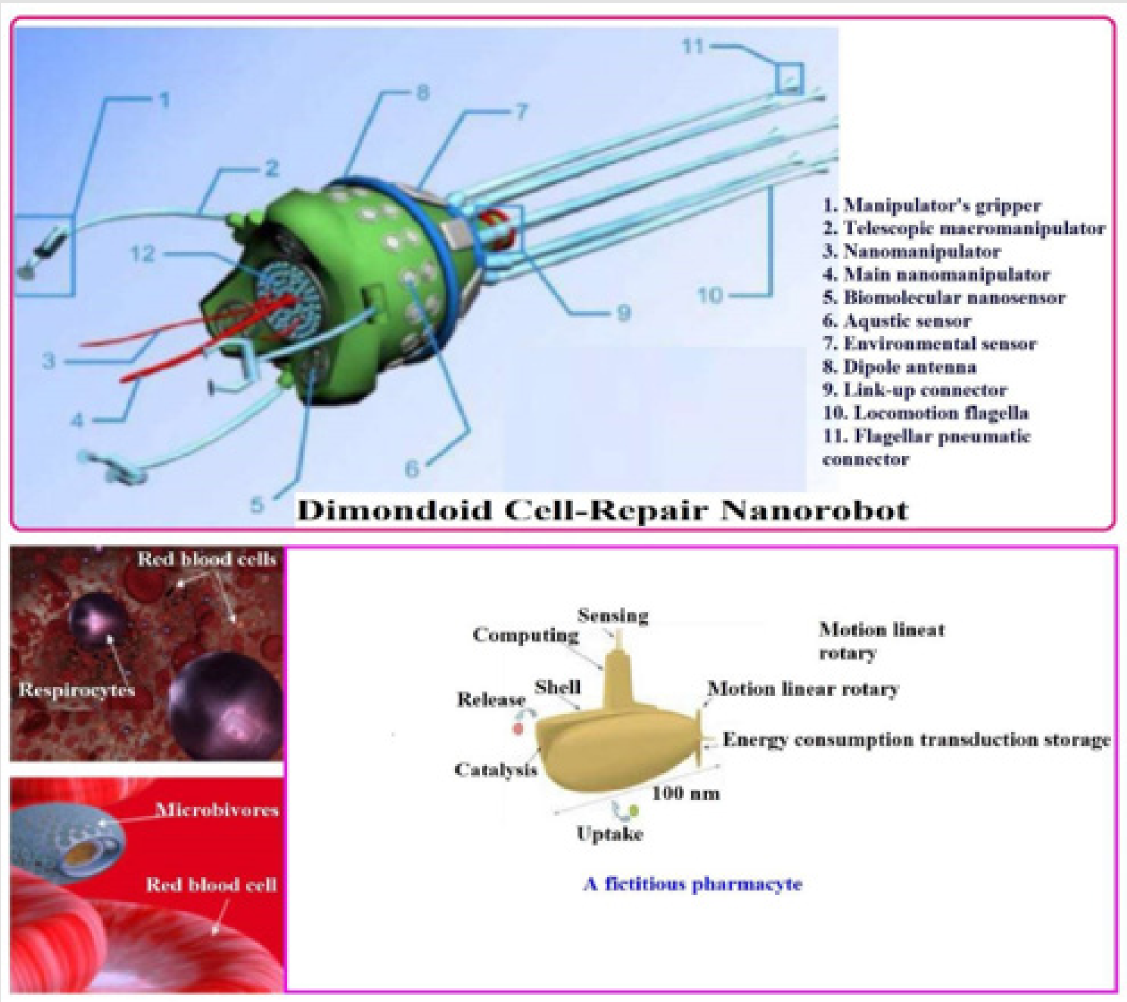

Figure 2: Types of nanorobots.

Ideal Characteristics of Nanorobots

They are 1-100 nm in size and range in size from 0.5 to 3 microns; otherwise, they may block capillary flow. Nanorobots have a passive diamond shell that shields them from immune system attacks. By encoding data to acoustic waves with carrier wave frequencies ranging from 1 to 100 MHz, it may communicate with the doctor. In order to replace broken or worn-out pieces, it can reproduce itself [24].

Technique for Making Micro/Nanorobots

The two basic categories of micro/nanorobot production are top-down and bottom-up. Physical vapor deposition (direct deposition and grazing angle deposition), roll-up technique, and 3D printing technology employing laser direct writing are a few of them [25].

Maintenance of Oral Hygiene

While allowing the healthy flora of the mouth to flourish in a balanced ecosystem, intelligent nanorobots in mouthwash might

 DOI: 10.26717/BJSTR.2023.49.007774

identify and get rid of bad germs. The tools would also be able to identify food, plaque, or tartar particles and lift them off the teeth so they could be cleaned away. It could access surfaces that floss or toothbrush bristles cannot since it is suspended in liquid and mobile. Nanorobots that live in the mouth are distributed by dentifrice patrols. In addition to preventing tooth decay, they protect the mouth from halitosis [26]. It might be disassembled in the region by nanorobots. Robots must remove the obstruction without allowing any tiny pieces to enter the bloodstream, where they could spread to other organs and create more problems [26] (Figure 3). To prevent impeding blood flow, which promotes wound healing, the robot must be small enough. The clottocyte, also known as an artificial platelet clottocyte, is one type of nanorobot whose clotting process may be up to 1,000 times faster than that of the body [27]. Clottocyte therapy for people with serious open wounds.

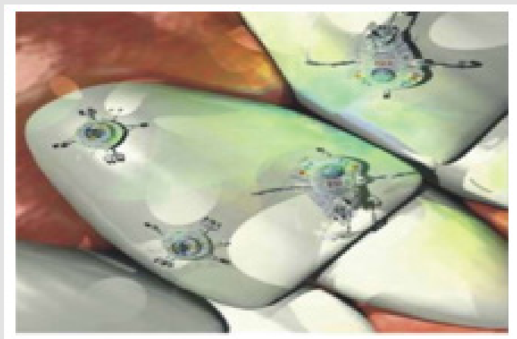

Figure 3: Nano robotic oral prophylaxis.

Kidney Disease

Nanorobots can use ultrasonic shocks to break kidney stones. Huge kidney stones are extremely painful and do not dissolve in the urine. A nanorobot breaks up small stones so that they can be removed by urination [28].

Diagnosis and Treatment of Diabetes

Using a nanorobot architecture based on nano bioelectronics, diabetes can be efficiently treated. A computational technique with the use of medical nanorobotics for diabetes is simulated using clinical data. With the suggested 3D prototyping, a patient can be well-informed about preventing hyperglycemia. A relevant medical nanorobotics platform can be developed for in-vivo health monitoring [29]. The medical Nanorobot architecture then allows the patient's mobile phone to receive the crucial measured data [30]. If the glucose level exceeds the target of 130 mg/dl, the mobile phone will display or sound an alarm at any time [31,32] (Figure 4). Microchips with human molecules added to them are present. The chip is anticipated to provide an electrical signal once the molecules recognize a disease. An example of specialized sensor nanobots that can be injected into the blood beneath the skin to evaluate the blood's composition and find any potential diseases is shown. They can be used to monitor blood sugar levels as well. Advantages include simplicity of manipulation and inexpensive production costs [33] (Figure 5).

Figure 4: Nanorobots used in diabetes.

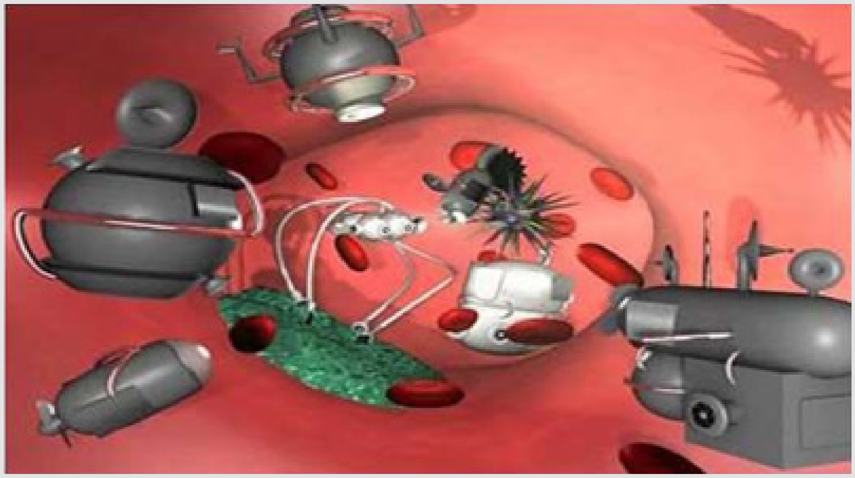

Figure 5: Nanorobots in blood vessel for diagnosis and imaging.

Figure 6: Destruction of cancer cells by nanorobots (Pharmacytes).

In Cancer Treatment

Cancer can be successfully treated using modern treatment techniques and medical technologies. Yet, the speed at which the illness was identified has a substantial impact on the likelihood that a cancer patient would survive. A malignancy should, if at all feasible, be discovered at least prior to the onset of metastases [34]. To successfully treat patients, it is imperative to develop efficient targeted medication delivery to reduce the negative effects of chemotherapy. Nano robots' capacity to go through the bloodstream makes them useful in these essential cancer therapeutic areas. Nanorobots with chemical biosensors mounted inside the body of the patient can be used to identify the early stages of tumor cell development [35]. Micro sensors included within the device can be utilized to assess the strength of E-cadherin signals. This article provides a hardware architecture based on nano bioelectronics for the use of nanorobots in cancer therapy. The studies and conclusions for the suggested model are produced using real-time 3D simulation (Figure 6).

In Gene Therapy

Medical nano robots can quickly fix inherited problems by comparing the molecular structures of the DNA and proteins found in the cell to desired or known reference structures. Any errors can then be corrected, or the necessary modifications can be introduced. In some cases, chromosome replacement treatment is superior to CY for repairing a broken chromosome. A repair vessel created by an assembler resides in the nucleus of a human cell and performs specific genetic maintenance. The nano machine stretches a super coil of DNA between its lower set of robot arms, and then delicately pulls an unwound strand of DNA through an aperture in its prow for analysis. The chain's regulatory proteins are segregated by upper arms, which then deposit them in an intake port [36,37]. The more

DOI: 10.26717/BJSTR.2023.49.007774

substantial nano-computer, which is situated outside the nucleus and connected to the cell-repair ship by a communications link, compares the information in its database to the molecular structures of DNA and proteins. While being smaller than the majority of bacteria and viruses, the repair vessel would be able to perform treatments and cures that are unimaginable to modern medical professionals. The repair vessel would be smaller than the majority of bacteria and viruses if the structural flaws in either structure are fixed and the proteins are reattached to the DNA chain, which re-coils into its original form with a diameter of only 50 nanometers. When trillions of these devices were present in a patient's bloodstream, internal medicine would take on a new meaning. It would be possible to treat diseases at their molecular level, potentially curing disorders like cancer, viral infections, and arteriosclerosis.

In Dentistry

The rising interest in the possible dental applications of nanotechnology has led to the emergence of a new field termed nano dentistry. Nano robots can realign and straighten an unequal set of teeth as well as increase the durability of teeth by using oral anesthesia, tooth desensitization, and tissue manipulation. Also, it is explained how nanorobots perform curative, restorative, and preventive treatments [38,39]. Nano dentistry procedures employ a number of tissue engineering techniques for significant tooth repair. A biologically autologous whole replacement tooth with both mineral and cellular components is created and placed largely utilizing nanorobotics to replace the entire dentition. Sapphire, a material developed by dental nanotechnology, increases the resilience and beauty of teeth. The higher enamel layers are replaced by covalently bonded artificial material, such as sapphire [40]. His material is 100–200 times more durable to failure and hard than ceramic. Similar to enamel, sapphire is moderately susceptible to acid damage [41]. Sapphire provides the best aesthetic and traditional whitening sealant alternatives. An innovative sort of restorative material that increases tooth durability is called nano composites. Nano agglomerating isolated nanoparticles and evenly spreading them in resins or coatings produce nano composites [42,43].

The nano-iller are made of an alumino silicate powder with an alumina to silica ratio of 1:4 and an average particle size of 80 nm. The nano iller has a remarkable hardness, outstanding color density, translucency, aesthetic appeal, high polish, and a 50% reduction in filling shrinkage. It also has a refractive index of 1. 503.They blend much better with a tooth's natural structure and are preferred to conventional composites (Figure 7). Those with coronary artery disease are treated with heart bypass surgery. This is carried out in order to enhance blood flow to the heart muscles. There are hazards associated with the treatment even if many arteries may be bypassed. Using a nanorobot is a different option. A body and an interior region, the latter of which is propelled by an electric motor, make up the nanorobot. Together with the electric motor, the device also includes a revolving needle, a microprocessor, a camera, and an artery thermometer. The microprocessor will control the entire procedure [44,45]. Radioactive material is delivered into the area outside the nanorobot in order to follow its movements. This can be switched at any time with a magnetic switch. The induced nanorobot can remove the plaque and crush it into tiny pieces [46]. The nanorobot is told to anchor to a blood vessel that is easily accessible from the outside once the task is complete (Figure 8).

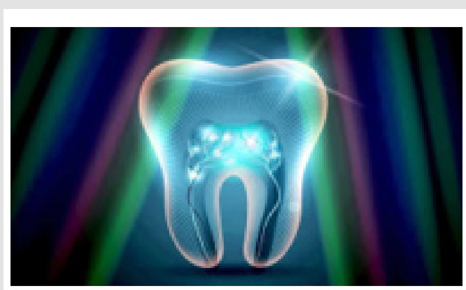

Figure 7: Nanorobots generate heat to deep clean the teeth.

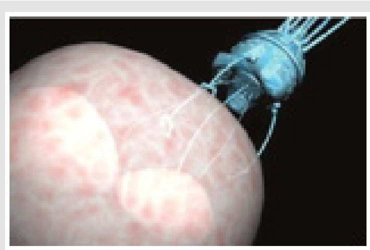

Figure 8: Nanorobot performing cell surgery.

 DOI: 10.26717/BJSTR.2023.49.007774

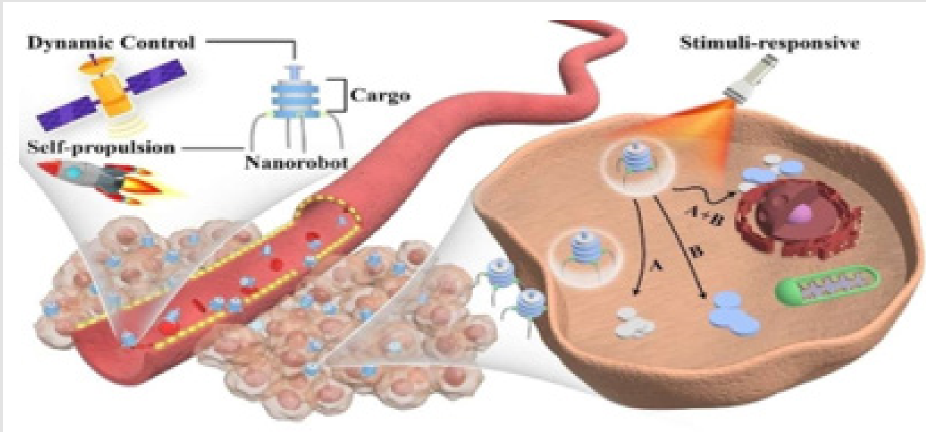

Figure 9: Nanorobots for targeted drug delivery.

Targeted Drug Delivery System

The hexagonal barrel-shaped DNA-based nanorobot may carry a variety of payloads. It is held together by two DNA aptamer «locks,» which are tiny strands that can attach to antigen sites. The locks are opened, the robot moves when it comes into touch with antigens on the surface of specific cells [47] (Figure 9).

Conclusion

An order of magnitude smaller than ever before, the scientific community is currently experiencing an innovation in technological development. The advancement of our technology and our constant investigation of ever-smaller sizes allow us to have more control over both our environment and ourselves. In the past, the scientific community and the society at large underwent tremendous upheavals as we learned to affect the world on a smaller scale. Similar to how the period of microscopes gave rise to the field of bacteriology or the dawn of the atomic age with the study of particle physics, nanotechnology is set to revolutionize many of the paradigms with which we think about sickness diagnosis, treatment, prevention, and screening. Outside of the medical realm, nanotechnology will have a significant impact on our daily lives through industries like telecommunications and agriculture. This review paper provided a concise overview of the broad field of nanotechnology and its minor but significant subset, nanodevices and nanorobotics in medicine. The potential uses of nanorobotics are expanding across all medical disciplines, broadening the therapeutic options available, and boosting the efficacy of existing treatments. Nanorobotic technology will most likely find widespread use in medical applications within a generation.

Data Availability

All of the required data will be available upon request to the corresponding author.

Authors' Contributions

The author wrote the review article alone.

Acknowledgment

The author is grateful to thank those individuals who gave help directly or indirectly.

Financial Support and Sponsorship

There is no financial support and sponsorship.

Conflicts of Interest

There are no conflicts of interest.

References

1. Anastasia Terzopoulou, Xiaopu Wang, Xiang Zhong Chen, Mario Palacios Corella, Carlos Pujante, et al. (2020) Nelson, B.J.J. Biodegradable Metal-Organic Framework-Based Microrobots (MOFBOTs). Adv Healthc Mater 9(20): 2001031.
2. Wu Z, Chen Y, Mukasa D, Pak OS, Gao WJ (2020) Medical micro/nanorobots in complex media. Chem Soc Rev 49: 8088-8112.
3. Fukuda T, Kajima H, Hasegawa Y (2004) Intelligent robots as artificial living creatures. Artif. Life Robot 8: 101-110.
4. Gao W, Wang J (2014) The environmental impact of micro/nanomachines: A review. ACS Nano 8: 3170-3180.
5. Qiu F, Bradley J Nelson (2015) Magnetic helical micro-and nanorobots: Toward their biomedical applications. Engineering 1(1): 21-26.
6. Tanyong Wei, Jiang Liu, Dongfang Li, Shuxun Chen, Yachao Zhang, et al. (2020) Development of Magnet-Driven and Image-Guided Degradable Microrobots for the Precise Delivery of Engineered Stem Cells for Cancer Therapy. Small 16: 1906908.
7. Zhang Y, Zhang L, Yang L, Vong CI, Chan KF, et al. (2019) Real-time tracking of fluorescent magnetic spore-based microrobots for remote detection of C. diff toxins Sci Adv 5(1): 9650.
8. Nicolini, A, Carpi, A (2004) Advanced breast cancer: An update and contro-

versies on diagnosis and therapy. Biomed Pharmacother 57(10): 439-446.

9. Huang C (2013) Diagnosis and treatment trends in biomedicine. Biomedicine 3: 147.
10. Taheri A, Mohammadi Amin M, Moosavy SH (2009) A numerical strategy to design maneuverable micro-biomedical swimming robots based on biomimetic flagellar propulsion. World Acad Sci Eng Technol 54: 500-504.
11. Shivalkar S, Gautam PK, Chaudhary S, Samanta SK, Sahoo AK (2021) Recent development of autonomously driven micro/ nanobots for efficient treatment of polluted water. J Environ Manag 281: 111750.
12. Barbosa G, Silva PAF, Luz GVS, Brasil LM (2015) Nanotechnology applied in drug delivery. World Congress on Medical Physics and Biomedical Engineering. Jaffray D (Edn.,), Springer Cham Switzerland pp. 911-914.
13. Freitas RA Jr (2005) What is nanomedicine?. Nanomedicine 1: 2-9.
14. Coluzza I, van Oostrum PD, Capone B, Reimhult E, Dellago C (2013) Sequence controlled self-knotting colloidal patchy polymers. Phys Rev Lett 110: 075501.
15. Mallouk TE, Sen A (2009) Powering nanorobots. Sci Am 300: 72-77.
16. Da Silva Luz GV, Barros KVG, De Araújo FVC, Da Silva GB, Da Silva PAF, et al. (2016) Nanorobotics in drug delivery systems for treatment of cancer: a review. J Mat Sci Eng A 6: 167-180.
17. Wang J (2009) Can man-made nanomachines compete with nature biomotors?. ACS Nano 3(1): 4-9.
18. Lee HY, Lim NH, Seo JA, Gilson Khang, Cho Sun Hang, et al. (2005) Preparation of poly(vinylpyrrolidone) coated iron oxide nanoparticles for contrast agent. Polymer 29(3): 266-270.
19. Liu HL, Ko SP, Wu JH, Myung-Hwa Jung, Ji Hyun Min, et al. (2007) One-pot polyol synthesis of monosize PVP-coated sub-5 nm Fe3O4 nanoparticles for biomedical applications. J Magn Magn Mater 310(2: part 3): e815-e817.
20. Yu DH, Liu YR, Luan X, Hao Wu, Chao Fang, et al, (2015) IF7-conjugated nanoparticles target annexin 1 of tumor vasculature against P-gp mediated multidrug resistance. Bioconjug Chem 26: 1702-1712.
21. (2014) IEEE Spectrum. Graphene transforms itself into a sphere for drug delivery.
22. Vartholomeos P, Fruchard M, Ferreira A, Mavroidis C (2011) MRI-guided nanorobotic systems for therapeutic and diagnostic applications. Annu Rev Biomed Eng 13: 157-184.
23. Dixon KL (2003) The radiation biology of radioimmunotherapy. Nucl Med Commun 24(9): 951-957.
24. Mazumder S, Biswas GR, Majee SB (2020) Applications of nanorobots in medical techniques. IJPSR 11: 3150.
25. Zhang Y, Zhang Y, Han Y, Gong X (2022) Micro/nanorobots for medical diagnosis and disease treatment. Micromachines 13(5): 648.
26. Padovani GC, Feitosa VP, Sauro S, Tay FR, Duran G, et al. (2015) Advances in dental materials through nanotechnology facts, perspectives and toxicological aspects. Trends in Biotechnology 33(11): 621-636.
27. Besinis A, De Peralta T, Tredwin CJ, Handy RD (2015) Review of nanomaterials in dentistry interactions with the oral microenvironment, clinical applications, hazards, and benefits. ACS Nano 9: 2255-2289.
28. Pokki J, Ergeneman O, Chatzipirpiridis G, Luhmann T, Sort J, et al. (2016) Protective coatings for intraocular wirelessly controlled microrobots for implantation: corrosion, cell culture and *in-vivo* animal tests. Journal of Biomedical Materials Research 105(4): 836-845.
29. Hoop M, Ribeiro AS, Rosch D, Weinand P, Mendes N, et al. (2018) Mobile magnetic nano catalysts for bio orthogonal targeted cancer therapy. Adv Functional Materials 28: 1705920.
30. Singh VV, Soto F, Kaufmann K and Wang J (2015) Micromotor based energy generation. Angewandte Chemie Inter-national Edition 127: 7000-7003.
31. Jafari S, Mair LO, Weinberg IN, Baker MJ, Hale O, et al. (2019) Magnetic drilling enhances intra-nasal transport of particles into rodent brain. Journal of Magnetism and Magnetic Materials 469: 302-305.
32. Qiu F, Fujita S, Mhanna R, Zhang L, Simona BR, et al. (2015) Magnetic helical microswimmers functionalized with lipoplexes for targeted gene delivery. Advanced Functional Materials 25: 166671.
33. Rohit Kumar, OmprakashBaghel, Sanat Kumar Sidar Prakash Kumar Sen, Shailendra Kumar Bohidar. "Applications of Nanorobotics". International Journal of Scientific Research Engineering & Technology (IJSRET) 3(8): 1131-1136.
34. Fisher B (2008) Biological research in the evolution of cancer surgery: a personal perspective. Cancer research 68(24):10007-10020.
35. Hill C, Amodeo A, Joseph JV, Patel HR (2008) Nano-and microrobotics: how far is the reality?. Expert Review of Anticancer Therapy 8(12): 1891-1897.
36. Adleman LM (1995) On constructing a molecular computer. DNA based computers 27: 1-21.
37. Hamdi M, Ferreira A, Sharma G, Mavroidis C (2008) Prototyping bio-nanorobots using molecular dynamics simulation and virtual reality. Microelectronics Journal 39(2):190-201.
38. Cavalcanti A (2003) Assembly automation with evolutionary nanorobots and sensor-based control applied to nanomedicine. IEEE Transactions on Nanotechnology 2(2): 82-87.
39. Martel S, Mohammadi M, Felfoul O, Lu Z, Pouponneau P (2009) Flagellated magnetotactic bacteria as controlled MRI-trackable propulsion and steering systems for medical nanorobots operating in the human microvasculature. The International journal of robotics research 28(4): 571-582.
40. Cavalcanti A, Chairman CE (2009) Nanorobot Invention and Linux: The Open Technology Factor. An Open Letter to UNO General Secretary, Melbourne, Australia.
41. Vanderheiden G (2006) Over the Horizon: Potential Impact of Emerging Trends in Information and Communication Technology on Disability Policy and Practice. National Council on Disability.
42. Drexler KE (1992) Nanosystems: molecular machinery, manufacturing, and computation. John Wiley & Sons.
43. Mehra P and Nabhi K (2013) A Nanorobotics the changing face of dentistry. International Journal of Science and Research 5(3): 192-197.
44. Kwan JJ, Myers R, Coviello CM, Graham SM, Shah AR, et al. (2015) Ultrasound-propelled nanocups for drug delivery. Small 11(39): 5305-5314.
45. Pokki J, Ergeneman O, Chatzipirpiridis G, Luhmann T, Sort J, et al. (2017) Protective coatings for intraocular wirelessly controlled microrobots for implantation: corrosion, cell culture and *in-vivo* animal tests. Journal of Biomedical Materials Research 105: 83645.
46. Guyer RA and Macara IG (2015) Loss of the polarity protein PAR3 activates STAT3 signaling via an atypical protein kinase C (aPKC)/NF-κB/ interleukin-6 (IL-6) axis in mouse mammary cells. Journal of Biological Chemistry 290(13): 8457-8468.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2023.49.007774

Girum Tefera Belachew. Biomed J Sci & Tech Res