Research Article

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Nanoscale molecular reactions in microbiological medicines in modern medical applications

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Abstract: Everything around us is made up of atoms and molecules. The properties of quantum atoms are sought to understand the behavior of a particular object. But with the advent of research, it was discovered that there is a quantity smaller than the molecular size. The nanoscale measures a fraction of a billionth of a meter. The atom of an object measures 0.1 nm. Since atoms are the building blocks of matter, at the nanoscale one can combine these atoms to create new materials. The proposed model displays the properties of these nano-scale elements in modern medical applications. The nano-scale research of matter is fascinating because it is the basic phase in which atoms are held together. Therefore, by manipulating material at this level, one can create many different types of objects. This proposed model calculates the operation requirements and expects the results. Based on the operational requirements, the proposed model provides the suggestions. This will be helpful for the medical researchers to identify the proper medical treatments based on the microbiological requirements.

Keywords: atom, molecular size, nanoscale, quantum atoms

1 Introduction

The utterance nano expresses to a fraction as a billionth of a gauge. It is smaller than the wavelength of light. Nanotechnology refers to all research related to manipulation at the nano-scale level. It has been found that the quantum properties of a nano-scale object differ from those of the atomic scale [1–6]. Beyth et al. [1] discussed that nanoscale materials are used for bulk applications. Nano-fillers are formed, which are used in solar cells to reduce their production cost. Nanotechnology has completed an important part to the area of bio-medical medication. In their study, Brahim et al. [2] examined the significance of nanotechnology in various areas, including tissue manufacturing, controlled drug release, and biosensor development. Nanoscale structures may be constructed with remarkable accuracy using methods like DNA nanotechnology and DNA origami, enabling the development of sophisticated DNA architectures and functioning nano-devices. Nanotechnology has aided the construction of synthetic DNA and the study of other nucleic acids. Brede and Labhasetwar [3] expressed the assembly of materials; this technology helped to shape well-formed molecules. New fabrication techniques such as nanolithography and atomic deposition were developed [4].

In the Casals et al. [5] emphasized the focus of nanotechnology studies on nano-scale materials. The science of manipulating material to create high performance is called nanotechnology and microprocessors are called

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nanoparticles. Chapman et al. [6] expressed that nanotechnology is used to produce pharmaceutical products it is referred to as nanomedicine. Nanotechnology is widely used to make electronic devices called nanoelectronics. The nanotechnology has two types of approaches – down-increase draw near and top-bottom draw near. Inside the downstream draw near, products are formed from small components that move toward larger components. Cheng et al. [7] discussed the top-down approach, nanomaterials are formed from large companies. DNA nanorobots, or DNA-based nanomachines, have been made possible thanks to advancements in nanotechnology. Targeted medication delivery, molecular sensing, and gene control are among a few of the biological functions that these nanoscale devices are intended to accomplish. DNA nanorobots provide unparalleled opportunities for progress in health and biotechnology due to their ability to exert fine-tuned control over molecular interactions. For many years, nanotechnology has provided the basic scientific foundation for nanotechnology, nanophotonics, and nanonomics, as well [8]. Nanophotonics is the study and application of nanoscale light-matter interactions. Using nanostructures and nanoscale materials to manipulate and control light is involved. Nanonomics examines nanotechnology's economic effects. Nanotechnology impacts industry, healthcare, energy, and the environment. Therefore, research related to nanotechnology is very extensive, including organic chemistry, molecular biology, surface science, energy storage, molecular engineering, semiconductor physics, and micro-fabrication. The nanoscale is up to 1–100 nm. It is smaller than the micro-scale and larger than the atomic size [9–11]. It is important to have a strong background in many sciences as the research surrounding this technology encompasses various characteristics of the subject. It shows the different pace and growth that is occurring in the medical world [12]. Nanotechnology has played a crucial role in the development of nucleic acid sensors, which are essential for a variety of applications, such as disease diagnosis and environmental monitoring. Nanoscale materials, including nanowires, nanoparticles, and nanotubes, can be engineered to detect specific nucleic acid sequences with high sensitivity and selectivity, resulting in rapid and precise detection methods. Technology has taken it to the next level by diagnosing and treating a variety of more complex diseases. Thus, the development of the medical field is greatly beneficial to the people [13]. Nanotechnology has made significant contributions to the medical field, revolutionizing disease diagnostics, treatment strategies, and drug delivery systems. Nano-bots are the next generation of nano-machines [14]. They can sense and adapt to changes in their environment, make complex calculations, communicate, move actively, gather at the molecular level, repair, or procreate. Such advanced nanotechnologies have great potential for use in medicine [16]. These are machines that make it possible to control nanorobots. The craving to create nano-computers, the longing to make quantum-based computing, unlocks up never-ending potential for the use of nanotechnology in medication. Nanorobots, also known as nanobots or nanoscale robots, have a tremendous amount of potential to revolutionize medicine and healthcare. Some of the areas in which nanorobots could make a difference in these fields include targeted drug delivery, site-specific diagnostics, minimally invasive surgeries, microsurgery, and tissue engineering, biosensing and monitoring, cleaning, detoxification, and navigating the circulatory system [17].

At the nanoscale, the laws of quantum mechanics of matter are very different from its atomic level. For example, a substance that acts as an insulator in molecular form can act as a semiconductor during nano-scale fracture. At this level, the melting point of the material may in addition transform payable to the increase in shell region [18]. All the research surrounding nanotechnology today involves exploring these properties at the nanoscale and learning how to apply them to new applications [19–22]. The nanotechnology today refers to the science of creating products from the bottom up using the tools and technology available today to create high-performance products.

2 Proposed method

The proposed nanoscale molecular identifier (NSMI) makes it possible to create absolutely any substance by manipulating the individual atoms of matter shown in Figure 1. It will not only transform other technologies and defeat aging and disease but will also provide wonderful material wealth to mankind. In practice, nanotechnology solves the following important tasks in medicine, pharmaceuticals, and related fields:

- Creating solid bodies and surfaces with modified molecular structure. In practice, it can act as metals, mineral and organic compounds, nano-tubes, biologically compatible polymers (plastics), and other materials that mimic the tissues of organisms, drug delivery vehicles, or implants.
- Development of nano-container technologies for vector drug distribution.
- Synthesis of new chemical compounds by the formation of molecules without chemical reactions. Over the next 10–20 years, this will lead to the expansion of new medicine for the synthetics, pharmacists, and physicians "designing" based on a specific disease and a particular patient.

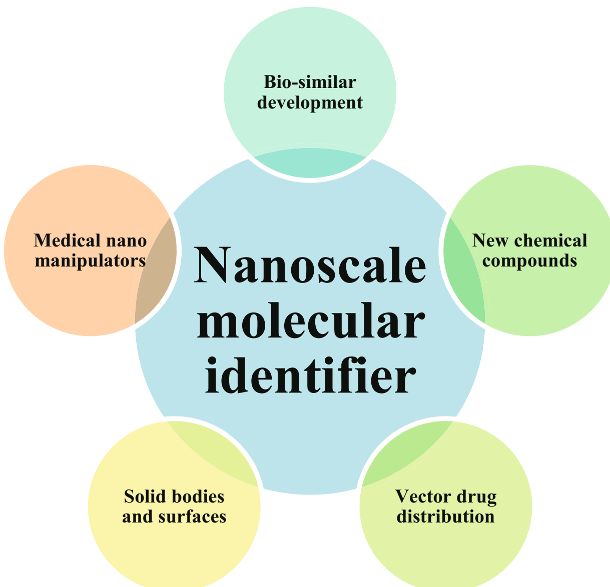

Figure 1: NSMI-focused modules.

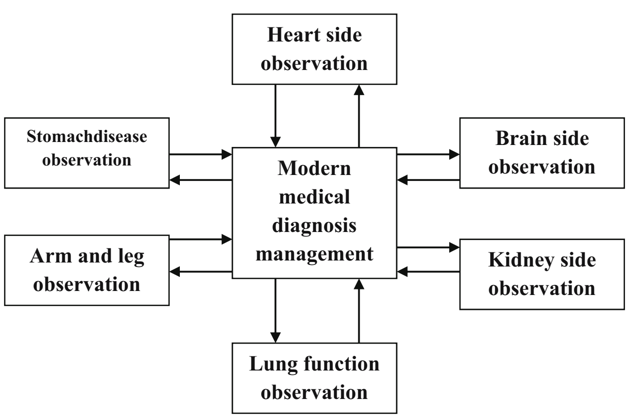

Figure 2: Modern observation of human body.

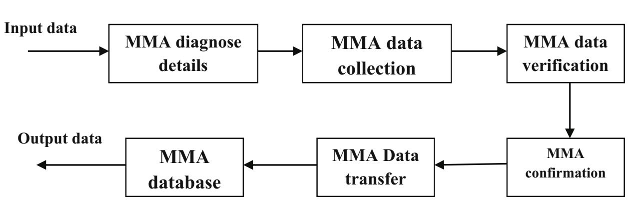

Figure 3: Proposed blocks of MMA.

- Bio-similar: development of autoimmune (self-propagating) systems based on bacteria, viruses, and protozoa.
- Developing precision medical nano-manipulators and diagnostic devices.

Considering an atom as a detail, nanotechnologists develop methods to create objects with specific properties from these details. Many companies already know how to combine atoms and molecules into certain structures. Figure 2 shows modern observation for human body.

In the future, any molecules will be collected like a child designer because they can create any chemically. Figure 3 structures that can be described by an appropriate formula.

2.1 Modern medical application (MMA) data set details

MMA refers to the utilization of advanced technologies, techniques, and innovations in the field of medicine. It encompasses the integration of cutting-edge tools and methodologies to enhance patient care, improve diagnostic capabilities, and refine treatment approaches. MMA encompasses a wide range of disciplines and technologies, including nanotechnology, robotics, artificial intelligence, genomics, and more.

2.1.1 MMA 1 restoration at the cellular level

In the human body, cell death and the formation of replacement cells continue. By regulating these, the various tissues of the human body can receive large quantities of new cells. Nanobots and other devices can be used for manipulations at the molecular level to recover cells [7].

2.1.2 MMA 2 cardio-vascular scheme

Cardiology is one of the key components of nanotechnology. In particular, nano-robots can perform a number of functions, such as repairing damaged heart tissue. Another option for using nanotechnology in medicine is to clean the arteries from atherosclerosis and other types of complications [15].

2.1.3 MMA 3 cancer treatment

The first steps in using nanotechnology in oncology have already had great success. The functions of some nano-devices allow us to target cancer cells very precisely and destroy them without harming the healthy cells around them [8].

2.1.4 MMA 4 old age

Nanotechnology cannot be used in medicine to eliminate some of the signs of aging. Nanotechnology treatments for the elderly offer immense benefits. Thus, they can solve various problems in the body.

2.1.5 MMA 5 fitting of devices

Implants used in traditional medicine today instead create the necessary structures by introducing nano-robots into the body [21].

2.1.6 MMA 6 nano-towers

This device is another great example of how nanotechnology can be used in medicine. It is designed for the operation of nanostructures. Nano-towers can be used to move or insert nano-devices into the body before inserting them. As a rule, nanotubes are used in the construction of nano-towers [4].

2.1.7 MMA 7 distribution of drugs and medicines

Automated devices that dispense drugs to the body increase the stability of their systems because they deliver drugs to the system as needed. In medicine, such nanotechnologies make it possible to program delivery systems so that they release certain drugs in a timely manner and without the possibility of human error [4].

2.1.8 MMA 8 virtual reality

Nanotechnology in medicine makes it easy for physicians to study the human body through nanopod injection. Created virtual reality allows medical personnel to perform certain complex functions more “realistically.”

2.1.9 MMA 9 bone regeneration

The use of nanotechnology helps to accelerate bone regeneration. Nanoparticles contain a variety of chemical compounds that can bind to bone tissue and even help with spinal cord injury.

2.1.10 MMA 10 gene therapy

In medicine, nanotechnologies are used to penetrate the human body and make changes in its genome. As a result, it can cure a variety of genetic diseases.

2.1.11 MMA 11 stem cells

In medicine, nanotechnology can help turn mature stem cells into the desired cell type. Studies in mice have shown that nanotubes can be used to convert adult stem cells into functional neurons.

2.1.12 MMA 12 visualization

Applications in medical nanotechnology have the potential to accomplish much work much easier and more visually. Thus, the quality of the particular work and its practical functions can be easily completed.

2.1.13 MMA 13 diabetics

With the use of nanotechnology in medicine, such as lenses, blood collection becomes unnecessary to detect the level of sugar. It is easy to calculate the amount of sugar in the human body and its deficiency in various quantities.

2.1.14 MMA 14 surgery

Today, you will not surprise anyone with the invention of the modern world like robotic surgeons. Although nanosurgery is a promising industry that uses some lasers, nano-devices are designed to perform surgical operations.

2.1.15 MMA 15 fits

This is another problem with the use of nanotechnology in medicine. Nano-chips are being developed to control seizures in epilepsy patients. They are designed to pick up signals given by the brain, analyze them, and adjust the brain, making it easier to control seizures [21].

2.1.16 MMA 16 touch feedback

The nano-chip is very important. The main function of the sensors is to transmit the signals generated when they touch. Thus, the various jobs that are given there are easily done.

2.1.17 MMA 17 prosthesis management

Nanotechnologies also have their place in artificial medicine. They help the brain cope with the control of artificial organs. There are already ample examples of nano-chips being used for this purpose.

2.1.18 MMA 18 medical control

Nanotechnology is used in various therapies in the medical field to control, calculate and analyze various tasks. Thus, the various parameters that exist in Hinduism can be easily calculated.

2.1.19 MMA 19 medical records

This nanotechnology plays a major role in the process of diagnosing and documenting various diseases in the body of patients.

2.1.20 MMA 20 preventing diseases

Nanotechnology in medicine can actually prevent a variety of diseases. Therefore, nano-devices, if properly programmed, can help prevent many diseases by detecting problems before they intensify. They also help prevent chronic diseases [22].

2.1.21 MMA 21 prenatal diagnosis

Nanotechnologies are used in medicine for prenatal diagnosis. Nano-devices can penetrate the uterus or even the fetus without any damage. Thus, they can help diagnose and eliminate fetal problems that may occur while still in the womb.

2.1.22 MMA 22 individual medicine

Nanotechnologies in medicine help to prescribe the most accurate treatment and determine its course, taking into account the individual needs of the body, as it has the potential to adapt to any person's genes.

2.1.23 MMA 23 research

Nanotechnology in medicine makes it possible to advance medical research quickly, providing the tools needed to do so, through which a person learns new things about the function and structure of his body. Nanotechnologies in medicine can provide the building materials needed for the human body [15].

3 Results and discussion

The proposed NSMI was compared with the existing alternative antimicrobial approach, co-joined molecular recognition, nanoscale delivery systems, and nanoparticles for cancer imaging.

3.1 MMA drug transport

In this case, we see nanoparticles, which are transported as specific structures or combinations thereof; to provide intact treatments to specific areas of the body; in small doses to reduce side effects. Figure 4 shows the comparison of MMA drug transport.

3.2 Restricted output

Essentially, the idea of controlled release consists of nanostructures responsible for delivering drugs to the affected area; but they will only release it once they have recognized the area in question, in response to a particular stimulus. Figure 5 shows the comparison of restricted output [23].

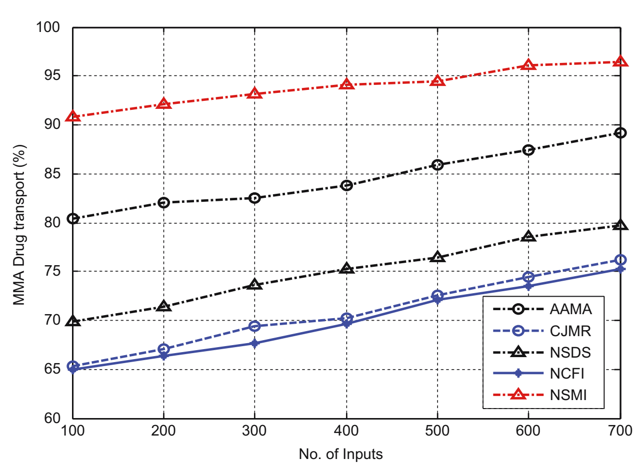

Figure 4: Comparison of MMA drug transport.

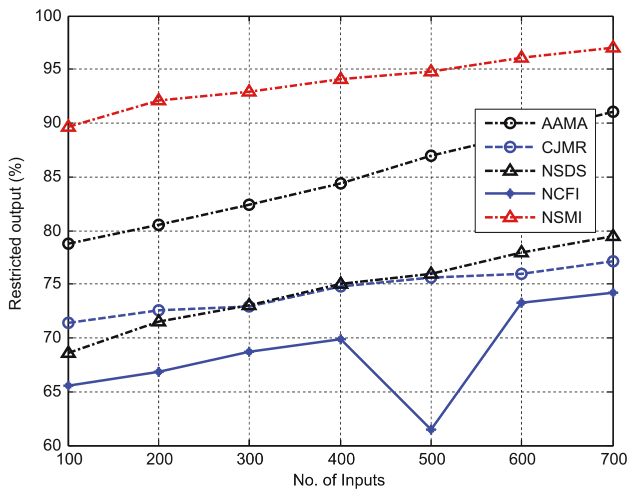

Figure 5: Comparison of restricted output.

3.3 Cell regeneration

In the field of cell regeneration, nanomedicine has had interesting implications, making it possible to diversify its function. Figure 6 shows the comparison of cell regeneration [24].

3.4 Nerve regeneration

Nanostructures work effectively to seal cells and tissues; but in addition, they can be used to guide and stimulate the growth of cells, which act as scaffolds for the growth of renewed nerve tissue. Figure 7 shows the comparison of nerve regeneration [25].

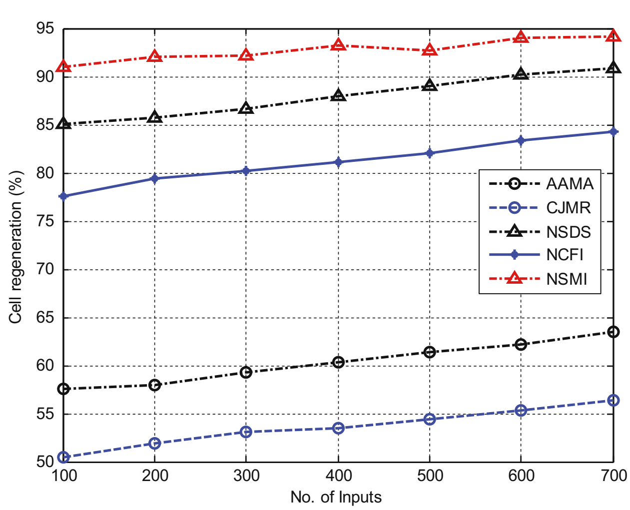

Figure 6: Comparison of cell regeneration.

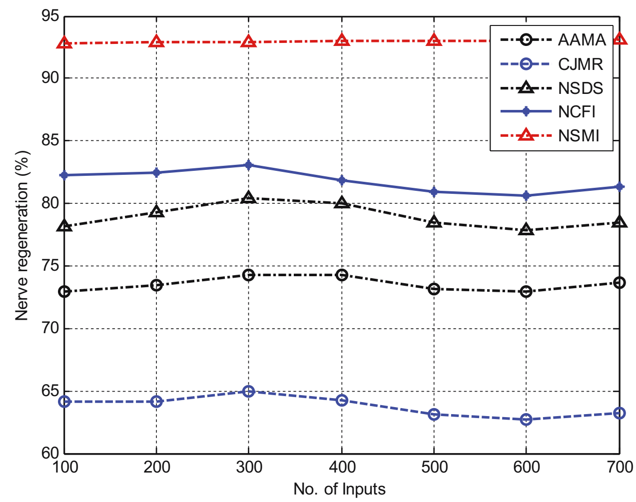

Figure 7: Comparison of nerve regeneration.

3.5 Brain regeneration

Various investigations have found that nanoparticles act as the basis for those free radicals that act as brain protectors against cell death, superoxides can be caused by nitric oxide or various free radicals associated with ischemia and stroke, as well as damage to the brain or spine. Figure 8 shows the comparison of brain regeneration [26].

3.6 Imaging

Nanoparticle systems are also used as imaging agents, which can detect a variety of diseases; among them, we find iron oxide, cerium oxide, and perfluorocarbon, as well

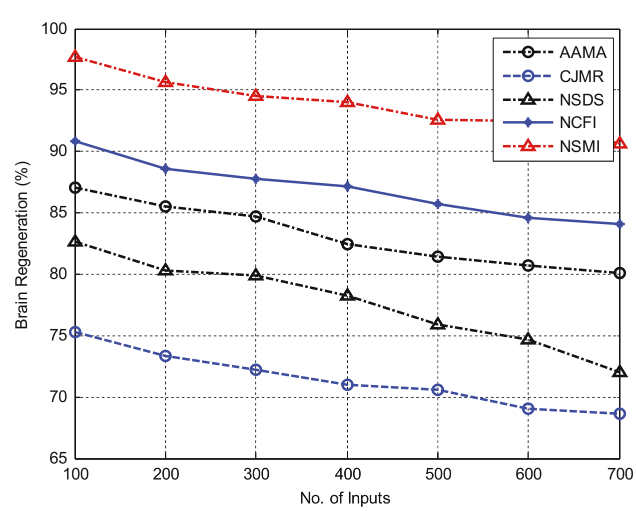

Figure 8: Comparison of brain regeneration.

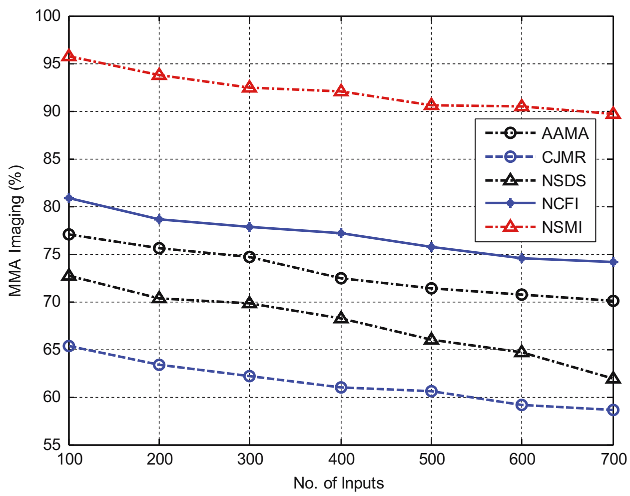

Figure 9: Comparison of MMA imaging.

as platinum nanoparticles or quantum dots. Figure 9 shows the comparison of MMA imaging. Using these systems, it is possible to detect various tumors called nuclear magnetic resonance. All the information we have collected about this is medical nanotechnology, which we believe was your choice; Likewise, to further expand this information, we are going to send you a video on nanomedicine and cancer treatment [27,28].

4 Conclusion

The development of the field of nanotechnology has contributed to the evolution of various new sciences. Using nanotechnology, we can manipulate the properties of materials to suit our needs. Materials can be made more durable, stable, stronger, lighter, more reactive, better conductors, and so on. The disadvantages related to nanotechnology usually occur with the development of new technology. The impact of nanotechnology on environmental conditions is greatly feared. The impact of this technology on the world economy is also worrying. Future research in the field of nanotechnology involves the development of nanorobotics and its applications in medicine. New nanoproduction devices are proposed for future commercial applications. Nanomines are proposed to facilitate the development of new nanomaterials and nano-systems. Its properties are made of things that can be easily modified and controlled externally. New terms such as biotechnology and femto technology have been incorporated into this technology use.

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References

[1] Beyth N, Houri-Haddad Y, Domb A, Khan W, Hazan R. Alternative antimicrobial approach: nano-antimicrobial materials. Evid Based Complement Altern Med. 2015;2015:1–17.
[2] Brahim S, Narinesingh D, Guiseppi-Elie A. Bio-smart hydrogels: co-joined molecular recognition and signal transduction in biosensor fabrication and drug delivery. Biosens Bioelectron. 2002;17(11–12):973–81.
[3] Brede C, Labhasetwar V. Applications of nanoparticles in the detection and treatment of kidney diseases. Adv Chronic Kidney Dis. 2013;20(6):454–65.
[4] Cao Y, Wang B, Lou D, Wang Y, Hao S, Zhang L. Nanoscale delivery systems for multiple drug combinations in cancer. Future Oncol. 2011;7(11):1347–57.
[5] Casals E, Gusta MF, Cobaleda-Siles M, Garcia-Sanz A, Puntes VF. Cancer resistance to treatment and antiresistance tools offered by multimodal multifunctional nanoparticles. Cancer Nanotechnol. 2017;8:1–9.
[6] Chapman S, Dobrovolskaia M, Farahani K, Goodwin A, Joshi A, Lee H, et al. Nanoparticles for cancer imaging: The good, the bad, and the promise. Nano Today. 2013;8(5):454–60.
[7] Cheng R, Feng F, Meng F, Deng C, Feijen J, Zhong Z. Glutathione-responsive nano-vehicles as a promising platform for targeted intracellular drug and gene delivery. J Control Rel. 2011;152(1):2–12.
[8] Cho SK, Pedram A, Levin ER, Kwon YJ. Acid-degradable core–shell nanoparticles for reversed tamoxifen-resistance in breast cancer

by silencing manganese superoxide dismutase (MnSOD). Biomaterials. 2013;34(38):10228–37.

[9] Ganesan P, Ko HM, Kim IS, Choi DK. Recent trends in the development of nanophytobioactive compounds and delivery systems for their possible role in reducing oxidative stress in Parkinson's disease models. Int J Nanomed. 2015;10:6757.

[10] Velusamy P, Kumar GV, Jeyanthi V, Das J, Pachaiappan R. Bio-inspired green nanoparticles: synthesis, mechanism, and antibacterial application. Toxicol Res. 2016;32:95–102.

[11] López-Vargas ER, Ortega-Ortíz H, Cadenas-Pliego G, de Alba Romenus K, Cabrera de la Fuente M, Benavides-Mendoza A, et al. Foliar application of copper nanoparticles increases the fruit quality and the content of bioactive compounds in tomatoes. Appl Sci. 2018;8(7):1020.

[12] Singh P, Kim YJ, Zhang D, Yang DC. Biological synthesis of nanoparticles from plants and microorganisms. Trends Biotechnol. 2016;34(7):588–99.

[13] Mourdikoudis S, Pallares RM, Thanh NT. Characterization techniques for nanoparticles: comparison and complementarity upon studying nanoparticle properties. Nanoscale. 2018;10(27):12871–934.

[14] Niemeyer CM. Self-assembled nanostructures based on DNA: towards the development of nanobiotechnology. Curr Opin Chem Biol. 2000;4(6):609–18.

[15] Bhatia S. Nanoparticles types, classification, characterization, fabrication methods and drug delivery applications. Natural Polymer Drug Delivery Systems: Nanoparticles, Plants, Algae. India: Springer; 2016. p. 33–93.

[16] Khan I, Saeed K, Khan I. Nanoparticles: Properties, applications and toxicities. Arab J Chem. 2019;12(7):908–31.

[17] Golinska P, Wypij M, Ingle AP, Gupta I, Dahm H, Rai M. Biogenic synthesis of metal nanoparticles from actinomycetes: biomedical applications and cytotoxicity. Appl Microbiol Biotechnol. 2014;98:8083–97.

[18] Duan H, Wang D, Li Y. Green chemistry for nanoparticle synthesis. Chem Soc Rev. 2015;44(16):5778–92.

[19] Baranowska-Wójcik E, Szwajgier D, Oleszczuk P, Winiarska-Mieczan A. Effects of titanium dioxide nanoparticles exposure on human health – a review. Biol Trace Elem Res. 2020;193:118–29.

[20] Siva S, Marimuthu C. Production of biodiesel by transesterification of algae oil with an assistance of nano-CaO catalyst derived from egg shell. Int J ChemTech Res. 2015;7(4):2112–6.

[21] Armstead AL, Li B. Nanotoxicity: emerging concerns regarding nanomaterial safety and occupational hard metal (WC-Co) nanoparticle exposure. Int J Nanomed. 2016;11:6421.

[22] Grasso G, Zane D, Dragone R. Microbial nanotechnology: challenges and prospects for green biocatalytic synthesis of nanoscale materials for sensoristic and biomedical applications. Nanomaterials. 2019;10(1):11.

[23] Acharya S, Sahoo SK. PLGA nanoparticles containing various anticancer agents and tumour delivery by EPR effect. Adv Drug Deliv Rev. 2011;63(3):170–83.

[24] Arora P, Sindhu A, Dilbaghi N, Chaudhury A, Rajakumar G, Rahuman AA. Nano-regenerative medicine towards clinical outcome of stem cell and tissue engineering in humans. J Cell Mol Med. 2012;16(9):1991–2000.

[25] Sedaghati T, Seifalian AM. Nanotechnology and bio-functionalisation for peripheral nerve regeneration. Neural Regen Res. 2015;10(8):1191.

[26] Liaw K, Zhang Z, Kannan S. Neuronanotechnology for brain regeneration. Adv Drug Deliv Rev. 2019;148:3–18.

[27] Walmsley GG, McArdle A, Tevlin R, Momeni A, Atashroo D, Hu MS, et al. Nanotechnology in bone tissue engineering. Nanomedicine. 2015;11(5):1253–63.

[28] Yao Y, Zhou Y, Liu L, Xu Y, Chen Q, Wang Y, et al. Nanoparticle-based drug delivery in cancer therapy and its role in overcoming drug resistance. Front Mol Biosci. 2020;7:193.