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NANOBOTS USED IN CANCER TREATMENT

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ABSTRACT

This review paper aims to present an overview of the latest trends and developments in nanorobotics for cancer treatment. Nanorobotics are primarily utilized for their ability to identify and eliminate cancer cells. In addition to their significant role in cancer treatment, nanotechnology has also demonstrated its value in early detection and therapeutic interventions. Nanorobotics have the potential to enhance the specificity and effectiveness of various chemical, physical, and biological processes to destroy cancer cells, all while minimizing damage to healthy cells. The main focus of this review is on the use of nanorobotics for the diagnosis and treatment of diseases such as cancer, heart conditions, diabetes, and kidney disorders. In order to improve medical treatments, nanorobotics carries out a variety of tasks at the nanoscale, such as movement, sensing, signaling, information processing, and intelligence. This study explores contemporary cancer treatments while offering a thorough explanation of nanorobotics, including its elements, uses, and function in cancer therapy. It seeks to provide insights into the future of nanomedicine by illuminating how nanorobotics may enhance the precision and efficacy of cancer treatments.

Keywords: Nanorobotics, Nanotechnology, Diabetes, Nanomedicine, Cancer, etc.

INTRODUCTION

Nanomedicines have been created to improve and safeguard human health by treating and preventing diseases using tools at the monomolecular level and by utilizing biological knowledge of the human body. Over the past few decades, nanomedicines have advanced quickly, showing great promise and application prospects, especially in the treatment of tumors. Among the most promising uses of nanomedicines are nanobots, which enable a variety of medical procedures to be performed in hard-to-reach and distant parts of the body.

Independent nanostructures with an engine or the ability to transform different forms of energy into mechanical forces in order to perform medical treatments are known as medical nanobots. Nanobots can communicate directly with cells and even enter them thanks to their small size, which allows them to access biological processes. The design and operation of functional nano-to-molecular-scale devices is known as nanobots, and it is an interdisciplinary field that has found widespread use in the diagnosis and treatment of cancer. These nanobots can target tumor or illness areas, carry out particular biomedical tasks (like diagnostics or therapeutic actions), and distribute therapeutic payloads (such medications, genes, or sensing molecules). They also feature an active or passive power system that can benefit from internal blood flow or biological fluids or external power sources like NIR light, ultrasound, or magnetic forces. [1]

The active power system is the primary distinction between nanocarriers and nanobots. While Nano medicines or nanocarriers can be considered part of nanobots, they lack an active power system. Researchers worldwide are committed to developing cancertargeting nanobots, aiming to incorporate them into clinical practice and help modernize medical treatment. Nevertheless, one of the significant challenges of Nano robotic technology is the successful transition of these tools from research to real-world clinical applications. Cancer is a formidable disease that affects people regardless of their socioeconomic status, age, or gender. The term "cancer" is attributed to Hippocrates, who theorized that an imbalance of four bodily fluids—blood, phlegm, yellow bile, and black bile—was responsible for the disease, particularly an increase in black bile.

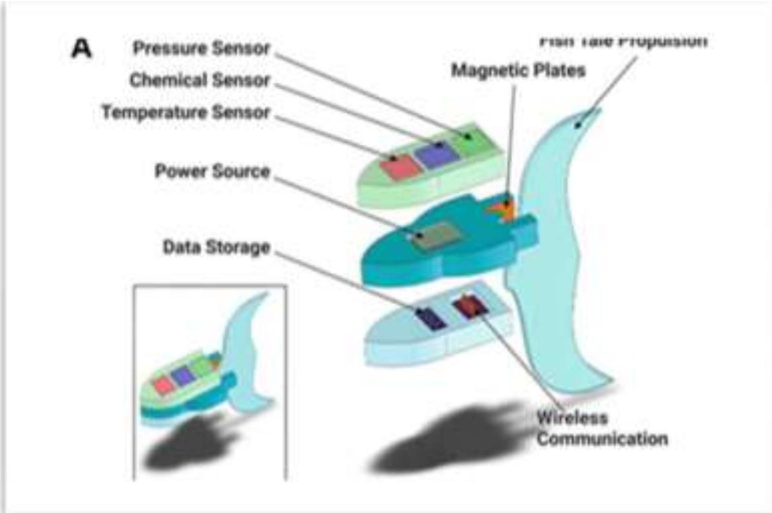


Figure 1: Nanobots

Cancer has been found in the skeletal remains of mummies from Egypt and Greece as well as in a man from ancient Amara, which is now in Sudan, providing historical evidence that the disease existed even in ancient civilizations. Even though cancer was less common in antiquity, Egyptian literature and art contain references to its cures. In the past, scientists have long thought that cancer was caused by exposure to carcinogens, such as those created when wood was burned in fires. Cancer rates have increased as a result of increasing exposure to radiation and toxins brought on by modern lifestyle changes, dietary practices, environmental factors, and industrial improvements, according to a wealth of studies. Factors such as alcohol consumption, tobacco use, obesity, age, hormonal changes, and chronic inflammation are also significant contributors to the development of this disease.

The main important aspects of Nano robotics in cancer therapy are used to recognize and destroy cancer cells, Nano robotics with chemical biosensors can be used to perform detection of tumor cells in early stages of development inside the patient's body.

- Nanobots destroyed cancer cells in the body.
- Removing blockages in blood vessels
- Replace DNA Cells.

Figure 2: Nanobots

MATERIALS OF NANOBOTS

The biocompatibilities of materials were the main factor taken into account when designing nanobots, which operate at nanoscale scales inside tumor tissues and cells. Since a microrobot's functionality is mostly dependent on its surface and materials, materials science or surface science presents the first challenge in building a nano robot to carry out medical activities. The motion control of a nanorobot in a biological milieu is significantly impacted by the molecular interactions between living species and the robot's surfaces. The majority of materials used to make nanobots are biocompatible or biodegradable. When their functions are complete, these biodegradable compounds can dissolve or vanish. In the meantime, they should be able to perform a variety of precise tasks, such as detecting the presence of tumor cells or tissues, delivering and releasing nanocargoes in response to physical cues, specific disease biomarkers, variations in local pH and temperature, etc. These materials should also be pliable and deformable to guarantee the mechanical qualities and workability of nanobots in human biological microenvironments. They need to be more maneuverable in three dimensions, in viscous and elastic body fluids, as well as in phantom organs. Besides, when designing nanobots to perform adaptive tasks in a variety of different biological environments, stimulating responsive materials becomes significant important.

TYPES OF NANOBOTS

1. Pharmacyte
2. Diagnosis and Imaging
3. Respirocyte
4. Microbivores
5. Clottocytes
6. Chromallocyte

1. Pharmacyte

These medical nanobots, measuring between 1 and 2 µm in length, is designed to carry a 1 μm^3 dose of medication in its storage compartment. It operates through a pump mechanism and is equipped with molecular markers or chemotactic sensors, ensuring high precision in its functions. The robot derives its energy from oxygen sourced from local environments such as blood, gastric fluid, or cytoplasm. After completing its task, the nanorobot can either be extracted or recycled using a process known as centrifugal Nanoseparation.

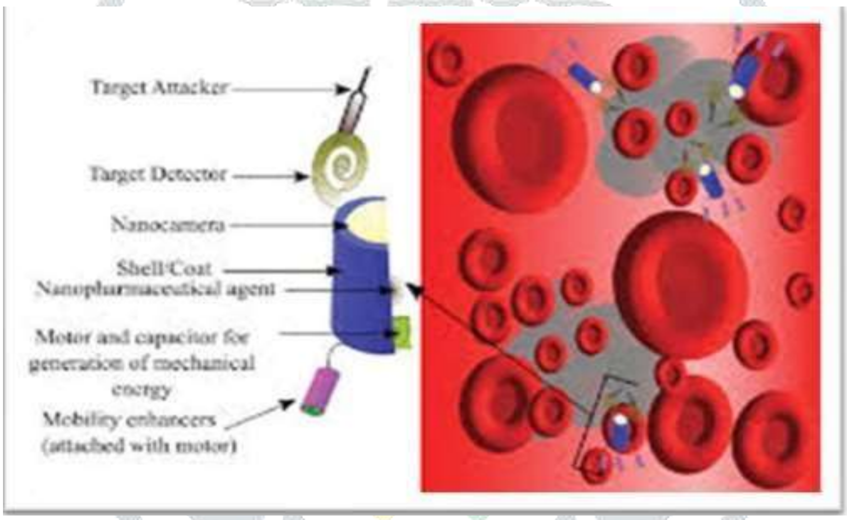


Figure 3: Pharmacyte

2. Diagnosis and Imaging

These nanobots feature microchips coated with human-like molecules. The chip produces an electrical signal when these chemicals identify the existence of a disease. For example, specialized sensor nanobots can be injected into the bloodstream or placed under the skin, where they analyze blood composition and provide alerts about any potential health issues. They can also be used for monitoring blood sugar levels. The main advantages of these nanobots are their affordability and ease of handling. These nanobots feature microchips coated with human-like molecules. The chip produces an electrical signal when these chemicals identify the existence of a disease. For example, specialized sensor nanobots can be injected into the bloodstream or placed under the skin, where they analyze blood composition and provide alerts about any potential health issues. They can also be used for monitoring blood sugar levels.

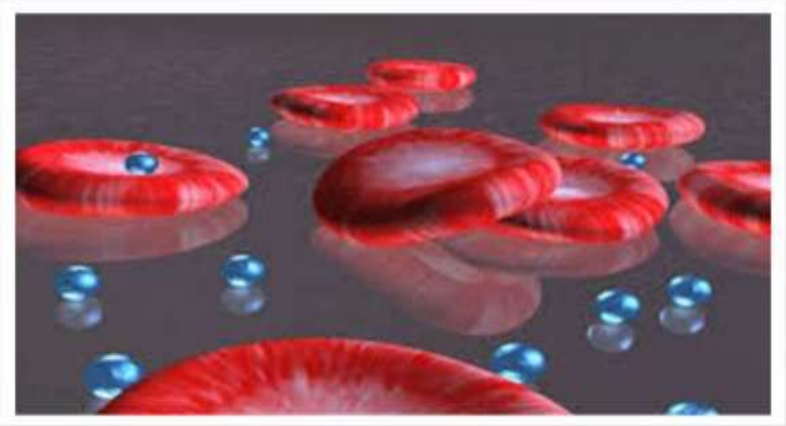


Figure 4: Nanobots attacking RBC

3. Respirocyte:

It is a red blood cell-expressing nanorobotics that carries oxygen. Endogenous serum glucose provides energy. Compared to red blood cells (RBCs), progenitor cells provide tissues with 236 times more oxygen and acid per unit volume.

Figure 5: Respirocyte

4. Microbivores

This flat, spherical device, which has a major axis diameter of 34 µm and a minor axis diameter of 2.0 µm, is intended for use in nanomedicine applications. To break down the microorganisms they have collected, these nanobots can continually require up to 200 pW of energy. Phagocytic cells may digest about 80 times more volume per unit volume/second than macrophage cells, according to another investigation.

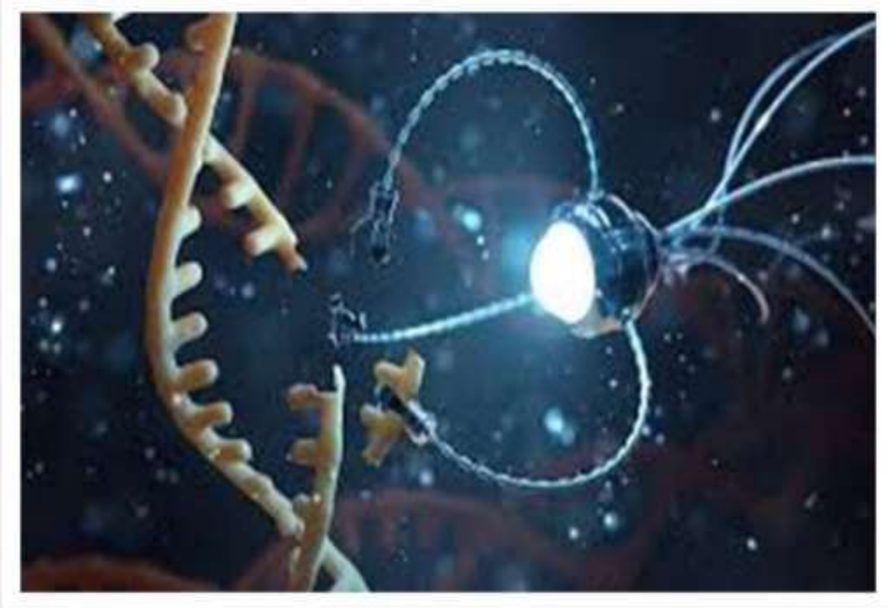


Figure 6: Microbivores

5. **Clottocytes :**

This is a nanorobot with a unique and fun ability that can use blood clots or artificial devices to "instantly" stop bleeding. As we all know, platelets are spherical, nucleated blood cells with a diameter of 2 microns. Platelets bind to the bleeding site: here they strengthen, become sticky, and combine to form a cushion that helps close the blood vessels and stop bleeding. They also prescribe medications that help blood clot.

6. **Chromallocyte:**

The chromallocyte could potentially stop the aging process by restoring the effects of genetic diseases and other genetic damage by replacing complete chromosomes in individual cells. In order for the repair machines to restore the cell as a whole, the repair system inside the cell will first assess the contents and functions of the cell before acting at the molecular and structural level. [2]

STRUCTURE AND DESIGN OF NANOBOTS:

Due of its strength and inertness, carbon is used to make the components of nanobots, together with diamond or fullerenes. Other substances that are utilized at the nanoscale include silicon, fluorine, sulfur, nitrogen, oxygen, and hydrogen.

The features of nanobots are as follows,

- **Medicine cavity:**

This is a hollow section in nanobots used to hold small drugs inside the robot, which can deliver drugs directly to the site of injury or infection.

- **Microwave emitters and Ultrasonic signal generators:**

They are employed to kill cells before they rupture, including cancerous cells. With the correct microwave signal, nanobots can eliminate the compounds found in cancer cells. Kill the hand's walls without causing any harm to them. As an alternative, the robot can heat cancer cells to the point of destruction by sending out microwave or ultrasonic signals.

- **Probes, knives and chisels:**

Plaque and obstructions are removed with the help of these probes, blades, and chisels. These aid in the processing and destruction of information by nanobots. They may also need a device to break the blood vessels into smaller pieces. If part of the artery breaks and enters the artery, this can cause further problems in the artery.

- **Electrodes:**

Nanobots heat cells until they die or are destroyed by using electrodes to create electric current.

- **Lasers:**

Lasers are used to burn dangerous substances like plaque, blood clots, and malignant cells. 1. e. Tissues are vaporized by these lasers. In the difficult task, a strong laser is used to vaporize malignant cells without endangering the surrounding tissues.

APPLICATION IN MEDICAL SCIENCE:-

The uses of nanotechnology in the medical profession are covered in this section. Many people's lives can be saved by these applications, which can significantly enhance the way various diseases are now treated.

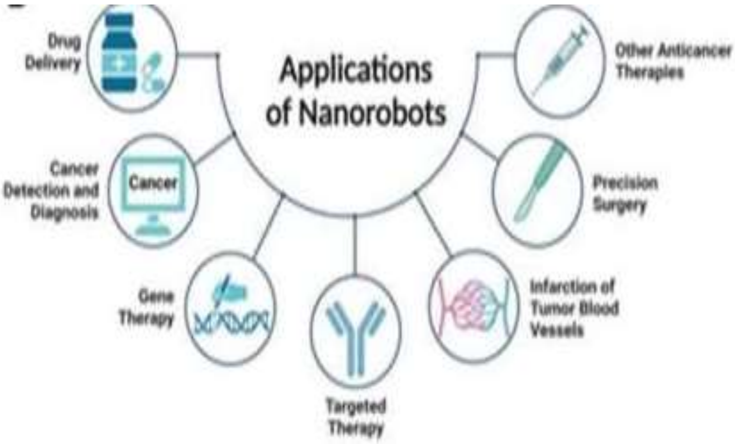


Figure 7: Application of nanobots

- **Drug Delivery System:-**

Nanobots are robots that are only a few nanometers wide and perform a very specialized task. They work incredibly well for delivering drugs. Typically, medications travel throughout the body before reaching the location where the sickness is present. The medicine can be precisely targeted with nanotechnology, increasing its effectiveness and lowering the likelihood of any negative side effects.

- **Disease Diagnosis and Prevention:-**

Scientists working in nanobiotechnology have effectively created microchips with human molecules on them. When the molecules identify symptoms of an illness, the chip is intended to send out an electrical impulse signal. It is conceivable to put specialized sensor nanobots beneath the skin to evaluate the blood's composition and alert people to potential illnesses. Additionally, they can be used to track blood sugar levels. Such nanobots have the advantages of being easily portable and being incredibly inexpensive to generate. [3]

USES IN CANCER DECTECTION AND DIAGNOSIS

Rapid advancements in the creation of nanobots for cancer detection and diagnostics are providing creative approaches to early diagnosis and treatment. Early detection of cancer is critical for improving survival rates, making the creation of effective diagnostic technologies essential.

1. Nanobots for Tumor Detection:

Maheswari et al. proposed a nanorobot designed to detect tumor cell growth in living organisms through positron emission tomography (PET). This system includes an embedded control mechanism powered by Arduino software, allowing for task-specific programming of the nanorobot. The nanorobot is constructed from isotope-labeled nano-carbon materials, ensuring safety and stability when used in the human body. After completing its diagnostic tasks, the nanorobot is safely expelled from the body naturally. It is equipped with sensors, power devices, and cameras and uses advanced algorithms to calculate optimal movement paths and avoid obstacles.

2. DNA-Based 3D Nanobots:

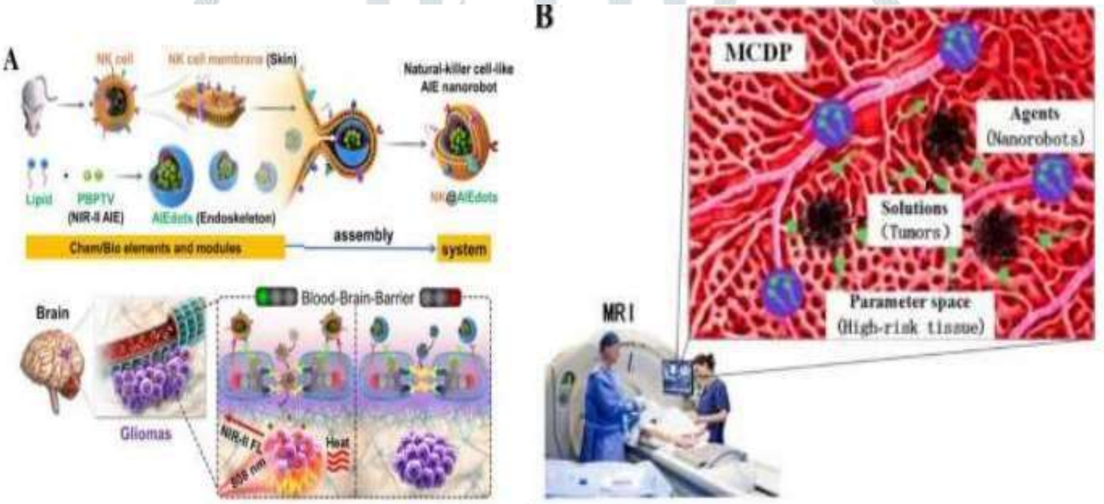
To target overexpressed biomarkers on the surface of cancer cells, Peng et al. created a 3D DNA nanorobot. Because of its ability to use Boolean logic, this nanorobot can identify and communicate with malignant cells. It is a promising tool for cancer detection and tailored treatment because to its combined diagnostic and therapeutic properties (theranostic potential).

3. Glucose-Responsive Nanobots:

A nanorobot that can identify cancer cells in the bloodstream was created by Dolev et al. In order to detect the higher glucose levels found in cancer cells—which are frequently greater than in healthy cells—it integrates a glucose sensor. The nanorobot opens a compartment and releases therapeutic medications at the tumor location when this glucose-driven electric current activates a nanoelectromechanical relay. The nanorobot's ability to collect blood energy enables it to detect and treat cancer on its own.

4. Nanobots Mimicking Natural Killer (NK) Cells:

Deng et al. produced nanobots that simulate the function of natural killer (NK) cells, which are immune cells capable of crossing the blood-brain barrier (BBB). These nanobots are designed with aggregation-induced emission (AIE) features, allowing them to emit intense fluorescence in the near-infrared range for high-contrast tumor imaging. They present a promising method for brain tumor imaging and treatment since they can get across the BBB's tight junctions and gather at the locations of brain tumors. These developments in nanorobot technology represent important improvements in the accuracy and efficacy of cancer diagnosis and therapy. They increase the possibility of early diagnosis and individualized treatment by promising more focused therapies with fewer side effects.



A. Diagram illustrating the synthesis and assembly of NK@AIEdots, and their role in modifying tight junctions (TJs) of the blood-brain barrier (BBB) to facilitate targeted brain tumor delivery, enabling both imaging and therapeutic inhibition.
B. Visual representation of the MCDP framework

KEY FUNDAMENTALS OF NANOBOTS IN THE TREATMENT OF CANCERS

1. Developmental Challenges of Nanobots:

Nanobots are minuscule machines made to carry out particular duties, but developing those presents many challenges, chief among them being the design and management of their operations. These difficulties result from the particular circumstances under which they operate, which are different from those faced by conventional, larger robots.

2. Diversity in Composition and Design:

Nanobots are not built with a conventional structure; rather, their design and composition change based on the technologies employed in their production as well as their intended function. Their general efficacy and usefulness are impacted by this diversity.

3. Continuous Progress in Nano robotics:

The future of these devices is being shaped by ongoing advancements and breakthroughs in the fast developing field of nano robots.

4. Medical Uses of Nanobots:

One of the most exciting uses for nanobots is in medicine, where they may be employed to carry out activities like administering tailored therapies, such as targeting cancer cells inside the human body. These medicinal nanobots are still in the early stages of development, nevertheless, and have not yet been widely used in clinical settings.

5. Design Standards for Medical Nanobots:

Medical nanobots must be designed to meet stringent safety, efficacy, and scalability standards in order to effectively treat diseases like cancer. To guarantee that the robots can function dependably inside the human body, these requirements are essential.

ADVANTAGES OF NANOBOTS:

- Use of more bioavailable nanorobotics drug delivery devices.
- Only for medical uses, including curing cancerous illnesses.
- Reach remote parts of the human body that surgeons cannot reach.
- Since drug molecules are transported by nanobots and release the desired one, the wide interface area is utilized during mass transfer.
- Automated technology.
- Through computer control, efficient output volume, frequency and time buttons.
- Accuracy is higher.
- Drugs do not work in areas that do not need treatment, minimizing side effects.
- The size limit of nanobots is 3 microns, which allows them to flow easily through the body without clogging blood vessels.
- Cost-effective.[4]

DISADVANTAGES OF NANOBOTS

- If terrorists misuse nanobots, they could even be used as bioweapons and pose a threat to society. Just as nanobacteria that are present in our bodies can have serious effects on our bodies, so can nanobots that are foreign to us. Therefore, care must be taken to overcome this drawback. [5]
- Designing nanobots is costly and involves many complications. Further research is needed to ensure that the bots can overcome the body's immune response.
- Self-replicating nanobots have the potential to produce dangerous variants of themselves.[6,7]

CHALLENGES FACED BY NANOBOTS FOR CLINICAL CANCER TREATMENTS

- **Safety concerns**

  Although there are many exciting potential uses for nanobots in biomedical applications, especially the treatment of cancer, there are also serious safety issues. Patients could be harmed by malfunctioning nanobots, which could also have unforeseen negative effects and make therapy more difficult. For example, the use of tubular DNA nanobots carrying thrombin may not function as planned in tumors with underdeveloped blood arteries, thus failing to produce the intended therapeutic effect.

  A comprehensive and methodical approach is required to resolve these concerns and guarantee the security and efficacy of nanobots for cancer treatment. This includes rigorous preclinical and clinical trials to evaluate the biocompatibility, pharmacokinetics, and pharmacodynamics of these nanodevices within different biological environments. Additionally, establishing stringent quality control protocols during the manufacturing process is essential device failure and guarantee consistent performance across various batches of to reduce the chances of nanobots. [8, 9]

- **Scalability**

  The complicated and time-consuming nature of the manufacturing procedures makes it extremely difficult to scale up the creation and production of large numbers of nanobots for clinical cancer treatments. A number of crucial factors, including as supply chain management, cost, quality assurance, and production methods, must be addressed in order to resolve this scaling issue.

- **Cost**

  The high expense of creating and producing nanobots presents a major obstacle to their wider use. Innovations in nanomaterials and increases in manufacturing efficiency are necessary to lower production costs. For example, the total cost of nanobots could be significantly decreased by finding new, more affordable nanomaterial’s or improving ones that already exist. Moreover, closer cooperation among scientists, producers, and funding organizations might hasten the creation of more reasonably priced production methods. [10, 11]

- **Quality control**
  To ensure the safety and efficacy of nanobots, stringent quality control must be maintained throughout their mass production. This entails developing thorough testing and validation protocols to find any flaws and verify that the nanobots fulfil the necessary performance requirements. Additionally, incorporating in-process monitoring and real-time feedback mechanisms can enhance quality control by allowing manufacturers to quickly identify and resolve issues as they arise during production. [12]

CONCLUSION:

As was previously mentioned, research into the creation and use of nanorobotics in cancer treatment is expanding quickly. Data scientists and artificial intelligence specialists need to work together to improve medication delivery methods and healthcare in order to fully utilize nanobots in the treatment of cancer. They ought to collaborate with medical experts to investigate the behavior and capabilities of nanobots, as well as their applications in early diagnostics, cancer detection, minor surgery, treatment, and other cutting-edge nanorobot- assisted therapies. Researchers must address the unique needs and challenges faced by oncologists in light of new discoveries from both in vitro and in vivo investigations. This entails developing or altering nanobots or nanosubmarines with a cancer emphasis for specific diagnostic applications in order to advance research in nanorobotics and Nano- submarine technology. The ultimate objective is to improve cancer therapy approaches by bridging the gap between experimental research and practical clinical applications.

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REFERENCES

1. Advances of medical nanobots for future cancer treatments Tingyi Kong1, 2†, Pang Gao1, 3, 4†, Wang1*, Yi Fang1* and Kuok https://link.springer.com/content/pdf/10.1186/s13045-023-01463-z.pdf
2. Aafhtabkha Aniskha Pathan, and Swati Chu Hwang5* Deshmukh http://gsconlinepress.com/journals/gscbps/sites/default/files/GSCBPS-2023-0437.pdf P.
3. Aafhtabkha Aniskha Pathan, and Swati Deshmukh http://gsconlinepress.com/journals/gscbps/sites/default/files/GSCBPS-2023-0437.pdf P.
4. Daphne C. Disadvantages of Nano Robotics; 2012. Available from: https://www.scribd.com/doc/62640521/Disadvantages-of-NanoRobotics. [Last accessed on 2011 Aug 19].
5. Chang PL. Nanotechnology: Potential Pros and Cons for Humanity; 2014. Available from: https://www.consciouslifenews.com/nanotechnologypotential-pros-cons-humanity/1172870/.
6. Martin S. Self-Replicating Nanobots could destroy all Life on Earth, Warn Experts; 2017. Available from: https://www.express.co.uk/news/ science/825989/nanotechnology-nanobots grey-goo-end-of-the-world. [Last accessed on 2017 Jul 07].
7. Kabay ME. Self-Replicating Nanobots; 2010. Available from: https:// www.networkworld.com/article/2209510/security/self-replicatingnanobots.html. [Last accessed on 2010 May 24].
8. Lai X, Jiang H, Wang X. Biodegradable metal organic frameworks for multimodal imaging and targeting theranostics. Biosensors (Basel). 2021; 11:299.
9. Sohrabi Kashani A, Packirisamy M. Cancer-nano-interaction: from cellular uptake to mechanobiological responses. Int J Mol Sci. 2021; 22:9587.
10. Ullah R, Wazir J, Khan FU, Diallo MT, Ihsan AU, Mikrani R, et al. Factors influencing the delivery efficiency of cancer nanomedicines. AAPS PharmSciTech. 2020; 21:
11. Germain M, Caputo F, Metcalfe S, Tosi G, Spring K, Åslund AKO, et al. Delivering the power of nanomedicine to patients today. J Control Release off J Control Release Soc. 2020; 326:164–71.
12. Koo KM, Mainwaring PN, Tomlins SA, Trau M. Merging new-age biomarkers and nanodiagnostics for precision prostate cancer management. Nat Rev Urol. 2019; 16:302–17.