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Revolutionizing Cancer Therapy using Nanobots at the Frontier of Precision Medicine

M Giruba[1], Nimmi O S[2], Asiya Anas[3]

[1]Assistant Professor of Physics, Justice Basheer Ahmed Sayeed College for Women, Tamil Nadu, India.
[2]Assistant Professor, Biotechnology, Nehru Arts and Science College Coimbatore, India.
[3]Senior Lecturer / Environmental health, Hassan Usman Katsina Polytechnic Katsina, Katsina State, Nigeria
[1]giruba91@gmail.com, [2]nimmiosm@gmail.com,[3]asiyaanas70@gmail.com

Abstract

New cancer treatment trials are necessary due to the various severe side effects of chemotherapy and the non-specific distribution of drugs. Scientists have been endeavouring to enhance anti-cancer therapy by employing various drug delivery systems (DDS) to more accurately target tumour cells. Due to progress in the field of nanotechnology, medical therapy has significantly expanded, including the utilization of DNA nanobots to identify various forms of cancer cells. Nanobots, which are minuscule robots engineered to function at the cellular level, possess significant potential for transforming cancer treatment. These are little devices, specifically developed to locate and eradicate cancer cells with accuracy, while leaving unaffected healthy tissues. The current design of the nanobots enables them to identify and distinguish 12 distinct types of cancer cells. The purpose of this review paper is to emphasize the significance, functionality, and utilization of nanobots.

Keywords: Nanobots, Cancer, Drug, Cells, Tumor, Drug Delivery Systems, Colorectal Cancer.

I. INTRODUCTION

Cancer is a big group of illnesses that can start anywhere in the body. It spreads to other parts when bad cells grow too much and reach nearby areas or even move to other organs. The second type is when cancer spreads, which we call metastasis. It's one of the main reasons people die from cancer. Cancer is also called neoplasm and bad lump. It's thought that 9.6 million people died from cancer in the year 2018, making it the second biggest reason for death all over our world. Cancer causes one death out of every six that happen. Some of the most common types of cancer in men are stomach, prostate and lung. Others include liver and colorectal cancers too. But women often get thyroid cancer, breast cancer, womb (cervical) cancer spine or chest lungs and large intestine colon related cancers.
A continual production of new cells occurs throughout the human body. Normal cells go through a cycle that is typical: they grow, divide, and eventually die. In other hand, cancer cells do not adhere to this cycle throughout their life. Instead of dying, they continue to create new aberrant cells and multiply in an uncontrolled manner. A number of organs in the body, including the breast, liver, lungs, and pancreas, are invaded by these cells. It is also possible for them to travel through the lymphatic system and the bloodstream, causing them to spread to other areas of the body (Fig-1).

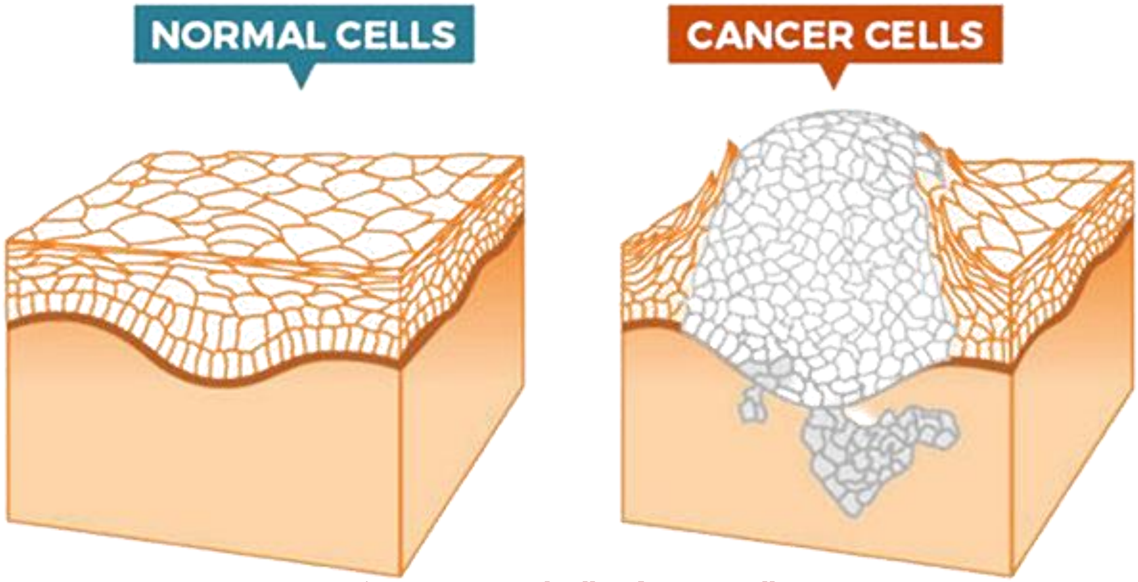

Figure 1: ***Normal cell and Cancer cell.***

The majority of cancer cases, which are projected to reach 61% by the year 2050, are now being reported in nations with low to moderate incomes. Experts have come to the conclusion that alterations in human lifestyle, food, and environmental variables have led to a rise in the number of occurrences of cancer [8].

Drugs are often administered to a particular target region as part of the therapeutic process. External treatment approaches, such as radiation and surgical procedures, are utilized in the event that an internal route for the delivery of drugs is not accessible. In order to battle illnesses, these strategies are frequently utilized interchangeably or in conjunction with one another. When it comes to treatment, the objective is to eliminate the tumors or the cause of the sickness in a way that is both selective and consistent over time.

Nanomedicine is a relatively new sector of medicine that aims to put the promise of nanotechnology to use in order to open up whole new therapeutic paths. One example of this would be the production of nanoparticles that are so small that they are molecule-sized. These nanoparticles might be used to detect and cure tough diseases, including cancer. Nanotechnologies are making a significant contribution to this field by enabling the creation of innovative methods for the delivery of drugs [1] [7].

There are two components that make up an ideal medication delivery system: the capacity to control the release of the medicine and the ability to target specific areas [2]. Through the process of selectively targeting and eliminating malignant or damaging cells, it is possible to drastically limit the severity of adverse effects and assure that the treatment is effective.

II. SOME OF THE POTENTIALLY USEFUL APPLICATIONS OF NANOBOTS IN CANCER TREATMENT INCLUDE THE FOLLOWING

2.1. Targeted Drug Delivery:

The usual chemo drugs often hurt good cells too along with bad ones, which leads to big problems as side effects. It might be possible to give nanobots the power finds and stick to special signs on cancer cells. This would allow them to function as Trojan horses and deliver powerful medications directly to the location of the tumor. This focused strategy would reduce the amount of harm that is done to healthy tissues and might perhaps boost the effectiveness of the treatment [3] (Fig-2).

Figure 2: ***Nanobot delivering drug to cancer cell***

2.2. Minimally Invasive Surgery:

Nanobots provide the promise of enabling precise surgical treatments to be carried out inside malignancies, which are now unreachable using traditional methods. Just picture a swarm of these microrobots, each one armed with a small laser or knife, carefully eradicating malignant cells while leaving healthy tissue alone. As a result, patients may have shorter recovery periods after less intrusive and more successful procedures [4].

2.3. Enhanced Diagnostics:

Nanobots can help find cancer early by watching the body's blood system. They could become tools for finding out about diseases. With biosensors, they found special signs linked to cancer growing. This helped them diagnose and act faster on the problem. People with cancer might live longer if this happens.

2.4. Personalized Medicine:

A person's cancer cells could have unique features like a specific gene change. Nanobots can be made to focus on this by programming them that way. If we use this personal approach for treatment, it could help make plans more effective and specific to each person. This might lead to better outcomes for patients in the end.

2.5. Overcoming Drug Resistance:

Cancer cells might become strong and not get affected by normal medicines. This would make treating them pointless. Nanobots that can change and find ways around resistance systems are being developed. This holds a lot of promise for making treatment last longer [10].

There have been great advances in the development of nanobot-based cancer treatment, albeit it is still in its early phases. Scientists are always working to improve these minuscule devices' design, operation, and targeting methods. One possible future for cancer treatment is a horde of nanobots operating inside of us, systematically eliminating cancer with pinpoint accuracy and negligible collateral damage [5]. It is indisputable that nanobot-based cancer therapy has the potential to be beneficial, and researchers are working hard to overcome the obstacles that stand in the way of implementing this game-changing technology [9].

Due to its nascent development, nanorobotics has not yet produced any authentic nanobots that have undergone experimental analysis. Nevertheless, notable advancements have emerged in this domain, leading to the execution of some trials using nanoscale apparatuses that may be regarded as progenitors of nanobots. An illustration of this may be seen in the study conducted by scholars at the University of California, San Diego. They have devised a technique to fabricate minuscule robots that are propelled by DNA and capable of ambulating, changing direction, and transporting small weights. These robots are constructed using DNA strands that are folded into precise configurations, and their functionality is enabled by the introduction of fuel molecules. Through experimental means, the researchers have successfully manipulated the motion of these robots using light, and have also utilized them to do basic tasks, such as retrieving and transporting goods (Fig-3).

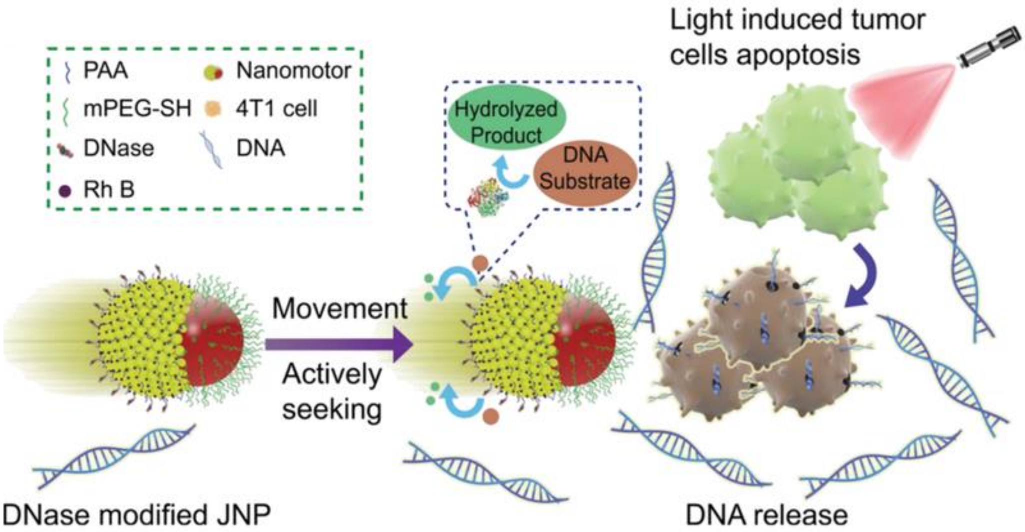

Figure 3: ***DNA Powered nanorobots***

III. DESIGNING OF NANOBOTS

Nanorobots are mostly made of materials that the body can accept or break down. These things that break down easily can dissolve or go away after they have done what they're supposed to do. For nanorobots to work properly inside small spaces in the human body, it's very important that they use materials. These should be bendable and hold their shape well as both things are needed for keeping them fit to do a job right and have good rigidity. They need better speed and quickness in three ways, especially when dealing with thick body fluids that are hard to move. This also includes pretend parts of the body.

In order for nanorobots to function independently within the body, the energy source that provides driving forces is of the utmost importance. It is possible for the type of driving force to have a significant impact on the pace at which a nanorobot moves, as well as its controllability and biocompatibility and therefore, subsequent uses within a biosystem setting. It is essential to make certain that nanorobot is able to move about freely and have adequate strength to counteract the resistance that is emanating from the TME. In order to resist the Brownian motion, it is necessary for nanorobots to have variety of distinct methods that enable them to function under low Reynolds number limitations. Additionally, it is necessary for nanorobots to have a collection of diverse navigation strategies.

Recently, blood sugar and other body fluids have been used to power nanorobots made through enzyme reactions. DNA folding is a big step forward in the basic area of tiny robots. A single DNA strand can get squashed into a flat shape and then combine to form a small three-dimensional structure. This tiny piece is able to release its load when it comes in touch with the special sign that cancer has left behind on our body.

The protective shell of viral capsids keeps the virus's genes safe from harm caused by surroundings.The fabrication of nanorobots involves a series of steps: In a step by step way, materials are put together one after another; self-organizing polymers produce bowl shaped stomatal cells that can be filled with catalysts. Engineered structures and magnetic connections are made by connecting tiny particles.

The making of smaller and more complex machines called nanorobots also uses other high-tech methods such as glancing angle deposition, rolled up lithography and 3D printing. Nano-robots that work with both living and manmade parts use special forces to put themselves together. Natural polymers like chitosan and gelatin can be mixed with magnetic nanoparticles to make tiny robots that move using a magnetic field. These biodegradable robots could continuously reach the place they need by following instructions from the right guidance payloads in terms of normal magnetic fields. When let go, the cargo or parts could travel towards the sick place to do fix-up work [6].

Nanobots may be employed in many different industries in the future, including manufacturing, healthcare, and environmental cleanup. Nanobots, on the other hand, are not yet a reality since there are a few obstacles that need to be overcome first. The difficulty of producing and assembling electronics at the nanoscale is one of the challenges that may be encountered. Furthermore, the necessity to create new materials and ways for powering and managing nanobots is another barrier that must be overcome.

Regardless of these obstacles, nanorobotics is a rapidly growing area, and it's probable that actual nanobots will be developed soon.

IV. CONCLUSION AND DISCUSSION

Through the provision of a foundation for advancements in the biotechnological, medical, and pharmaceutical sectors, nanotechnologies have, without a shadow of a doubt, contributed to the enhancement of the quality of life of affected individuals. Through the use of nanobots, which can be trained to identify and attach to certain markers on cancer cells, powerful medications may be delivered directly to the location of the tumor. This reduces the amount of time that healthy tissues are exposed to the adverse effects of the medication, which have the potential to result in increased efficacy and less toxicity. Nanobots have the potential to be created to carry out a variety of functions, including the imaging of tumors, the delivery of medications, and even the direct destruction of cancer cells using mechanical or surgical methodologies. The therapy of cancer may be approached in a more comprehensive manner because to its adaptability. Because nanobots could be swallowed or injected, there would be no need for an extensive surgical procedure. This might shorten the amount of time it takes for patients to heal and lower the likelihood of problems.

Nanobots in cancer therapy have great promise to revolutionize cancer treatment, but more research and development is needed to overcome the current obstacles. To safely and effectively translate this technology into clinical practice, scientists, engineers, ethicists, and legislators must collaborate.

It is still difficult to precisely design and direct nanobots. It is of utmost importance to guarantee their effectiveness and safety when used by humans. A person's immune system may mistake nanobots for invaders and launch an attack on them. There has to be research into stealth technology and biocompatible materials. Consideration and ethical frameworks are required for issues like as possible abuse, unexpected repercussions, and fair access to this technology.

Additional areas for research are; advancements in nanofabrication techniques and the development of biocompatible materials. Advancement of more precise targeting mechanisms and medication delivery systems. Thorough investigations into the safety and effectiveness of nanobots in animal models. Initiate dialogues around the ethical ramifications and societal consequences of this technology. Through the resolution of these problems and the ongoing pursuit of research, nanobots has the capacity to emerge as a formidable instrument in the battle against cancer.

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Conflicts of Interest

The authors declare no conflict of interest.

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