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A REVIEW ON NANOROBOT IN CANCER TREATMENT

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Abstract:
Early detection and diagnosis of many cancers is very challenging. Late stage detection of a cancer always leads to high mortality rates. It is imperative to develop novel and more sensitive and efective diagnosis and therapeutic methods for cancer treatments. The development of new cancer treatments has become a crucial aspect of medical advancements. Nanobots, as one of the most promising applications of nanomedicines, are at the forefront of multidisciplinary research. With the progress of nanotechnology, nanobots enable the assembly and deployment of functional molecular/nanosized machines and are increasingly being utilized in cancer diagnosis and therapeutic treatment. In recent years, various practical applications of nanobots for cancer treatments have transitioned from theory to practice, from in vitro experiments to in vivo applications. In this paper, we review and analyze the recent advancements of nanobots in cancer treatments, with a particular emphasis on their key fundamental features and their applications in drug delivery, tumor sensing and diagnosis, targeted therapy, minimally invasive surgery, and other comprehensive treatments. At the same time, we discuss the challenges and the potential research opportunities for nanobots in revolutionizing cancer treatments. In the future, medical nanobots are expected to become more sophisticated and capable of performing multiple medical functions and tasks, ultimately becoming true nanosubmarines in the bloodstream.

Key-words:- *Nanorobots, Cancer treatment, Drug delivery, Targeted therapy.*

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INTRODUCTION:

CANCER:-

Cancer is a disease in which some of the body's cells grow uncontrollably and spread to other parts of the body. Cancer can start almost anywhere in the human body, which is made up of trillions of cells. Normally, human cell grow and multiply (through a process called cell division) to form new cells as the body needs them. When cells grow old or become damaged, they die, and new cells take their place.[1] Nanotechnology is the investigation, design, creation, combination, control, and utilization of materials, gadgets, and frameworks at the nanometre scale (One meter comprises of 1 billion nanometres). It is winding up progressively critical in fields like building, farming, development, microelectronics, and healthcare [2].

Nanorobots are nano devices that will be utilized to maintain and securing the human body against pathogens [3]. Although a few analysts trust that it is a logical transformative structure that did not create until the late 1980s, proof of nanotechnology goes back to 1959. Others trust that people have accidentally utilized nano technological strategies for a great many years, maybe significantly more. Be that as it may, nanotechnology is still crisp, giving another field to logical research [4]. Recent advances in atomic science and materials science have displayed a combination of supra sub-atomic or nanoparticle-based specialists that play out an assortment of complex theranostic actions, for example, self-governing coordinated development [5], modern Boolean-rationale based biosensing, and so forth [6– 7].

There are two fundamental sorts of nanobots; constructing agents and self-replicators. Constructing agents are basic cell-molded nanobots that can decipher particles or molecules of various sorts, and are constrained by explicit specific projects. Self-replicators are on a very basic level constructing agents that are fit for copying themselves at an exceptionally huge, quick rate; it is this kind of duplication that guides the development of extensive scale applications or sending of nanobots for substantial scale undertakings [8].

The controlling of the nanorobots should be possible by utilizing neighborhood glucose and oxygen for vitality. In a clinical situation, another alternative would be remotely provided acoustic vitality.

Different wellsprings of vitality inside the body can likewise be utilized to supply the fundamental vitality for the gadgets. They will have straightforward locally available PCs equipped for performing around 1000 or fewer calculations for every second [9].

Nanofabrication and assembly :- Right now, researchers have prevailing to grow just organic Nano robotic frameworks, though, artificial Nano robots are as yet an idea that is being investigated forcefully. The key test in the advancement of these frameworks is their manufacture and gathering at Nano-scale. Different systems are being created for Nano control including scanning probe microscopy (SPM) and Atomic Force Microscopy(AFM) as a few promising techniques for little scale improvement of Nano devices [10 - 11].

CAUSES OF CANCER :-

1)Genetic factors:
1) Environmental factors
2) Lifestyle factors
4) Biological Factors
5) Infections

TYPES OF CANCER :-

Cancer is classified based on the tissue of origin.
1. Carcinoma
2. Leukemia
3. Lymphoma
4. Brain and Spinal Cord Cancers
5. Other common cancer

DIAGNOSIS OF CANCER :-

1. Imaging:
2. Biopsy (Gold standard)
3. Blood Tests

SYMPTOMS OF CANCER :-

1. Unexplained weight loss
2. Fatigue and Pain
3. Changes in skin
4. Changes in bowel or bladder habits
5. Unusual bleeding or discharge

SIDE EFFECTS OF CANCER TREATMENT :-

CHEMOTHERAPY
RADIATION THERAPY SURGERY
TARGETED THERAPY
HORMONAL THERAPY
STAGING OF CANCER
Cancer stages describe how far cancer has spread.
Stage 0: Very early, localized
Stage I: Small tumor, local
Stage II: Bigger tumor, no spread
Stage III: Local spread to lymph nodes
Stage IV: Metastasis to other organs.

TREATMENT OF CANCER :-

1. Surgery
2. Chemotherapy
3. Radiotherapy
4. Immunotherapy
5. Targeted Therapy

Prevention of Cancer:-
Avoid smoking/alcohol
Healthy diet + exercise
HPV & Hepatitis B vaccination
Avoid excessive sun exposure
Regular cancer screening.

NANOTECHNOLOGY:-
Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale.[12] Nanotechnology has been at the center of the stage when technological advancements are considered and has expanded massive attention over time. made of carbon, metal, metal oxides, or organic matter.[13]

Nanomedicine is a key part of biotechnology and medicine, improving diagnostics, treatments, and disease prevention. By using nanotechnology, it has made healthcare better and helped create new ways to diagnose and treat diseases.[14]

Scientists are using nanotechnology in medicine to improve tools like sensors, diagnostic surfaces, and purification kits. New devices are being created to work inside the body for early diagnosis and treatment. By combining medicine, technology, and nanoengineering, innovations like nanorobots for surgery and drug delivery systems are helping doctors understand diseases better and find better treatments.[15]

Nanotechnology involves the process of designing, fabricating, and manipulating materials at the nanoscale.[16].

NANOROBOTS :-
The study of robots at the nanoscale is defined as nanorobotics, and incorporated technology is known as nanotechnology. Nanorobots are devices capable of sensing, actuating, signalling, processing information, intelligence, or exhibiting swarm behaviour at the nanoscale.[17]

They are comprised of various components that carry out specific tasks; the components are constructed at the nanoscale size and can range from 1–100 nanometers . Nanobots (A.K.A. nanorobots), which are currently the focus of an emerging field of research, are also referred to as nanites, nanoids, nanomachines, or nano-mites ; however, in general, nanobot consists of two words—‘nano’ and ‘bot’. ‘Nano’ refers to very small or minute, and ‘bot’ refers to a device that can be controlled by a program. i.e. a short term for a robot.[18]

Nanorobots have several potential applications in the medical field including cancer treatment, surgery, precision medicine[15], diabetes monitoring, dentistry, blood monitoring and drug delivery. Currently, mobile phones are proving to be a useful feedback device in accomplishing data transmission for communication, control, and energy supply inside the body.[19]

Due to their small sizes, nanorobots can directly interact with cells and even penetrate them, providing direct access to the cellular machineries. As an interdisciplinary technology, nanorobots address the assembly and utilization of functional nano-to-molecular scale machines and have been widely used in cancer diagnosis and treatment.[20] Cancer is the 3rd leading cause of death globally as almost every six deaths is caused by it . By 2030, it's expected to be 26 million new cases of cancer with almost 17 million deaths per anum.[21]

The countries with low-to-middle income account for most cancer cases that are expected to be 61% by 2050. In 1965, the International Agency for Research on Cancer (IARC) was established, with the mission of conducting multidisciplinary investigations into the causes of human cancers.[22] After conducting several studies, particularly on the structure of genes, experts have concluded that changes in human lifestyle, diet, and environmental factors have resulted in an increased number of cancer cases.[23]

Natural nanorobots existing in biological systems:-
We have witnessed great advances in nanotechnology in the past decades, and a large number of novel nanotechnologies have been discovered and applied to a wide range of felds. However, living organisms present us with some impressive natural nanomachines which can be viewed as “bionanorobots” [24 - 25]. Tese natural nanorobots that can both rotate and transport chemical loads following predetermined tracks with subnanometer precision and high efciency are essential for a plethora of cellular functions [26].

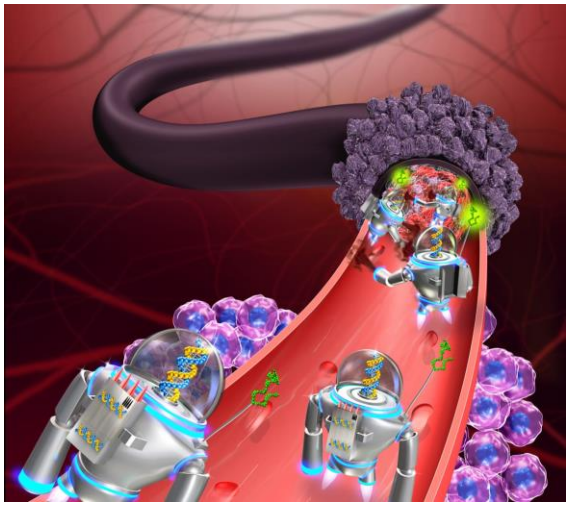
Nanorobots core:-
After satisfying the previous fundamental requirements, an ideal nanorobot core is required. Much more research is needed before nanorobots can achieve widespread biological applications [27]. DNA origami is one of the greatest advancements in the core project of nanorobotics. A single-stranded DNA can be collapsed into a two-dimensional shape and eventually form a three-dimensional nanostructure, which can release its payloads upon binding with a specifc cancer biomarker [28-29].

Fabrication of nanorobots:-
When researchers design and build small-scale robots, they are motivated by the need to fnd active

materials that can consistently convert diferent forms of energy into motion. Te frst generation of nano-engines for small-scale robots relied on their simple geometry and manufacturing procedures [30]. Trough electrochemical reduction of salts corresponding to metals within nano/micron symmetric pores, these early nanorobots were fabricated [31].

TYPES OF NANOROBOTS :-

1. Drug Delivery Nanorobots
2. Diagnostic Nanorobots
3. Thermal Nanorobots
4. Gene Editing Nanorobots



CANCER FIGHTING NANOROBOTS SEEK AND DESTROY TUMORS.

ADVANTAGES :-

1. Targeted delivery
2. Enhanced Efficacy
3. Reduce Dosage
4. Immunotherapy Enhancement
5. Multi Functionality

DISADVANTAGES :-

1. Cost
2. Public Acceptance
3. Limited Control
4. Immune Response

Challenges:-

Very expensive
Ethical concerns
Risk of immune reaction

MECHANISM OF ACTION OF NANOROBOTS:-

Drug Loading

⬇

Nanorobots are equipped with the anticancer drug for precise delivery.

Targeting Cancer

⬇

Nanorobots use specific ligands to locate and bind to cancer cells.

Cell Entry

⬇

The cancer cell internalizes the nanorobots through endocytosis.

Drug Release

⬇

Inside the cancer cell, nanorobots release the drug into the cytoplasm.

Cancer Cell Death

⬇

The released drug causes the cancer cell to die by disrupting its function.

IMPORTANCE OF NANOROBOTS FOR HEALTH:-

Cancer treatment:-

Drug Delivery Systems for Anticancer Drugs:-

The Paclitaxel is directed by intravenous infusion and assumes a job in the treatment of breast cancer. Among the unfavorable impacts experienced some genuine, are bone marrow concealment and combined neurotoxicity [32]. Camptothecin is utilized in the treatment of neoplasias because of restraint of sort I topoisomerases, a fundamental enzyme for cell replication hereditary material [33]. Clinical trials are ponders in people to gauge the parameters of security and adequacy of new drugs, it is basic for the landing of new therapeutic options in the market [34].

In any case only a couple of DDS achieved further developed phases of clinical assessment, for example, fundamentally comprising of doxorubicin, paclitaxel, camptothecin and platinum edifices [35]. Doxorubicin was stacked on the outside of Single-Walled Carbon Nanotubes (SWNTs) [36].

Limitations of Chemotherapy:-

The Conventional chemotherapeutic agents work by decimating quickly separating cells, which is the primary property of neoplastic cells. This is the reason chemotherapy additionally harms ordinary sound cells that separate quickly, for example, cells in the bone marrow, macrophages, digestive tract, and hair follicles [37].

Treatment:-

Cancer can be effectively treated with current phases of restorative advances and treatment devices with the assistance of the nanorobotics. Decide the definitive factor to chances for a patient with cancer to endure is: the means by which prior it was analyzed, another vital angle to accomplish a fruitful treatment for patients is the advancement of proficient focused on drug delivery to diminish the symptoms from chemotherapy [38].

Cancer could be characterized as the gathering of diseases described by the uncontrolled development and spread of anomalous cells in the body is the

thing that characterizes cancer, and the quantity of people influenced every year keeps on climbing [39].

At present, the nanorobots are customized to perceive 12 kinds of cancer cells. Also, the sub-atomic engines of these gadgets can change their compliance under outside boosts of bright light and drill through cell bilayers to initiate rot of undesirable cells or to acquaint adjusted species and drugs with specifically target sites. A few techniques created by researchers planned to combine drug-stacked nanoparticles where the helpful agents will cling to the cancer cell and will discharge the drug locally. The connection of nanoparticles to cancer cells can be acknowledged by the RNA strands situated to the outside of nanoparticles [40]

CONVENTIONAL METHODS OF NANOROBOTS IN CANCER TREATMENT:-

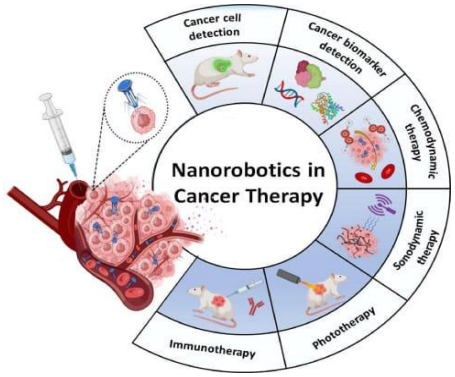
Most people with cancer receive surgery, chemotherapy, radiation therapy, or other conventional therapies at some point during treatment, and many will have a combination of these treatments. Injection of drugs affects both cancerous and non cancerous cells in conventional method.

So, the main types of cancer treatment include : Surgery, Radiation Therapy, Chemotherapy, Immunotherapy, Targeted Therapy, Hormone Therapy.

THE MAJOR DRAWBACKS OF THE CONVENTIONAL METHODS USED IN THE CANCER THERAPY:-

Injection of drugs affects both cancerous and non cancerous cells in conventional method. There are various side effects with the conventional methods as it effects both the cancerous and non cancerous cells.

Surgery and radiation therapy remove, kill, or damage cancer cells in a certain area which also effects healthy cells. The time to heal is longer with the conventional methods that includes methods like surgery, radiation therapy. Some of the side effects that that occur when conventional method.



NANOROBOTICS IN CANCER THERAPY.

THE MODERN TECHNOLOGY USED TO CURE CANCER THERAPY:- Nanotechnology offers promising advancements in cancer therapy. Nanorobots, like Nanokillers, can target cancer cells directly and deliver drugs precisely where needed, minimizing side effects. These tiny robots can find and repair damaged organs, detect tumors, and even destroy them with controlled doses of chemotherapy drugs.

Respirocytes are nanorobots that help identify tumors and release drugs directly at cancer cells. They can also track their progress, reporting the number of cancer cells they've encountered and treated. Nanomedicine enables non-invasive devices that can enter the body, detect cancer in early stages, and deliver targeted treatments with minimal harm to healthy tissue.

These nanorobots have vibrating cilia-like structures and nanosensors to identify cancerous tissues, while gold-coated shells allow them to attach to and treat malignant cells.

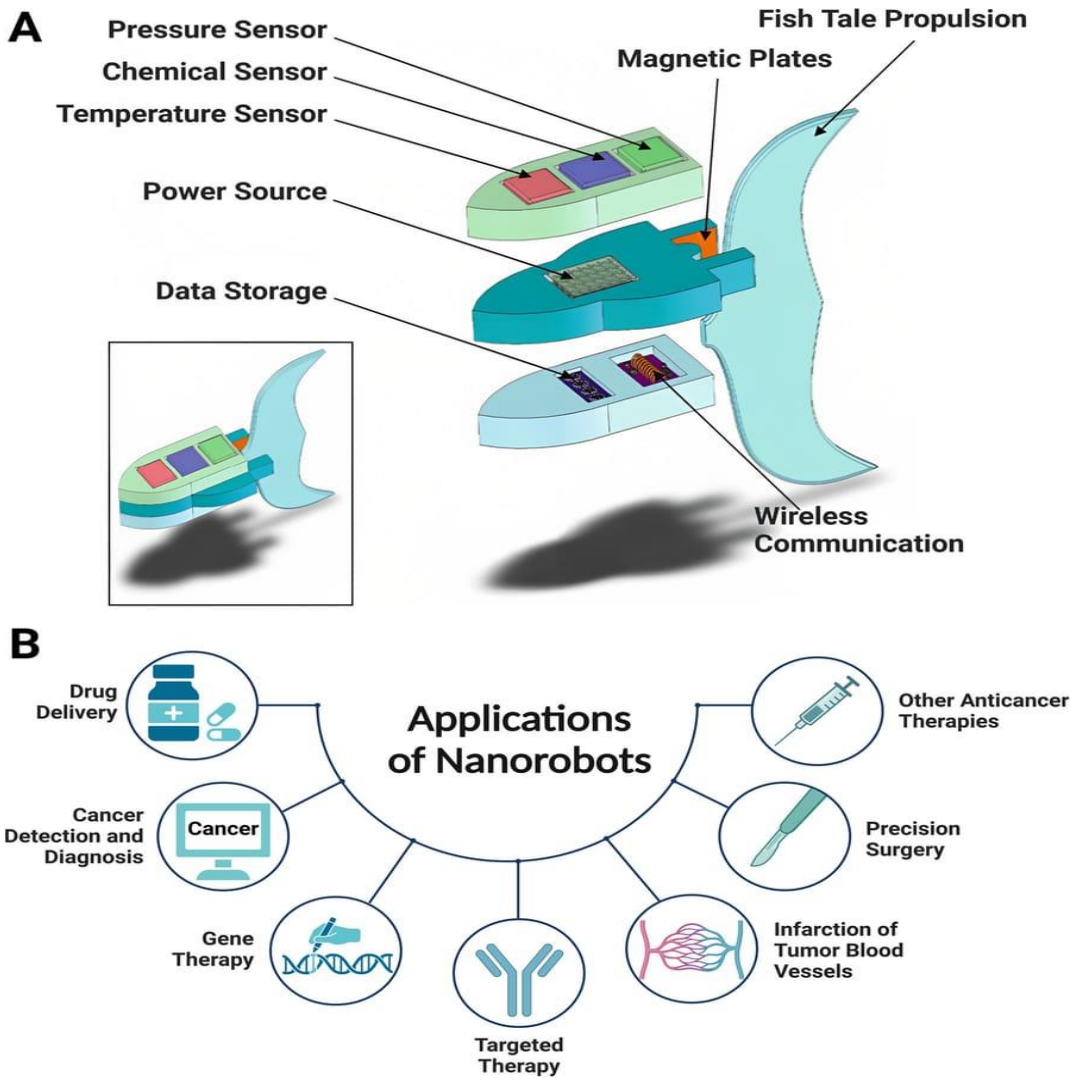
CHEMOTHERAPY DRUG DELIVERY USING NANOROBOTS IN CANCER TREATMENT:-

Recent advancements in drug delivery use nanorobots with nanosensors to target specific cancer cells and regulate drug release. Traditional chemotherapy drugs kill rapidly dividing cells, but they also harm healthy cells, causing side effects like immune suppression, hair loss, and organ damage.

Nanorobots can deliver chemotherapy drugs directly to cancerous cells, minimizing damage to healthy tissue. By targeting only tumor cells, they reduce side effects and improve treatment effectiveness. These robots help maintain the correct drug levels in the bloodstream for longer, ensuring better outcomes for cancer therapies.[41]

APPLICATIONS OF NANOROBOTS :-

1. Medical Applications:
A. Cancer Treatment:
B. Disease Diagnosis:
C. Surgery:
D. Tissue Repair:
E. Infection Control:
2. Pharmaceutical Applications:
3. Environmental Applications:
A. Pollution Control:
B. Air & Water Purification:
4. Industrial & Technological Applications:
A. Manufacturing:
B. Electronics:
C. Food Industry:
5.Defense & Security Applications:



APPLICATION OF NANOROBOTS.

CONCLUSION :

Nanorobots offer significant promise in transforming cancer treatment through targeted drug delivery, early detection, and personalized therapies. By minimizing side effects, enhancing treatment efficacy, and overcoming challenges like drug resistance, they could provide a more effective, less invasive approach to managing cancer.

Additionally, their integration of therapy and diagnostics (theranostics) opens up new possibilities for real-time monitoring and dynamic treatment. However, challenges such as safety, scalability, and regulatory approval need to be overcome. With continued advancements in technology and research, nanorobots could revolutionize cancer care, improving outcomes and quality of life for patients.

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