SARADA VIDYA MANDIR

Nanobots: A proposed Model on Targeted Drug Delivery

Submitted by-

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Kountik Roy

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TUMOUR

For understanding Cancer, we have to first know what is Tumour.

Tumour: -

A tumor is an abnormal mass of tissue that forms when cells in the body grow and divide more than they should or do not die when they should. Tumors can develop in any tissue, gland, organ, skin, or bone and can vary in size from very small to quite large.

Types Of Tumours: -

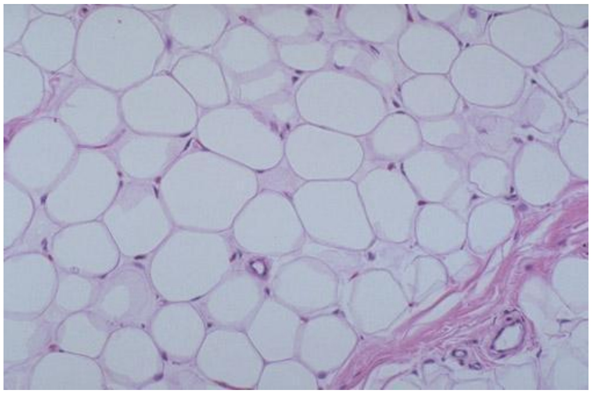
- **Benign tumour:** These are non-cancerous, do not invade nearby tissues, and generally do not spread to other parts of the body. They are usually not life-threatening but can cause problems if they press on vital organs or structures.

- **Premalignant tumour:** These are not yet cancerous but have the potential to become malignant over time.

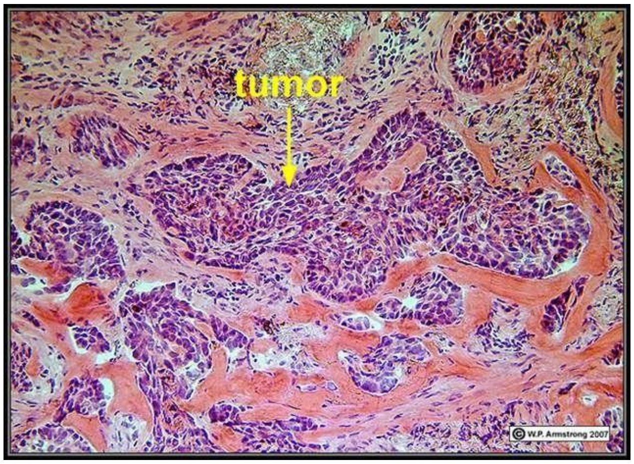
- **Malignant tumour:** These are cancerous, characterized by uncontrolled growth, the ability to invade surrounding tissues, and the potential to spread (metastasize) to distant parts of the body.

<u>Normal Cells Vs Tumour Cells</u>

Normal cells are the building blocks of the body, each designed to perform specific functions essential for health and survival. They grow and divide only when necessary, responding to signals from the body to maintain proper tissue structure. When they become old or damaged, normal cells undergo programmed cell death (apoptosis) to prevent accumulation of faulty cells. They stick together in the right place, forming organized tissues, and mature into specialized types such as muscle or red blood cells, each with a distinct role. Structurally, normal cells have a uniform appearance, with organized internal components like the nucleus, mitochondria, and other organelles, all enclosed by a cell membrane that controls the movement of substances in and out. This precise regulation of growth, specialization, and self-destruction ensures that normal cells support the body's structure and function without causing harm.

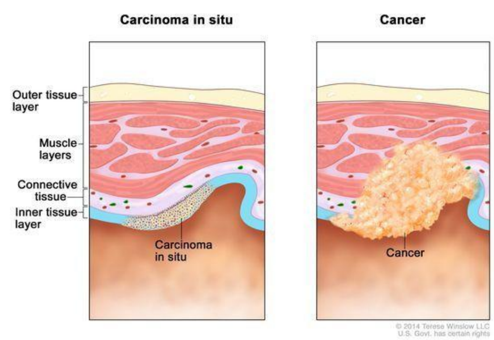


Tumor cells are abnormal cells that grow and divide uncontrollably, ignoring the body's normal regulatory signals. Unlike healthy cells, they often have irregular shapes, large and misshapen nuclei, and a disorganized internal structure. Tumor cells lose the ability to specialize, which means they no longer perform normal cellular functions within tissues. They can invade surrounding tissues, causing damage and disruption, and, in the case of malignant tumors, can spread to distant organs through a process called metastasis. Tumor cells also avoid programmed cell death (apoptosis) and can stimulate the growth of new blood vessels (angiogenesis), ensuring they receive the nutrients and oxygen needed for their rapid growth and survival.



Malignant Tumour

Malignant tumors, also known as cancerous neoplasms, represent a serious and aggressive form of abnormal tissue growth in the body. Unlike benign tumors, which remain localized and generally grow slowly, malignant tumors are characterized by their ability to invade surrounding tissues and spread to distant organs, a process known as metastasis. This invasive behaviour is one of the defining features of cancer and is responsible for much of the harm that malignant tumors cause. Malignant cells often look very different from the normal cells from which they originated; they show a high rate of proliferation, less differentiation (a state called anaplasia), and significant abnormalities in size and shape, particularly in their nuclei. These cells also exhibit genetic instability, frequent and abnormal mitoses, and the ability to evade normal mechanisms that control cell growth and death.



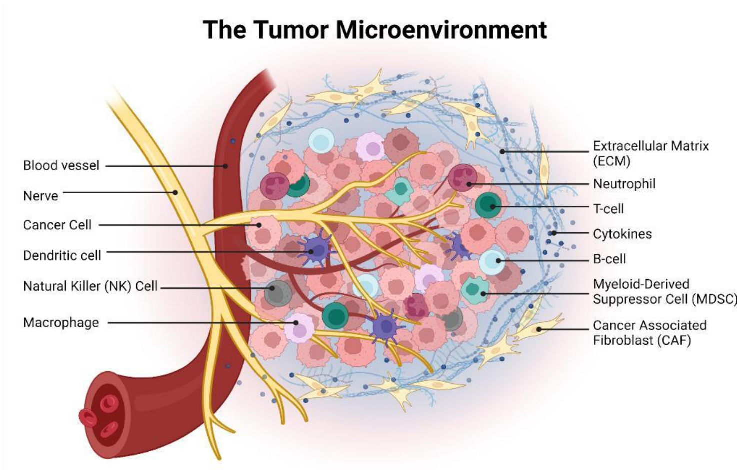
The term "**cancer**" encompasses a wide variety of malignant Tumours, including carcinomas (arising from epithelial cells), sarcomas (from connective tissue), leukaemia (from blood-forming tissues), and lymphomas (from the lymphatic system). Malignant Tumours disrupt normal organ function by infiltrating healthy tissues and consuming resources, and their ability to metastasize makes them especially challenging to treat. Under the microscope, malignant tumours often appear as disorganized masses of poorly differentiated cells with large, irregular, and darkly staining nuclei. Their aggressive nature means they can rapidly increase in size, break through normal tissue boundaries, and establish new Tumours in distant organs. Because of these features, early detection and prompt, aggressive treatment—such as surgery, chemotherapy, or radiation therapy—are critical to improving outcomes for patients with cancer.

Tumour Micro-Environment (TME):

The tumor microenvironment (TME) is the complex and dynamic environment that surrounds and interacts with a tumor within the body. It consists not only of cancer cells but also of a variety of other cell types, including immune cells, fibroblasts, endothelial cells (which form blood vessels), and various signaling molecules and extracellular matrix components. The TME plays a crucial role in tumor development, progression, and response to treatment. It provides physical support, nutrients, and growth factors that help cancer cells survive and proliferate. At the same time, the TME can suppress the body's immune response against the tumor and promote processes like angiogenesis (formation of new blood vessels) and metastasis (spread of cancer to other organs). Because the TME influences how tumors grow and respond to therapies, it has become a major focus of cancer research, with new treatments being developed to target not just the cancer cells, but also the supportive and protective environment around them.

Factors Of Tumour Micro-Environment :

Acidic pH: Tumors often have an acidic environment due to increased glucose uptake and lactate production, which can affect immune cell function and promote invasion.



Oxidative stress: High levels of reactive oxygen species (ROS) are found in hypoxic tumors, influencing cancer cell survival, drug resistance, and genetic instability.

Abnormal blood vessels: Tumor vasculature is often disorganized, leading to poor oxygen and nutrient delivery, further contributing to hypoxia and uneven drug distribution.

Fibrosis and stiff extracellular matrix: Excessive connective tissue and altered matrix proteins can make the tumor physically rigid, affecting cell movement and therapy penetration.

Using Nanotechnology to Treat Cancer

Nanotechnology is revolutionizing cancer treatment by enabling highly targeted and effective therapies that minimize harm to healthy tissues. Unlike traditional approaches such as surgery, chemotherapy, and radiation, which often affect both cancerous and normal cells, nanotechnology allows for the precise delivery of drugs, genes, or therapeutic agents directly to tumor cells. Nanoparticles, which are extremely small carriers made from materials like liposomes, polymers, or carbon nanotubes, can be engineered to recognize and bind specifically to cancer cells. This targeted approach enhances the concentration of drugs at the tumor site while reducing side effects elsewhere in the body

- Nanotechnology enables highly targeted delivery of cancer drugs directly to tumor cells, reducing damage to healthy tissues and minimizing side effect.
- Nanoparticles can be engineered to recognize and bind to specific markers on cancer cells, ensuring precise drug release at the tumor sit.
- Smart nanoparticles can respond to biological cues such as pH, temperature, or enzymes, allowing for controlled and responsive drug delivery.
- Nanotechnology improves cancer imaging and diagnostics, enabling earlier detection and more accurate monitoring of tumors using specialized nanoparticles for enhanced imaging techniques.

Nanobots: A Nano technology to treat Cancer

What are Nanobots?

Nanobots, also known as nanorobots, are extremely small robots typically measuring between 50 and 100 nanometers— much smaller than a human blood cell. These tiny machines are designed to perform specific tasks at the molecular or cellular level, especially in the field of medicine. Nanobots can be engineered to navigate through the human body, where they can diagnose diseases, deliver drugs directly to targeted cells, monitor health conditions, and even assist in surgical procedures.

How it Works?

- **Navigation**: - Through Constant Imaging of Sensor in the Nanobot or Through Contant Imaging of MRI scan Nanobots are navigate.
- **Mobility**: - For Mobility the Nanobot use a flagella like structure to swim in the lymph and blood vessels.
- **Detection**: - When Nanobots Detect any kind of Condition like Hypoxic condition or acidosis in the TME area it slow down or stop.
- **Delivery**: - When The Sensor in the nanobot detect any kind of TME Factor it release the payload.
- **Self-Destruction**: - After Finishing of the work, it automatically gets dissolved in the blood stream as it is made up of bio-polymer.

Proposed Model By Me

Nanobots are very complex, and very expensive to make. The Recent research paper have invented 5 types of nanobots, which works on the factors of TME. But my proposed contains all the sensors of all the factors of TME to detect, and release the drug. In my model, it works with a logic and even a minimal malfunction would self-destroy itself completely. It has a flagellum which helps it to swim in the lymph or the blood vessels. The other proposed model is applicable for only other animals like rats, dogs, monkey, etc. In my model I have thoroughly about each and every cancer treatment and cancer description with its existence in history. By thinking all the factors of human in-toxicity and the invasion of WBC. When The Sensor Detect the TME it will automatically release the drug and the drug will get diffused in the Cancer Cells. This model should be highly sterilised a patient should be kept in a Highly Sterilised Room. Which makes nanobots more costly. My proposed model can put a impactful result in the field of Onco-Welfare.

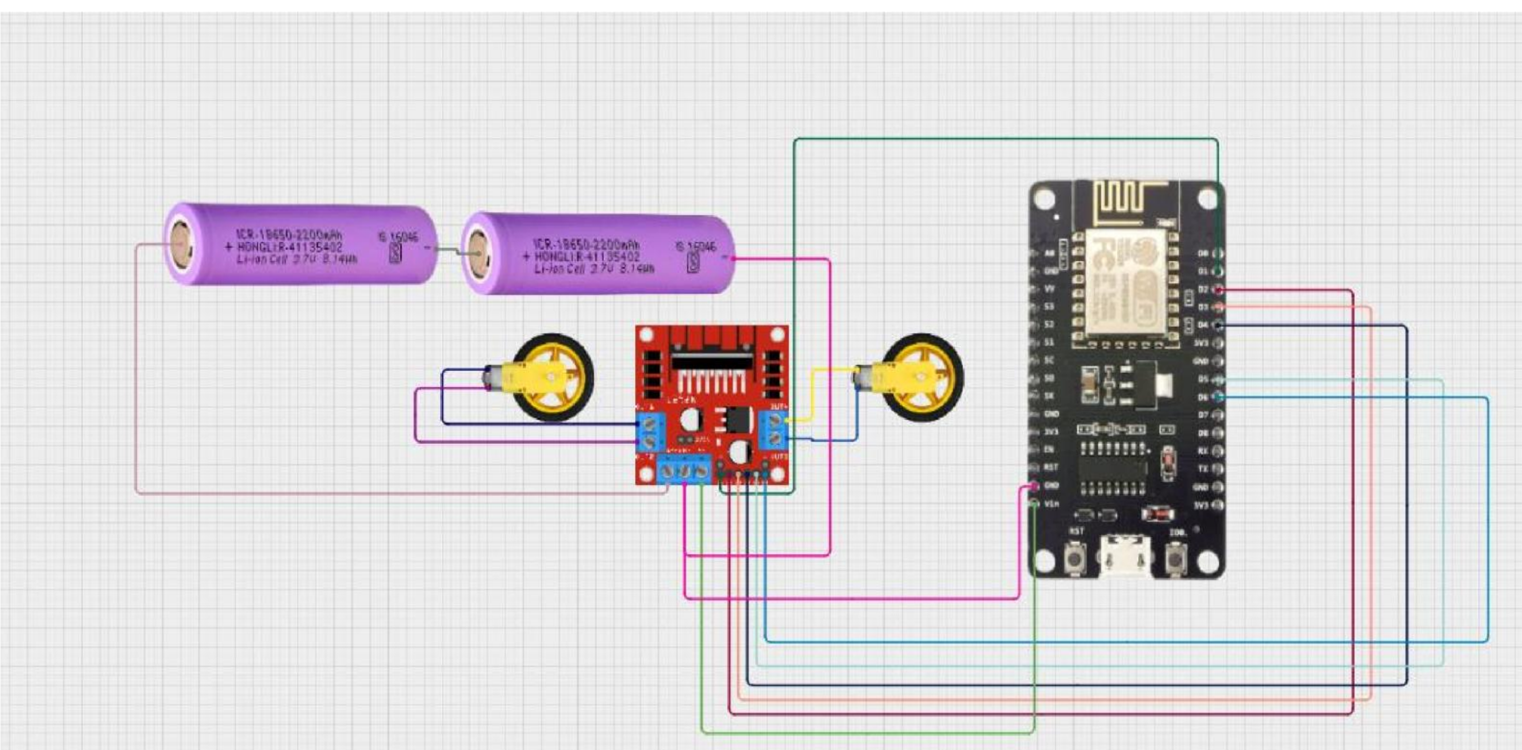
Prototypes Of My Model

The Prototype of my Nanobot model is very simple. The main circuit is wrapped in a plastic bottle which indicate nanobot. Which is floating in the transversely cut pipe which indicate the blood vessel/Lymph node. Now through Wi-Fi control I can move the boat and can release the coloured water(drug) in the fluid of the pipe through syringe and a pipe. Though it seems a very easy task to do, it requires a really in-depth knowledge in the field of oncology. One mistake in the nanotechnology can be life threatening for the person.

COMPONENTS USED: -

- **ESP8266**
- **L298N Motor Driver**
- **Gear Motor**
- **2 Wheels**
- **Jumper Wires**
- **218650 3.7V Lithium-ion battery**

CIRCUIT DIAGRAM:



Advantages:-

- **Targeted Drug Delivery**: Nanobots can deliver drugs directly to cancer cells, increasing treatment effectiveness and minimizing damage to healthy tissues.

- **Reduced Side Effects:** By focusing therapy on tumor sites, nanobots significantly decrease the systemic toxicity and harsh side effects commonly seen with traditional chemotherapy.

- **Overcoming Drug Resistance:** Nanotechnology can help bypass mechanisms that make cancer cells resistant to standard treatments.

- **Minimally Invasive:** Nanobot therapy is less invasive compared to surgery or radiation, potentially leading to faster recovery and fewer complications.

Disadvantages: -

- **Inflammation:** Nanobots, being foreign substances, can trigger immune responses and inflammation in the body.
- **Toxicity:** They are potential for being toxic in the body.
- **Filtration:** They can be rapidly cleared from the bloodstream by the liver and spleen that reduces the drug accumulation in tumours.
- **Complexity:** They have a highly complex design and fabrication which make it very expensive.
- **Monitoring:** From designing to navigation and control and also monitoring require a highly sophisticated instrument.

Future Prospects

The future prospects of nanobot therapy in cancer treatment are highly promising, with significant advancements anticipated over the next decade. The global market for nanorobots in healthcare is projected to grow rapidly, reaching up to $11 billion by 2030, driven by the increasing demand for precision medicine and breakthroughs in nano-technology.

One of the most exciting prospects is the evolution of nanobots from passive drug carriers to intelligent devices capable of autonomous navigation, environmental sensing, and adaptive therapy. Integration of artificial intelligence and machine learning is enhancing their ability to make real-time decisions within the body, further personalizing cancer treatment and allowing for dynamic responses to changes in the tumour microenvironment. Technological advances in nanofabrication, such as DNA origami and biodegradable materials, are making nanobots safer and more versatile, minimizing long-term risks and enabling their use in a broader range of medical applications.

Beyond oncology, nanobots are expected to play a growing role in regenerative medicine, gene therapy, and minimally invasive surgeries, expanding their impact across multiple fields of healthcare. Government funding, industry partnerships, and cross disciplinary research are accelerating the refinement and adoption of nanobot technologies, paving the way for them to become a gold standard in therapeutic management. As these innovations mature, nanobot therapy could revolutionize cancer treatment by providing highly effective, personalized, and less invasive solutions, ultimately improving survival rates and quality of life for patients worldwide.

CONCLUSION

Nanobot therapy represents a groundbreaking advancement in the fight against cancer, offering hope for more precise, effective, and less invasive treatments. By harnessing the power of nanotechnology, scientists and medical professionals can target cancer cells with unprecedented accuracy, reduce harmful side effects, and improve patient outcomes. While there are still challenges to overcome—such as ensuring safety, affordability, and long-term effectiveness—the rapid pace of research and innovation suggests that nanobot therapy could soon become a standard tool in oncology. As we look to the future, the integration of nanobots in cancer treatment holds the promise of transforming the way we diagnose, monitor, and cure cancer, ultimately improving the quality of life and survival rates for patients worldwide.

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