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Review Article

NANOROBOTS IN BRAIN TUMOR

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ABSTRACT
Nanomedicine is the process of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using molecular tools and molecular knowledge of the human body. In the relatively near term, nanomedicine can address many important medical problems by using nanoscale-structured materials and simple nanodevices that can be manufactured today, including the interaction of nanostructured materials with biological systems. The authors predict that technology-assisted medicine and robotics in particular, will have a significant impact over the next few decades. Robots will augment the surgeon's motor performance, diagnosis capability, and senses with haptics (feel), augmented reality (sight), and ultrasound (sound). Robotic devices have been used in cardiac surgery, urology, fetal surgery, pediatrics, neurosurgery, orthopedics, and many other medical disciplines. In this article, we present the Nanorobot drug delivery to brain tumor, paying special attention to the transformation trends of organizations, and the integration of robots in brain tumor and underscoring potential repercussions which may deserve more attention and further research.

KEYWORDS: Nanomaterials, Nanorobot, Nanorobotics, Brain Tumor, Nanodevice

INTRODUCTION OF BRAIN

The brain is a soft, spongy mass of tissue. It is protected by the bones of the skull and three thin membranes called meninges. Watery fluid called cerebrospinal fluid cushions the brain. This fluid flows through spaces between the meninges and through spaces within the brain called ventricles. Within the brain and spinal cord, glial cells surround nerve cells and hold them in place. The brain directs the things we choose to do and the things our body does without thinking (like breathing). The brain is also in charge of our senses (sight, hearing, touch, taste, and smell), memory, emotions, and personality. The three major parts of the brain control different activities:

- **Cerebrum—** It uses information from our senses to tell us what is going on around us and tells our body how to respond. It controls reading, thinking, learning, speech, and emotions.
- **Cerebellum—** The cerebellum controls balance and complex actions like walking and talking.
- **Brain Stem**— It controls hunger and thirst. It also controls breathing, body temperature, blood pressure, and other basic body functions**.**

BRAIN TUMORS (CANCER)

Cancer begins in cells, the building blocks that make up tissues. Tissues make up the organs of the body. Normally, cells grow and divide to form new cells as the body needs them. When cells grow old, they die, and new cells take their place. Sometimes this orderly process goes wrong. New cells form when the body does not need them, and old cells do not die when they should. These extra cells can form a mass of tissue called a growth or tumor. Brain tumors can be benign or malignant. Benign brain tumors do not contain cancer cells. Usually, benign tumors can be removed, and they seldom grow back. Cells from benign tumors do not invade tissues around them or spread to other parts of the body. However, benign tumors can press on sensitive areas of the brain and cause serious health problems. Unlike benign tumors in most

other parts of the body, benign brain tumors are sometimes life threatening. Very rarely, a benign brain tumor may become malignant[1].

Malignant brain tumors contain cancer cells. Malignant brain tumors are generally more serious and often is life threatening. The spread of cancer is called metastasis. The tumor may be contained within a layer of tissue or the bones of the skull or any another structure in the head may confine it. This kind of tumor is called encapsulated. Doctors sometimes group brain tumors by grade—from low grade (grade I) to high grade (grade IV). The grade of a tumor refers to the way the cells look under a microscope. Cells from high-grade tumors look more abnormal and generally grow faster than cells from low-grade tumors.

SYMPTOMS AND DIAGNOSIS OF BRAIN TUMORS

The symptoms of brain tumors depend on tumor size, type and location. It may be caused when the brain swells or fluid builds up within the skull. These are the most common symptoms of brain tumors as follows Headaches (usually worse in the morning), Nausea or vomiting, Changes in speech, vision, or hearing , Problems balancing or walking , Changes in mood, personality, or ability to concentrate , Problems with memory ,Muscle jerking or twitching (seizures or convulsions) , Numbness or tingling in the arms or legs , These symptoms are not sure signs of a brain tumor. Other conditions also could cause these problems[2].

Following are diagnosis methods of brain tumor.

Neurologic exam- The doctor checks for alertness, muscle strength, coordination, reflexes, and response to pain.

CT scan- An x-ray machine linked to a computer takes a series of detailed pictures of the head. The patient may receive an injection of a special dye so the brain shows up clearly in the pictures. The pictures can show tumors in the brain.

MRI—A powerful magnet linked to a computer makes detailed pictures of areas inside the body. Sometimes a special dye is injected to help show differences in the tissues of the brain. The pictures can show a tumor or other problem in the brain.

Biopsy- The removal of tissue to look for tumor cells is called a biopsy. A pathologist looks at the cells under a microscope to check for abnormal cells.

Nanorobotics- The technology of creating machines or robots at or close to the microscopic scale of a nanometre (10^{-9} metres). The interesting possibility that machines constructed at the molecular level (nano machines) may be used to cure the human body of its various ills. This application of nanotechnology to the field of medicine is commonly called as nanomedicine.

METHODS OF TREATMENT

Depending on the tumor type and stage, patients may be treated with surgery, radiation therapy, or chemotherapy. Some patients receive a combination of treatments. In addition, at any stage of disease, patients may have treatment to control pain and other symptoms of the cancer, to relieve the side effects of therapy, and to ease emotional problems. This kind of treatment is called symptom management, supportive care, or palliative care[3].

Surgery: Surgery is the usual treatment for most brain tumors. Surgery to open the skull is called a craniotomy. It is performed under general anesthesia. Patients who cannot have surgery may receive radiation or other treatment.

Radiation Therapy: Radiation therapy (also called radiotherapy) uses high-energy rays to kill tumor cells. The radiation may come from x-rays, gamma rays, or protons. The treatment schedule depends on the type and size of the tumor and the age of the patient. Each treatment lasts only a few minutes[6].

Chemotherapy: Chemotherapy, the use of drugs to kill cancer cells. It takes several weeks for the drug to kill the cancer cells.

INTRODUCTION OF NANOROBOT

Nanotechnology is a fascinating science for many scientists as it offers them many challenges. The proposed application of nanorobots can range from common cold to dreadful disease like cancer. It can be Pharmacyte, Respirocyte, Microbivores, Chromallocyte and many more. The study of nanorobots has lead to the field of Nanomedicine[4].

Nanorobots are theoretical microscopic devices measured on the scale of nanometers (1 nm equals one millionth of a millimeter). When fully realized from the hypothetical stage, they would work at the

atomic, molecular and cellular level to perform tasks in both the medical and industrial fields that have heretofore been the stuff of science fiction. (Fig 1). A doctor practicing nanomedicine would offer the patient an injection of a special type of nanorobot that would seek out cancer cells and destroy them, dispelling the disease at the source, leaving healthy cells untouched. The extent of the hardship to the patient would essentially be a prick to the arm. A person undergoing a nanorobotic treatment could expect to have no awareness of the molecular devices working inside them, other than rapid betterment of their health[5, 6].

Scientists report the exterior of a nanorobot will likely be constructed of carbon atoms in a diamondoid structure because of its inert properties and strength. Super-smooth surfaces will lessen the likelihood of triggering the body's immune system, allowing the nanorobots to go about their business unimpeded. Glucose or natural body sugars and oxygen might be a source for propulsion, and the nanorobot will have other biochemical or molecular parts depending on its task[7].

According to current theories, nanorobots will possess at least rudimentary two-way communication; will respond to acoustic signals; and will be able to receive power or even re-programming instructions from an external source via sound waves. A network of special stationary nanorobots might be strategically positioned throughout the body, logging each active nanorobot as it passes, and then reporting those results, allowing an interface to keep track of all of the devices in the body. A doctor could not only monitor a patient's progress but change the instructions of the nanorobots in vivo to progress to another stage of healing. When the task is completed, the nanorobots would be flushed from the body.

Design, shape, size and type of atoms, molecules, and computerized components included would be task-specific. Raw material for making the nanorobots would be nearly cost-free, and the process virtually pollution-free, making nanorobots an extremely affordable and highly attractive technology.

Although nanorobots applied to medicine hold a wealth of promise from eradicating disease to reversing the aging process (wrinkles, loss of bone mass and age-related conditions are all treatable at the cellular level), nanorobots are also candidates for industrial applications. In great swarms they might clean the air of carbon dioxide, repair the hole in the ozone, scrub the water of pollutants, and restore our ecosystems[8].

PROPERTIES OF NANOMEDICAL ROBOTS

Nanorobots will typically be 0.5 to 3 microns large with 1-100 nm parts. Three microns is the upper limit of any nanorobot because nanorobots of larger size will block capillary flow. The nanorobot's structure will have two spaces that will consist of an interior and exterior. The exterior of the nanorobot will be subjected to the various chemical liquids in our bodies but the interior of the nanorobot will be a closed, vacuum environment into which liquids from the outside cannot normally enter unless it is needed for chemical analysis. A nanorobot will prevent itself, from being attacked by the immune system by having a passive, diamond exterior. The diamond exterior will have to be smooth and flawless because this prevents Ieukocytes activities since the exterior is chemically inert and have low bioactivity. Nanorobots will communicate with the doctor by encoding messages to acoustic signals at carrier wave frequencies of 1-100 MHz. When the doctor gives a command to the nanorobots, the nanorobots can receive the message from the acoustic sensors on the nanorobots and implement the doctor's orders. These nanorobots can work together in response to environment stimuli and programmed principles to produce macro scale results[9].

Replication is a crucial basic capability for molecular manufacturing. However, in the case of nanorobots, we should restrict manufacturing to in vitro (in laboratory) replication. Replication in the body (in vivo) is dangerous because it might go out of control. If even replicating bacteria can give humans so many diseases, the thought of replicating nanorobots can present unimaginable dangers to the human body. When the nanorobots are finished with their jobs, they will be disposed from the body to prevent them from breaking down and malfunctioning[10].

NANOROBOT PARTS AND COMPONENTS

Nanobearings and Nanogears

One of the simplest examples is Drexler's overlap-repulsion bearing design, shown with end views and exploded views in Figure 2 using both ball-and-stick and space-filling representations. This bearing has 206 atoms of carbon, silicon, oxygen and hydrogen, and is composed of a small shaft that rotates within a

ring sleeve measuring 2.2 nm in diameter. The atoms of the shaft are arranged in 6 fold symmetry, while the ring has 14-fold symmetry, a combination that provides low energy barriers to shaft rotation.

Figure 3 shows an exploded view of a 2808-atom strained-shell sleeve bearing designed by Drexler and Merkle using molecular mechanics force fields to ensure that bond lengths, bond angles, Vander Waals distances, and strain energies are reasonable. This 4.8-nm diameter bearing features an interlocking-groove interface which derives from a modified diamond (100) surface. Ridges on the shaft interlock with ridges on the sleve, making a very stiff structure. Attempts to bob the shaft up or down, or rock it from side to side, or displace it in any direction (except axial rotation, wherein displacement is extremely smooth) encounter a very strong resistance. Molecular gears are another convenient component system for molecular manufacturing design-ahead. For example, Drexler and Merkle designed a 3557-atom planetary gear, shown in side, end, and exploded viewsin Figure 4. The entire assembly has twelve moving parts and is 4.3 nm in diameter and 4.4 nm in length, with a molecular weight of 51,009.844 daltons and a molecular volume of 33.458 nm^3.An animation of the computer simulation shows the central shaft rotating rapidly and the peripheral output shaft rotating slowly. The small planetary gears, rotating around the central shaft, are surrounded by a ring gear that holds the planets in place and ensures that all components move in proper fashion. The ring gear is a strained silicon shell with sulfur atom termination; the sun gear is a structure related to an oxygen-terminated diamond (100) surface; the planet gears resemble multiple hexasterane structures with oxygen rather than CH_2 bridges between the parallel rings; and the planet carrier is adapted from a Lomer dislocation array linked to the planet gears using C-C bonded bearings. Only when the gear was severely overdriven to 100 GHz did significant instabilities appear, although the device still did not self-destruct. One run at 80 GHz showed excess kinetic energy causing gear temperature to oscillate up to 450 K above baseline[11]. However, for a molecular system one could imagine that the gear is constructed and that the race is constructed all except for a last joining unit. The parts could be assembled and then the final connections on the face made to complete the design[12].

Nanomotors and Power Sources

Another class of theoretical nanodevice that has been designed is a gas-powered molecular motor or pump. The pump and chamber wall segment shown in Figure 5 contains 6165 atoms with a molecular weight of 88,190.813 daltons and a molecular volume of 63.984 nm^3. The device could serve either as a pump for neon gas atoms or (if run backwards) as a motor to convert neon gas pressure into rotary power. The helical rotor has a grooved cylindrical bearing surface at each end, supporting a screw threaded cylindrical segment in the middle. In operation, rotation of the shaft moves a helical groove past longitudinal grooves inside the pump housing. There is room enough for small gas molecules only where facing grooves cross, and these crossing points move from one side to the other as the shaft turns, moving the neon atoms along. The preliminary molecular dynamics simulations of the device showed that it could indeed function as a pump, although it is not very energy-efficient so further refinement of this initial design is warranted. [13].

Montemagno and Bachand modified a natural biomotor Using the tools of genetic engineering, they added metal-binding amino acid residues to ATPase, a ubiquitous enzyme whose moving part is a central protein shaft (or rotor, in electric-motor terms) that rotates in response to electrochemical reactions with each of the molecule's three proton channels (comparable to the electromagnets in the stator coil of an electric motor). Each motor molecule bonded tightly to nanoscale nickel pedestals prepared by electron beam lithography. Properly oriented motor molecules 12 nanometers in diameter were then attached to the pedestals with a precision approaching 15 nanometers, and a silicon nitride bar a hundred nanometers long was bound to the rotor subunit of each motor molecule, all by self-assembly.

Manufacturing Technology

The hardware architecture for a medical nanorobot must include the necessary devices for monitoring the most important aspects of its operational workspace: the human body. Depending on the case, different gradients on temperature, concentration of chemicals in the bloodstream, and electromagnetic signature are some of relevant parameters when monitoring patients. To reach this aim, data processing, energy supply, and data transmission capabilities can be addressed through embedded integrated circuits, using advances in technologies derived from nanotechnology and VLSI design. Manufacture nanorobots, where

the joint use of nanophotonic and nanotubes may even accelerate further the actual levels of resolution ranging from 248nm to 157nm devices[14].

Chemical Sensor

Manufacturing silicon-based chemical and motionsensor arrays using a two-level system architecture hierarchy has been successfully conducted before. Through the use of nanowires, existing significant costs of energy demand for data transfer and circuit operation can be decreased by up to 60%. CMOS-based sensors using nanowires as material for circuit assembly can achieve maximal efficiency for applications regarding chemical changes, enabling new medical applications. Sensors with suspended arrays of nanowires assembled into silicon circuits can drastically decrease self-heating and thermal coupling for CMOS functionality. Factors like low energy consumption and high-sensitivity are among some of the advantages of nanosensors. Passive and buried electrodes can be used to enable cross-section drive transistors for signal processing circuitry readout. The passive and buried aligned electrodes must be electrically isolated to avoid loss of processed signals. New materials such as strained channel with relaxed SiGe layer can reduce self-heating and improve performance. To further advance manufacturing techniques, Silicon-On-Insulator (SOI) technology has been used to assemble high-performance logic sub 90nm circuits[15].

Energy Supply

Electromagnetic radiation from light is used option for energy generation in determined open workspaces but not for in vivo medical nanorobotics, especially since lighting conditions. Kinetic energy can be generated from the bloodstream due to motion interaction with designed devices embedded with the nanorobot. Most recently, remote inductive powering has been used both for RFID and biomedical implanted devices to supply power on the order of milli watts. To operate nanorobots, a low frequency energy source may be enough. This functional approach presents the possibility of supplying energy in a wireless manner in order to operate sensors and actuators necessary for the controlled operation of nanorobots inside the human body. Nanocircuits with resonant electric properties can operate as a chip providing electromagnetic energy supplying 1.7 m at 3.3V for power, allowing the operation of many tasks with few or no significant losses during transmission. The energy received can be also saved in ranges of ~1μW while the nanorobot stays in inactive modes, just becoming active when signal patterns require it to do so. For communication, sending RF signals ~1mW is required. Allied with the power source devices, the nanorobots need to perform precisely defined actions in the workspace using available energy resources as efficiently as possible. A practical way to achieve easy implementation of this architecture will obtain both energy and data transfer capabilities for nanorobots by employing mobile phone in such process. The mobile phone should be uploaded with the control software that includes the communication and energy trans protocols[16].

Data Transmission

The application of devices and sensors implanted inside the human body to transmit data about the health of patients can provide great advantages in continuous medical monitoring. Most recently, the use of RFID for in vivo data collecting and transmission was successfully tested for electroencephalograms. For communication in liquid workspaces, depending on the application, acoustic, light, RF, and chemical signals may be considered as possible choices for communication and data transmission. Chemical signaling is useful for nearby communication among nanorobots for some teamwork coordination. Acoustic communication is more appropriate for longer distance communication and detection with low energy consumption as compared to light communication approaches. Although, optical communication permits faster rates of data transmission, its energy demand makes it not ideal for nanorobots. Work with RFID (Radio Frequency Identification Device) has been developed as an integrated circuit device for medicine. Using integrated sensors for data transfer is the better answer to read and write data in implanted devices. Mobile phones can be extremely practical and useful as sensors for acquiring wireless data transmission from medical nanorobots implanted inside the patient's body. It uses electromagnetic radio waves to command and detect the current status of nanorobots inside the patient. This occurs as a transponder device emits magnetic signature to the assive CMOS sensors embedded in the nanorobot, which enables sending and receiving data through electromagnetic fields. The nanorobots monitoring data

convert the wave propagation generated by the emitting signal through a well defined protocol. From the last set of events recorded in pattern arrays, information can be reflected back by wave resonance[17].

System Implementation

Simulation can anticipate performance and help in new device design and manufacturing, nanomechatronics control design and hardware implementation. The nanorobot design includes integrated nanoelectronics. The nanorobot architecture involves the use of mobile phones The nanorobot uses a RFID CMOS transponder system for in vivo positioning, using well established communication protocols which allow track information about the nanorobot position. The simulation includes the NCD (Nanorobot Control Design) software for nanorobot sensing and actuation. The nanorobot exterior shape consists of a diamondoid material, to which may be attached an artificial glycocalyx surface, that minimizes fibrinogen (and other blood proteins) adsorption and bioactivity, ensuring sufficient biocompatibility to avoid immune system attack. Different molecule types are distinguished by a series of chemotactic sensors whose binding sites have a different affinity for each kind of molecule. We simulate the nanorobot with sensory capabilities allowing it to detect and identify the nearby possible obstacles in its environment, as well as the biomedical target for its task, For instance, chemical detection can be very selective, e.g., for identifying various types of cells by markers[18].

System simulation

The development of microtechnology has lead on the 1980s to new tools for surgery, now nanotechnology will equally permit further advances providing better diagnosis, and new devices for medicine through the manufacturing of nanoelectronics. As a result from the advances on nanoelectronics, nanorobots may be considered a promising new technology to help with new treatments for medicine, here including improvement to assist patients who suffer from diabetes. (Fig 6)

The nanorobots are inside the vessel (with grid texture); they can be eitherobserved in 3D real time with or without the visualization of red blood cells. The bloodstream keeps the human body alive. Glucose carried through the blood stream is important to maintain the human metabolism working healthfully, and its correct level is a key issue in the diagnosis and treatment of diabetes. The simulated nanorobot prototype model has embedded CMOS nanobioelectronics. It features a size of ~2 micronmeter, which permits it to operate freely inside the body. The nanorobot computation is performed through embedded nanosensor; for pervasive computing, performance requires low energy consumption. Even with the immune system reaction inside the body, the nanorobot is not attacked by the white blood cells due biocompatibility. In the medical nanorobot architecture, the significant measured data can be then transferred automatically to the mobile phone[19].

NANOROBOT DRUG DELIVERY

Adriano Cavalcanti is CEO and chairman of CAN Center for Automation in Nanobiotech. Adriano and his colleagues have proposed a nanorobot platform should enable patient pervasive monitoring, and details are given in prognosis with nanorobots application for intracranial treatments. This integrated system also points towards precise diagnosis and smart drug delivery for cancer therapy. Fully operational nanorobots for biomedical instrumentation should be achieved as a result of nano bioelectronics and proteomics integration. The methodologies and the implemented 3D simulation described in our study served as a test bed for molecular machine prototyping. The numerical analysis and advanced simulations provided a better understanding on how nanorobots should interact inside the human body[20]. Hence, based on such information, we have proposed the innovative hardware architecture with a nanorobot model for use in common medical applications. The nanorobot takes chemical and thermal gradient changes as interaction choices for in vivo treatments. The use of mobile phones with RF is adopted in this platform as the most effective approach for control upload, helping to interface nanorobots communication and energy supply[21].

NANOROBOTS IN CANCER DETECTION AND TREATMENT

The development of nanorobots may provide remarkable advances for diagnosis and treatment of cancer. Nanorobots could be a very helpful and hopeful for the therapy of patients, since current treatments like radiation therapy and chemotherapy often end up destroying more healthy cells than cancerous ones. From this point of view, it provides a non-depressed therapy for cancer patients. The Nanorobots will be able to distinguish between different cell types that is the malignant and the normal cells by checking

their surface antigens (they are different for each type of cell). This is accomplished by the use of chemotactic sensors keyed to the specific antigens on the target cells. Another approach uses the innovative methodology to achieve decentralized control for a distributed collective action in the combat of cancer. Using chemical sensors they can be programmed to detect different levels of E-cadherin and beta-catenin in primary and metastatic phases. Medical nanorobots will then destroy these cells, and only these cells[22]. The following control methods were considered:

- Random: nanorobots moving passively with the fluid reaching the target only if they bump into it due to Brownian motion.
- Follow gradient: nanorobots monitor concentration intensity for E-cadherin signals, when detected, measure and follow the gradient until reaching the target. If the gradient estimate subsequent to signal detection finds no additional signal in50ms, the nanorobot considers the signal to be a false positive and continues flowing with the fluid.
- Follow gradient with attractant: as above, but nanorobots arriving at the target, they release in addition a different chemical signal used by others to improve their ability to find the target. Thus, a higher gradient of signal intensity of E-cadherin is used as chemical parameter identification in guiding nanorobots to identify malignant tissues. Integrated nanosensors can be utilized for such a task in order to find intensity of E-cadherin signals. Thus they can be employed effectively for treating cancer[23].

NANOPARTICLES KILL TUMORS IN THE BRAIN

Brain cancer is rare. But other types of cancers are not. Doctors know what drug to use, but they don't know how to target the tumor so the rest of the healthy cells won't be destroyed. Consider this: The researchers at the University of Michigan (U-M) Comprehensive Cancer Center have found a way to inject the drug Photofrin into nanoparticles, which in turn target the cancerous area -- a not too invasive process that resulted in the survival of brain cancer afflicted lab rats and extended their lifespans way longer than expected (fig 7). How does it happen? "Photofrin is drawn through the bloodstream to tumors. Doctors then use a special laser light to activate the drug, which collapses the blood vessels that feed the tumor. Without its blood supply, the tumor starves."We have seen but the tip of the iceberg! MIT scientists have devised remotely controlled nanoparticles that, when pulsed with an electromagnetic field, release drugs to attack tumors[24]. Here, dark gray nanoparticles carry different drug payloads (one red, one green). A remotely generated five-minute pulse of a low-energy electromagnetic field releases the green drug but not the red. A five-minute pulse of a higher-energy electromagnetic field releases the red drug, which had been tethered using a DNA strand twice as long as the green tether, as measured in base pairs[25]. Once you've identified a group of cells that needs some chemical substance delivered to it, you can simply release the agent from onboard tanks after the nanorobot arrives on the scene. A 1 cm^3 injection of 1-micron nanodevices could probably hold at least 0.5 cm^3 of chemical agent. Virtually all of these billions of nanites (in the 1 cm^3) will be smart enough to show up at the correct group of cells that are targeted for destruction, so delivery efficiency is virtually 100%. Onboard sensors can test for ambient levels of the chemical agent, to prevent overdose[26].

CONCLUSION

Nanotechnology-based cancer therapeutics and diagnostics, over the past decade, has evolved from nano-sized drug particles to functional nanomaterials that are capable of delivering heat, ionizing radiation and chemotherapeutic agents. Currently these are the only nanotechnology innovations that are feasible in terms of improvised treatment and cost-effectiveness. By incorporating multidisciplinary engineering innovations in nanotechnology, an avenue for development of enhanced, miniaturized and low cost diagnostic/imaging instruments and treatment machines has opened. The future possibility of tackling "pain- the bitter side of cancer therapy", through nanotechnology would be considered one of the biggest breakthroughs. miniaturized technologies (within sub millimeter and sub-micron) from diverse and interdisciplinary engineering sectors of electronics, mechanical and robotics, which can open new horizons in revolutionizing existing methods of cancer study, diagnosis and treatment. Strong initiatives and new evolved policies should be formed by the Health Departments in collaborations with relevant government or private organizations to provide subsidized cancer nanotechnology therapeutics. The

subsidy should also be extended to innovations from non-nanotechnology sector, which support and/or enhance the performance of cancer nanotechnology innovations.

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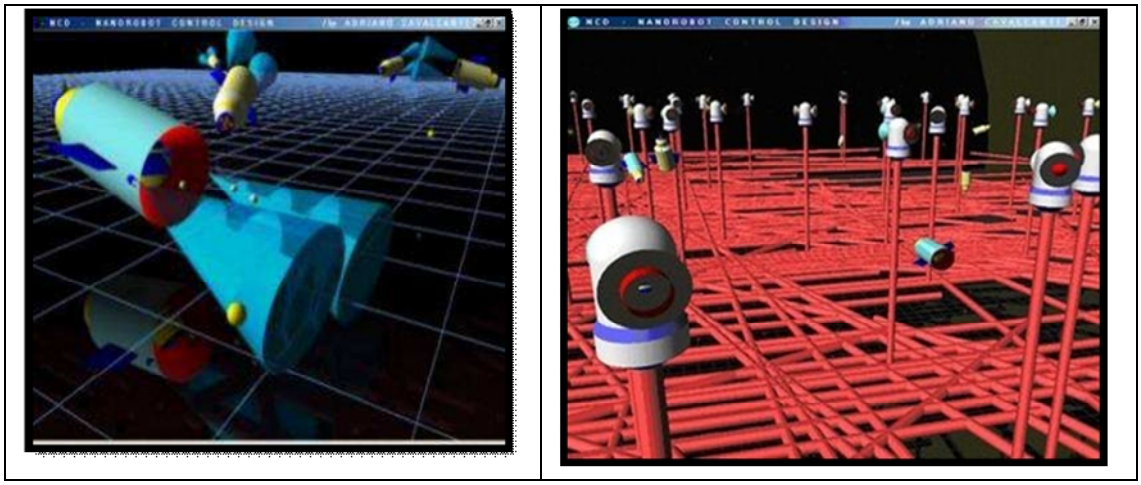
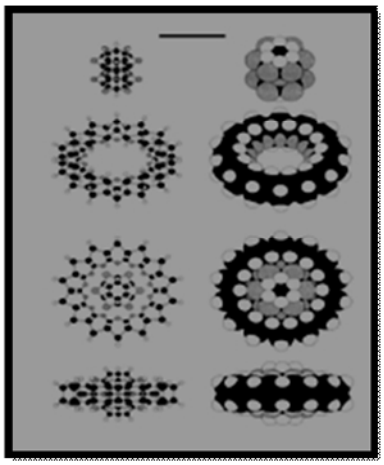


Fig 1: Nanorobots



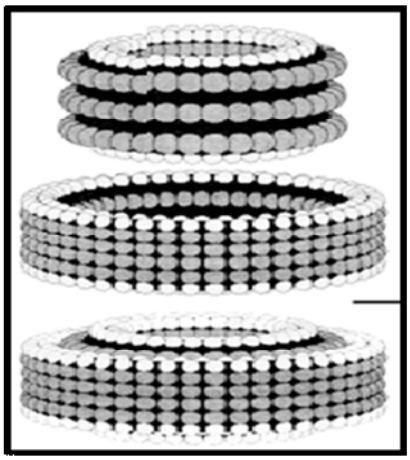


Fig2. End views and exploded views of a 206-atom overlap-repulsion bearing. Fig.3. Exploded view of a 2808-atom strained-shell sleeve bearing.

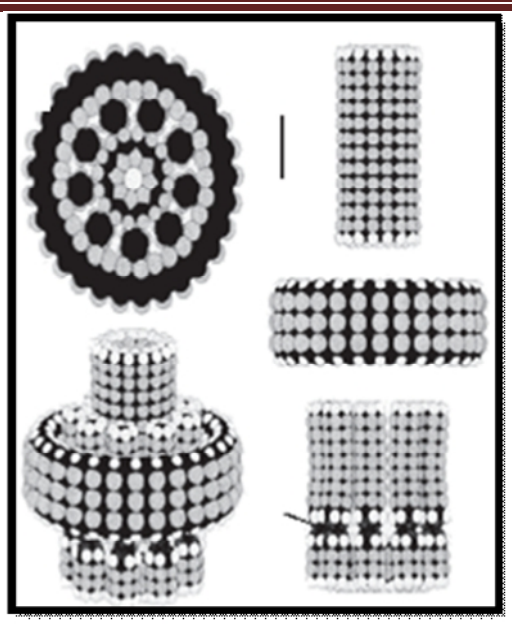
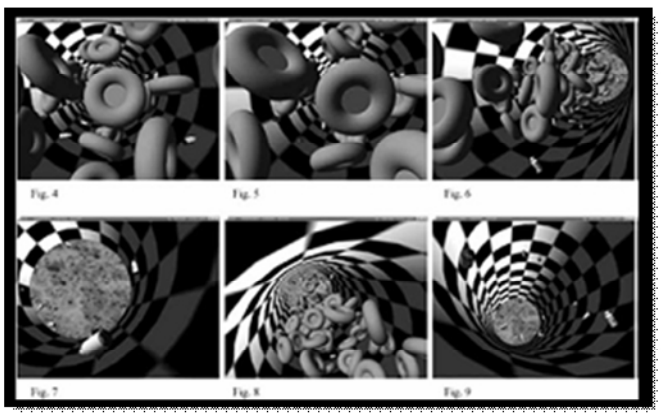


Fig 4. End side and exploded-view of a 3557-atom planetary gear.

Fig 5. Side views of a 6165-atom neon gas pump/motor.



Figs.6: (4-9) Set of different camera views in the simulator.

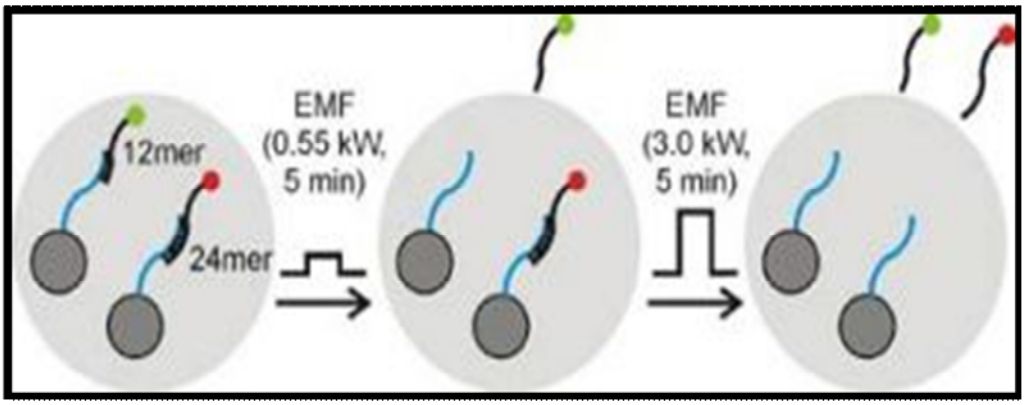


Fig 7: Nanoparticles kill tumors in the brain