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A Critical Review on Nanorobotics: An Emerging Tool in Medical Field

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ABSTRACT

Changes in human behavior and lifestyle over the last century have resulted in a dramatic increase in diseases world-wide and the health care industry is focusing on developing minimum invasive techniques for diagnosis, prevention, and treatment. Nanotechnology is likely to have a significant impact in different fields like medicine, electronics, etc. One such technique flourishes robots using nanotechnology which are mainly known as nanorobotics. Nanorobotics is an emerging technology that performs a specific task with precision at nanoscale dimensions. Nanobots are good applicants for advancement treatments with their size being very small. Nanobots are used for drug delivery systems and as a contrast agent. Nanorobots are specially used for the treatment of Alzheimer's disease and cancer. Present-day treatment includes surgeries that are considered to be outdated when compared to today's technology. One of the novel therapeutic technological concepts in nanorobotics includes the application of Respirocytes and microbivores.

INTRODUCTION TO NANOTECHNOLOGY

The 21st century's most hopeful technology is nanotechnology. Nanotechnology is a collective term that refers to the technological developments on the nanometer scale. The term 'Nanotechnology' generally refers to the science of engineering and technology conducted at the nanoscale which is about 1-100nanometeres. Nanotechnology is the study of extremely very small structures. The prefix "nano" is derived from a Greek word which means "dwarf". The word "nano" suggests that very small or miniature size. Nanotechnology is the treatment of individual atoms molecules or compounds into structures to produce materials and devices with a special property. Nanotechnology involves work from top-down or bottom-up that is reducing the size of the large structure to the smallest structure.

Nanotechnology is a multidisciplinary field, converges of basic sciences and applied disciplines like bio-physics molecular biology, and bio-engineering. It has created a powerful impact on fields like cardiology, ophthalmology, oncology, pulmonology, immunology, etc, and on highly specialized areas like gene delivery, brain targeting, tumor targeting, and oral vaccine formulation. Size reduction may be a fundamental unit operation having important applications in pharmacy. It helps in improving solubility and bioavailability, reducing toxicity, enhancing release, and providing better formulation opportunities for drugs. [1]

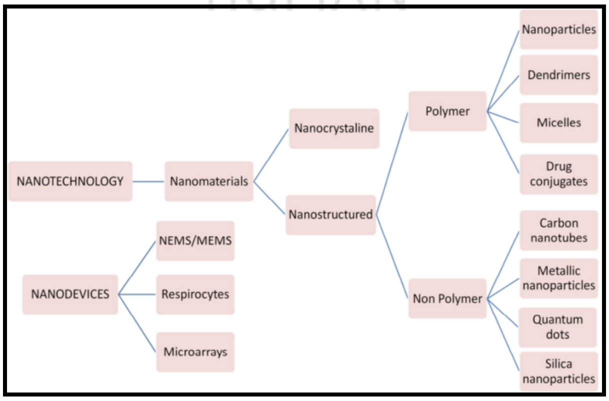


Figure No. 1: Schematic diagram of various types of pharmaceutical nanosystem

Pharmaceutical nanotechnology has provided additional fine-tuned diagnosis and focused treatment of disease at a molecular level. Pharmaceutical nanotechnology is the most innovative in the highly specialized field which will revolutionize the pharmaceutical industry in near future. Pharmaceutical nanotechnology presents revolutionary opportunities to fight against diseases. It helps in detecting the antigen associated with diseases such as cancer, diabetes mellitus, neurodegenerative diseases as well as detecting the microorganisms and viruses associated with infections. The current application of nanotechnology in pharmacy is the development of nanomedicine, tissue engineering, nanorobotics, as a carrier of diagnostic and therapeutic modalities and as a biosensor biomarker, image enhancement device, implant technology, bioactive surfaces, etc.

NANOTECHNOLOGY IN DRUG DELIVERY:

Nanotechnology can be used to overcome the poor bioavailability of drugs. Using a nano-drug delivery system significantly improves drug delivery. Being very small in size nanoparticles are taken up by the cells, unlike other bigger elements that are discarded that could force a patient to take higher doses. On the other hand, with nanoparticles prolonged targeted action of the drug can be achieved possibly reducing the drug dose. Moreover, nano drugs have the advantage of faster dissolution which leads to greater bioavailability. Smaller drug doses diminished toxicity and decreased dosing variability. One of the major impacts of nanoscience is the development of completely new forms of drugs.[2]

APPLICATION OF NANOTECHNOLOGY

- Cancer treatment: Nanotechnology can have a revolutionary impact on cancer diagnosis & therapy. It offers tremendous opportunities to aid & improve these conventional therapies by its nanotools.

- Implantable delivery systems: Nanotechnology is opening to new opportunities in implantable delivery system Some pharmaceutical novel nano-drug vascular carriers like ethosomes, transfer some, and some implant chips have been envisaged recently which may help in minimizing peak plasma level and decrease ADR.

- Nanotechnology in the treatment of neurodegenerative disorder: For the delivery of CNS therapeutics, various nanocarriers have been used. For the management of CNS condition such as Alzheimer’s disease, brain tumor, HIV, encephalopathy, and acute ischemic stroke has become possible.

- Gene therapy: In gene therapy, a normal gene is inserted in the place of an abnormal gene Conventional uses of viral vectors are associated with adverse immunologic, inflammatory reactions, and diseases in the host.[3]

NANOROBOTS

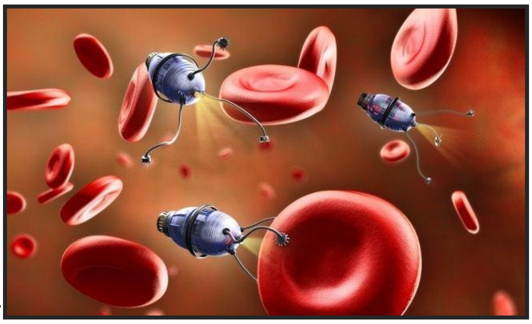
:

Figure No. 2: Nanorobots

The essence of nanotechnology is the ability to work at the molecular level, atom by atom, and to create large structures with the fundamentally new molecular organization. The main aim is to exploit the properties by gaining control of structures and devices at atomic, molecular, and supramolecular levels and to learn efficiently manufacture and use of these devices. Nanorobotics is a part of nanotechnology which deals with the study of designing, programming, manufacturing, and controlling of robots at the nanoscale. It refers to the hypothetical nanotechnology engineering discipline of designing and constructing nanorobots of size ranging from 0.1-10 µm. A nanorobot is an extremely small robot designed to perform a specific task with precision at nano-scale so they are known as nanorobots or nanoids. In the construction of nanorobotics, carbon will likely be the principal element used in the construction of nanorobot and comprised probably in the form of diamond/ diamondoid or fullerene nanocomposites. A nanorobot is often made of mechanical components such as bearing, gears, motors, etc. The outer shell of a nanorobot is constructed using diamondoid material because of its inert properties, high thermal conductivity, and strength. The super-smooth surfaces could reduce the chances of triggering the body's immune system. The nanoscale gears and other components designed for special purposes could be constructed using elements like hydrogen, sulfur, oxygen, carbon, nitrogen, silicon, etc. [4,5]

COMPONENTS OF NANOROBOTS

The various element in nanorobot includes power supply, motors, manipulators, onboard computers, fuel buffer tank, sensors, pumps, pressure tanks, and structural support. The substructures in a nanorobot include:

- **Payload:** This section holds a small dose of drug/medicine. The nanorobots could transverse within the blood and release the drug to the site of infection/injury.

- **Micro camera:** The nanorobot may contain a miniature camera. The operator will steer the nanorobot once navigating through the body manually.

- **Electrodes:** The electrode mounted on the nanorobot can form the battery using the electrolytes within the blood. These protruding electrodes generate an electric current to kill the cancer cell and heating the cells to death.

- **Lasers:** These will burn harmful material like arterial plaque, blood clots, or cancer cells.

- **Ultrasonic signal generators:** These generators are used to target and destroy kidney stones.

- **Swimming tail:** They need propulsion to get into the body as they travel against the flow of blood within the body.[6,7]

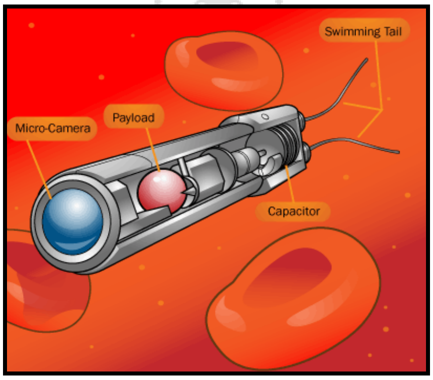


Figure No. 3: Structure of nanorobots

IDEAL CHARACTERS OF NANOROBOTS

- Nanorobot working in tissue could be as large as 0.5-3 microns, whereas one in the bloodstream needs to be 500-3000 nm.

- Injection of a dose of 3 cubic cm would be acceptable for the human body.

- It can communicate with the doctor by encoding a message to acoustic signals at the radio wave frequency of 1-100 MHz It might produce multiple copies of it to interchange units, and this method refers to as called self-replication.

- After the completion of the task, it can be retrieved by allowing it to fuse them via the usual human excretory channel or can also be removed by an active scavenger's system.

- The surface of nanorobots should be nanorobots to be made with smooth, flawless, diamond surfaces.

- The shape should be Flexibility which would make it easier for the device to enter the cytoplasm, affect micro hydrodynamic stability, and more.[10]

MECHANISM OF NANOROBOTS

The target has surface chemicals permitting the nanorobots to notice and acknowledge it to producing higher sensors and actuators with nanoscale sizes make them notice the supply of unleashing of the chemicals. NCD machine was developed, which is a package for nanorobots in environments with fluids dominated by Brownian movement and viscous instead of mechanical phenomenon forces. First, as some extent of comparison, the scientists used the nanorobots little Brownian motions to search out the target by random search. in an exceedingly second methodology, the nanorobots monitor for chemical concentration considerably on top of the amplitude. once sleuthing the signal, a nanorobot estimates the concentration gradient and moves toward higher concentration till it reaches the target. Within the third approach, nanorobots at the target unleash another chemical, that others use as an extra guiding signal to the target. With these signal concentrations, solely nanorobots passing inside some microns of the target area unit doubtless to notice the signal.[11]

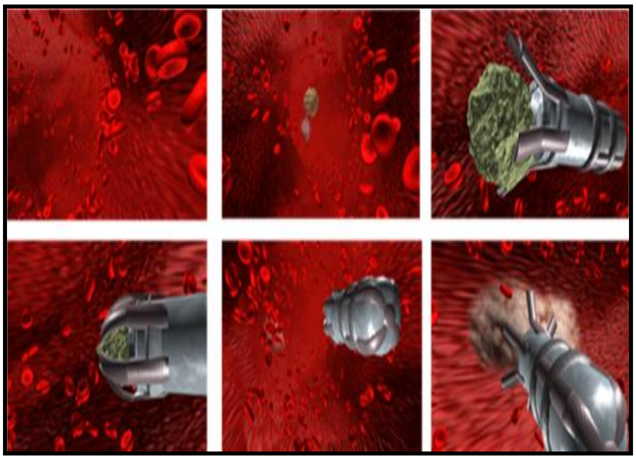


Figure No. 4: Mechanism of nanorobots

METHODS OF NAVIGATION

1) Positional: Where the nanorobot knows its place in the bod.

2) Functional: Where the nanorobot detects delicate variations in the environment to compare to a set of predefined conditions.

ADVANTAGES

- It additionally minimizes surgeon mistakes. Computer-controlled drug delivery and larger speed of drug action area unit its sublimity.
- It can monitor neuro-electric signals and stimulate bodily systems.
- Nanorobots can treat and restore lost tissue at the cellular level.
- Nanobots area unit is specific and correct with fewer facet effects that unleash medicine in a very controlled manner.
- Nanorobots will cure several senior ill-patients and renew their lives. HIV, cancer, and different harmful unwellness are beneath progress for the natural process.
- Provide speed and longevity and for drug deliver.
- Helpful for watching, identification, and fighting illness.
- Will treat and notice unwellness and restore lost tissue at the cellular level.[14]

DISADVANTAGES

- The initial design cost and installation cost is high.
- The design is very complicated and maintenance is difficult.
- The most daunting obstacle is the power supply.
- Electrical systems may create stray fields which may activate bioelectric-based molecular recognition systems in biology.

- Nanorobotics self-replicate and our immune system can be challenged if we depend a lot on nanotechnology.

- A cluster of different nanorobots is harmful.

- If the nanobots are misused by terrorists, it could even be used as bio-weapons and may become a threat to society.[8]

TYPES OF NANOROBOTS

The types of nanorobots designed by Robert A. Freitas Jr in the late 1990s as artificial blood are: Respirocytes, Microbivores, Clottocytes.[9]

1. RESPIROCYTE

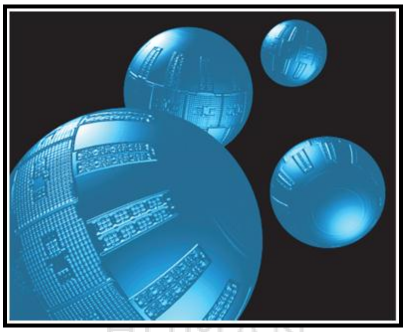


Figure No. 5: Respirocyte body

Respirocytes are the nanorobots designed as artificial mechanical RBC which are spherical and have a diameter of 1 µm. The outer shell is made up of a diamonded 1000 atm pressure vessel with a reversible molecule-selective pump. Respirocytes carry CO_2 and oxygen and carbon dioxide throughout the body. The Respirocytes is made up of 18 billion atoms that area unit exactly organized in a very diamondoid pressure tanks that may store up to 3 billion oxygen and carbon dioxide molecules. The respirocyte would deliver 236 times a lot of oxygen to the body tissues when compared to natural RBC. The respirocyte might manage the carbonous acidity which can be controlled by gas concentration sensors and an onboard nanocomputer. The stored gases are released from the tank in a very controlled manner through molecular pumps. The respirocyte exchange gases through molecular rotors.[5]

FUNCTIONALITY: For working a respirocyte would need the following components:

1. Molecular rotors: It is built from around 100,000 atoms, to pump gases in and out of the pressurized storage chambers, and collect glucose for energy. These would be functionalized with selective binding sites, restricting them from pumping all.

2. A power generator: It is similar in operation to a fuel cell, which would use glucose collected by a selective pump rotor to generate enough energy to power the device.

3. Water ballast chambers: It is used to control buoyancy.

4. Sensors: It is used to determine the concentrations of oxygen and carbon dioxide in the vicinity, and monitor the pressure within the gas storage tanks.

5. A tiny computer: It would be needed to interpret input from the sensors, and use the data to govern gas flow rates and power distribution. The computer would need only modestly processing power, by the standard of normal-sized computers, but the computing core and the data storage would have to fit inside a unit 124 nm across.

6. Pressure transducers: It is used as a receiver for programming instructions, sent by a physician via an encoded series of compression pulses.

7. Pressure Vessel: Given the goal of oxygen transport from the lungs to alternate body tissues, the simplest design for an artificial respirocyte is a microscopic pressure vessel.

8. Molecular Sorting Rotors: The key to successful respirocyte function is an active means of exchanging gas molecules into, and out of, pressurized microvessels. Molecular sorting rotors have been proposed that may be ideal for this task. Each rotor has binding site "pockets" along the rim is exposed alternately to the blood plasma and interior chamber by the rotation of the disk.

9. Device Scaling: The upper limit of physical device size is simple to specify because respirocyte must have prepared to access all tissues through blood vessels. They cannot be larger than human capillaries. The minimum possible respirocyte diameter is driven by operational necessities and by the minimum element size.[15]

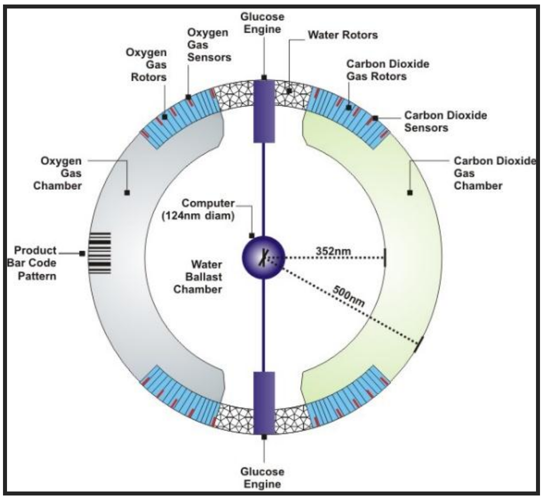


Figure No. 6: A proposed design for a respirocyte.

MECHANISM: Respirocytes consist of an oxygen vessel that contains oxygen gas, another is a carbon dioxide vessel that stores carbon dioxide and the third is a water ballet that helps to maintain buoyancy. There are specific rotors for the performance of controlled uptake and release of oxygen and carbon dioxide. There is also a rotor that enables the passage of glucose into the device, which is combined with the oxygen from the internal storage tank to supply the energy needed for the operating of respirocyte. This is often done by an embedded fuel cell. Respirocyte consists of an assembled repair vessel that is inbuilt within the human body to perform the maintenance of genetics by floating inside the nucleus. One vessel contains oxygen gas, another is a carbon dioxide vessel that stores carbon dioxide, and the third is a water ballet that helps to maintain buoyancy.[13]

HOW IT WORK: Respirocytes exchange gasses via molecular sorting rotors. The rotors have specially shaped tips to catch particular types of molecules. Gas molecules are stored tightly in tanks. Each respirocyte has three types of rotors. One gathers oxygen at the lungs or in production before introduction to the body and releases it and travel throughout the body. Another captures carbon dioxide while in the bloodstream and releases it at the lungs. The third take in glucose from the blood, that is burned during a reaction similar to cellular respiration to power the respirocyte. 12 identical pumps laid around the equator where the oxygen rotors on the right, water rotors in the middle, and carbon dioxide rotors in the left. There are gas concentration sensors that are on the surface of the respirocyte. When the respirocyte passes through the lung capillaries, oxygen partial pressure will be high and carbon dioxide partial pressure will be low, therefore the onboard nanocomputer commands the sorting rotors to load in oxygen and release of the carbon dioxide molecules. The water ballast chambers aid in maintaining buoyancy. The respirocytes are programmed to scavenge carbon monoxide and other poisonous gases from the body.[16]

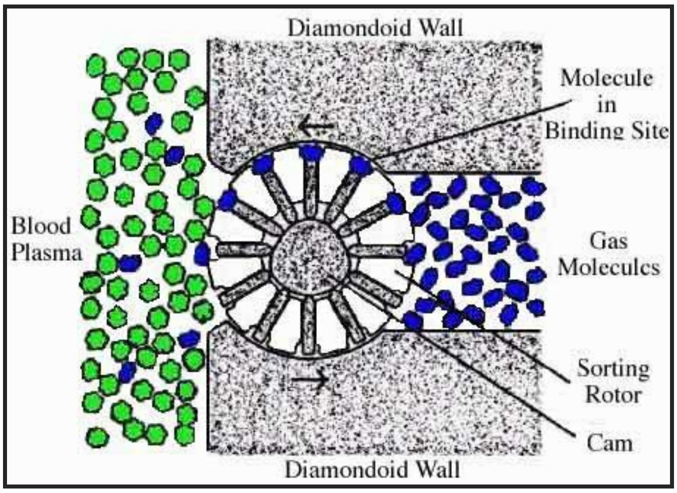


Figure No. 7: Gas exchange in Respirocytes

ADVANTAGES:

1. The great benefit could be derived from the rapid treatment of patients in trauma situations. Because these blood substitutes don't contain any of the antigens that can determine blood type, they can be used across all types without any immunological reaction.

2. Transfused blood is currently more cost-effective, but there are reasons to believe this may change. For example, the price of blood substitutes could fall as producing becomes refined.

3. Blood substitutes allow for immediate full capacity oxygen transport, as opposition transfused blood which might require about 24 hrs. to succeed full oxygen transport capacity due to 2,3-di phosphoglycerate depletion.

4. Blood substitutes can be stored for much longer than transfusable blood, and might kept at room temperature. Most hemoglobin-based oxygen carriers in trials nowadays carry a shelf life of between 1 and 3 years, compared to 42 days.

DISADVANTAGES:

1. The improvement of human performance made possible by respirocyte which could cause the body to overheat.

2. Only with actual testing of nanotechnological Respirocytes in a living body will determine for certain exactly however these devices can behave in the real world.

APPLICATION:

1. Transfusions & Perfusions: Respirocytes are used because of the active oxygen-carrying component of a universally transfusable blood substitute that's free of disease vectors like hepatitis, venereal disease, malarial parasites, or AIDS.

2. Treatment of anemia: Respirocytes in oxygenated from help to treat all forms of anemia, including acute anemia caused by a sudden loss of blood after injury or surgical intervention.

3. Cardiovascular and neurovascular application: Perfusion of Respirocytes should be useful in maintaining tissue oxygenation during coronary angioplasty, organ transplantation, and Siamese-twin separation and in cardiopulmonary bypass solutions.

4. Tumor therapy and diagnosis: The formulation of Respirocytes are used to probe tissue oxygen tension. Respirocytes may be used as informer devices to map a patient's whole-body blood pressure or oxygenations profile storing direct sensor data on each computer.

5. Asphyxia: Respirocytes enhances and support breathing in case of oxygen-poor environment or where normal breathing is physically not possible.

6. Underwater breathing: Respirocytes can act as in vivo scuba device. Their product relives in simple of dangerous hazards of deep ocean diving caisson disease, the nitrogen bubbles are formed in blood as t diver rises to the surface, from gas previously dissolved in the blood at a higher pressure in the greater depth. Respirocytes can act as long-duration perfusion to preserve living tissues.[17]

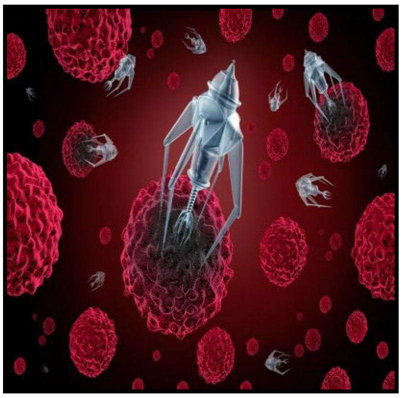


Figure No. 8: Diagrammatic representation of a respirocyte

2. MICROBIVORES

Microbivores are the nanorobot that functions as an artificial white corpuscles cell and conjointly referred to as nanorobotic phagocytes. The microbivore may be a spheroid device created from diamond and sapphire that measures 3.4 µm in diameter on its major axis and a pair of 2.0 µm diameter along the minor axis and consists of 610 billion exactly arranged structural atoms. It traps within the pathogens present in the bloodstream and breaks down into smaller molecules. The main function of microbivore is to absorb and digest the pathogens within the bloodstream by the method of phagocytosis. The microbivore includes of 4 fundamental components:

i. An array of reversible binding sites.

ii. An array of telescoping grapples.

iii. A morcellation chamber.

iv. Digestion chamber.

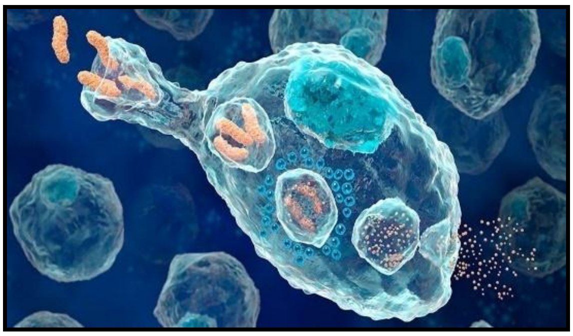


Figure No. 7: Microbivore phagocytic action

NEED OF MICROBIVORE: The existing treatments for many septicemic agents often require large quantities of medications that must be applied over a long period, often achieve only incomplete eradication of bloodborne pathogens using relatively low doses of devices which can be an additional welcome to the physician's therapeutic armamentarium. It is designed to treat septicemia (blood poisoning). Microbivores would be a class of medical nano-robots, made of a diamondoid arrangement of the atom that targets harmful pathogen within the bloodstream.[18]

HOW IT WORKS: The principal activity that drives microbivore scaling and design is that the method of digestion of organic substances. The microbivore digestive system has 4 fundamental components:

1) An array of reversible binding sites to initially bind.

2) Trap target microbes with an array of telescoping grapples to control the microbe, once trapped.

3) A morcellation chamber during which the microbe is minced into small, simple digested pieces.

4) A digestion chamber wherever the small pieces are chemically digestible.

During every cycle of operation, the target microorganism is sure to the surface of the microbivore like a fly on flypaper, via species-specific reversible binding sites. Telescoping robotic grapples emerge from silos within the device surface; establish secure anchorage to the microbe's cell membrane, then transport the microorganism to the ingestion port at the front of the device wherever the pathogen cell is internalized into 2-micron morcellation chamber. When adequate mechanical mincing, the morcellated remains of the cell are pitoned into a 2-micron digestion chamber where a preprogrammed sequence of 40 engineered enzymes are injected and extracted six times, progressively engineered enzymes are successively injected and extracted six times, progressively reducing the morcellate ultimately to nonresidue amino acids, mononucleotides, glycerol, free fatty acids, and simple sugars.

These simple molecules are then harmlessly discharged back to the bloodstream through an exhaust port at the rear of the device, finishing the 30-second digestion cycle. This "digest and discharge" protocol is conceptually similar to that of the internalization and digestion process practiced by natural phagocytes, except that the artificial process should be much faster and cleaner.

When treatment is finished, the doctor may transmit an ultrasound signal to inform the circulating microbivores that their work is finished. The nanorobots then exist in the body through the kidneys and are excreted with the urine in due course. The microbivore desires a variety of external and internal sensors to complete its tasks. External sensors embrace chemical sensors for glucose, oxygen, and carbon dioxide. Pressure sensors for acoustic communication are mounted within the nano-robot hull to permit the microbivore to receive external direction from the attending physician throughout in-vivo activities.

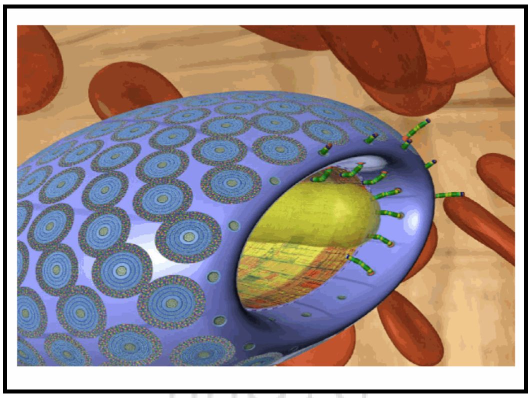


Figure No. 8: Structure of Microbivore

ADVANTAGES: Microbivores offer faster, more effective treatment for septicemia. It can be applied as sterilization agents or as a valuable tool in the molecular biopsy. Microbivore can be used in biopsy to detect and capture a potential pathogen. It decreases the need for broad-spectrum antibiotics like ampicillin, which can indiscriminately destroy helpful, naturally occurring bacteria in the body. The design for Microbivores could potentially be applied to create artificial red blood cells and platelets as well.[19]

DISADVANTAGES: The most significant risk posed by Microbivores is the potential for the long flagellar tails of bacteria to become severed during insertion into the ingestion port, releasing the immunogenic tail into the bloodstream. Microbivores are also at risk of being attacked by the body's natural phagocytes, decreasing their effectiveness, and producing an unnecessary immune response from the body.

APPLICATION: Microbivores are useful in the treatment of infections of the meninges and the cerebrospinal fluid (CSF). They are used in systemic inflammatory cytokine management and by slight alteration they can also be used to digest bacterial biofilms and in the treatment of bacterial infections of other fluids and tissues. Other variants of microbivores could patrol tissues, organs, pleural, synovial, or urinary fluids, pursuing bacteria as they disseminate beyond the bloodstream. Vasculomobile microbivores could follow cytokine gradients and collect at the sites of infection, thus increasing their microbicidal efficiency. Microbivores could also be used to rid the blood of viral pathogens, which are typically present during viremia. Fungemia's involving particle loads of 1-1000 CFU/ml are rapidly cleared by microbivores.[12]

3. CLOTTOCYTES

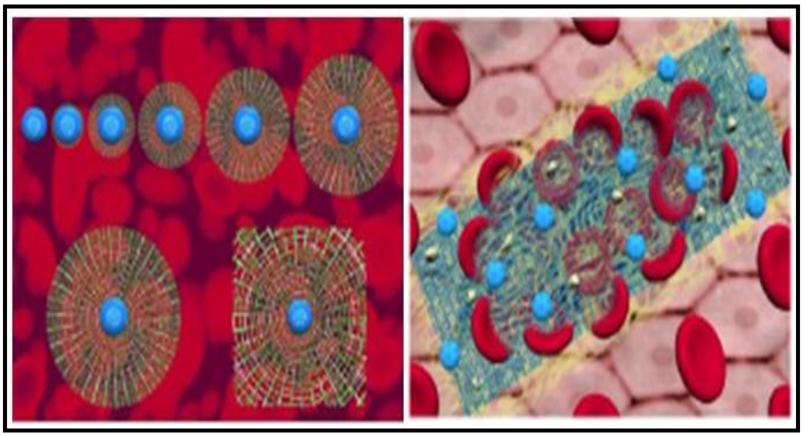


Figure No. 9: Structure of Clottocytes

Hemostasis is the process of blood clotting when there is damage to the endothelium cells of blood vessels by platelets. These platelets can be activated by the collision of exposed collagen from damaged blood vessels to the platelets. The whole process of natural blood clotting can take 2-5 minutes. The nanotechnology has shown the capabilities of reducing the clotting time and reducing blood loss. In certain patients, blood clots are found to occur irregularly. This abnormality is treated using drugs such as corticosteroids. The treatment with corticosteroids is associated with side effects such as hormonal secretions; blood/platelet could damage lungs and allergic reactions.[5]

The theoretically designed clottocyte describes artificial mechanical platelet or clottocyte that may complete hemostasis in about 1 sec. Its spherical nanorobot is powered by serum-ox glucose about a pair of 2 µm in diameter containing a fiber mesh that's compactly folded onboard. The time interval of clottocyte is 100-1000 times quicker than the natural hemostatic system. The fiber mesh would be biodegradable and upon unharness, a soluble film coating of the mesh would dissolve in contact with the plasma to show sticky mesh.

Reliable communication protocols would be needed to regulate the coordinated mesh release from unharness from the neighboringClottocytes and conjointly to control the multidevice-activation radius within the local clottocyte population. As clottocyte-rich blood enters the injured blood vessel, the onboard sensors of clottocyte quickly detect the modification in partial pressure, usually indicating that it bled out of the body. If the primary clottocyte is 75 μm far away from the air-serum interface, oxygen molecules from the air diffuse through human body temperature. This detection would be broadcasted quickly to the near Clottocytes through acoustic pulses. This permits the rapid propagation of a carefully controlled device-enablement cascade. The stickiness within the fiber mesh would be blood group-specific to trap blood cells by binding to the antigens present on blood cells. Each mesh would overlap on the neighboring mesh and attract the red blood cells to immediately stop bleeding. Researches area units still occur during this regard.[20]

APPLICATION

APPLICATION OF NANOROBOTS IN MEDICINE

- **Nanorobotics in Surgery:** Surgical nanorobots are mainly introduced into the human body through vascular systems and other cavities. Surgical nanorobots perform various functions like searching for pathogens and then diagnosis and correction of lesions by nano-manipulation synchronized by an on-board computer while conserving and contacting with the supervisory surgeon through coded ultrasound signals.

- **Diagnosis and Testing:** Medical nanorobots are mainly used for diagnosis, testing, and monitoring of microorganisms, tissues, and cells within the bloodstream. These nanorobots are capable of noting down the record and report some important signs such as temperature, pressure, and immune system's parameters in different parts of the human body.

- . **Nanorobotics in Gene Therapy**: Nanorobots are also applicable in treating genetic diseases, by relating the molecular structures of DNA and proteins within the cell.

- **. Nanorobots in Cancer Detection and Treatment:** Nanorobots with embedded chemical biosensors can be used to detect the tumor cells in the early stages of development inside the patient's body. Nanorobots could also carry the chemicals used in chemotherapy and to treat cancer directly at the site.

- **Diagnosis and treatment of diabetes:** The glucose monitoring nanorobot uses the chemosensor which involves the modulation of hSGLT3 protein glucose-sensor activity. These chemical sensors will effectively determine the need for insulin within the body and inject.

- **Dentistry:** The nanorobots designed for dental treatment are known as dentifrobots. These nanorobots will induce oral analgesia, desensitize teeth, manipulate the tissues to realign and straighten irregular set of teeth.[13]

WAYS IN WHICH NANOBOTS CHANGES THE FUTURE

- **Detect Bacteria:** Nanobots will be able to detect the presence of bacteria and other microbes in the human body, which determine what kind of response should be set based on the kind of infection.

- **Determines the Effectiveness of Drugs:** One of the biggest challenges in medicine is to figure out the effect that a particular medicine is having on the patient so that the medical expounder can tackle the problem by decreasing the side effects. Moreover, determining the effectiveness of the medicine is important because it allows the medical expounder to know how to treat the patient as early as possible.

- **Detect Particular Chemicals:** Nanobots will be able to detect the presence of particular chemicals in the human body, which will provide crucial information to medical expounders about the condition of the patient so that it can be used to ensure more efficient and effective treatment.

- **Clear Blocked Blood Vessels:** There is a lot of interest coming up with potential solutions as well as potential preventatives for cardiovascular disease which is one of the most common killers. Theoretically, blockages in blood vessels that are responsible for both strokes and heart attacks can be cleared by using nanobots. But practically, if these bots are not able to wholly solve the problem, they can reduce the chances of dying from either one of those conditions, which will be an incredible improvement even.

- **Serve as Antibodies:** Nanobots are used to boost the existing antibodies for individuals with weak immune systems who cannot manage all the bacteria and other microbes. Here, the nanobots used to potentially destroy the dangerous foreign substances in the human body. Alternatively, this consists of the nanobots that direct the existing immune processes at the sources of danger.

- **Clean Up Pollution:** In the future, it might be possible to use nanobots to clean up pollutions, thus restoring polluted environments to a clean and virgin condition. Inspecting the impacts that pollution will cause the health of entire ecosystems together with human health. Nanobots can be considered as an inestimable boon because nanobots would be deployable in toxic sites therefore reducing the risk to human counterparts.[18]

SUMMARY

In the field of medicine, the use of nanorobotics includes a wider scope than any other sub-field that has emerged to date. It provides enormous benefits over conventional medicine such as lower cost, quicker recovery, and low or almost no invasion. The nanorobotics exhibit strong potential to diagnose and treat various medical conditions like cancer, heart attack, arteriosclerosis, diabetes, kidney stones, etc. The nanorobot can allow us a personalized treatment, hence can achieve high efficacy against many diseases. Thus, nanorobotics is an ideal field to explore progressively. The Respirocytes would be 236 times faster when compared to normal RBC. The microbivore is an oblate spheroidal nanomedical device Used to measure 3.4 microns in diameter. Clottocytes may allow complete hemostasis in 1 second, even in a large wound. Hence Clottocytes appear to be about 10,000 times more effective as clotting agents than natural platelets. Future advances in the engineering of molecular machine systems permit the construction of the artificial Respirocyte and Microbivores and Clottocytes may find dozens of applications in therapeutic and critical care medicine. When the severe side effects of the existing therapies are been considered, the Nanorobots are found to be more innovative, supportive of the treatment, and diagnosis of viral diseases.

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