APPLICATIONS OF NANOTECHNOLOGY IN MEDICAL FIELD

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ABSTRACT-Technology is generally regarded as the utilization or application of science to benefit the society in various ways. Nanotechnology is a collective term referring to technological developments on the nanometre scale, usually 0.1-100 nm (nanometre). A nanometre is nothing but one-billionth of a meter, too small to be seen with a conventional laboratory microscope. Therefore, nanotechnology is an engineering & manufacturing application at the molecular scale. Nanomedicine is the medical application of nanotechnology ranges from the medical applications of nanomaterial and biological devices to nanoelectronic biosensors. Nanomedicine which is a relatively new field of science and technology refers to highly specific medical intervention at the molecular scale. It cures diseases or repairs damaged tissues, such as bone, muscle, nerve and so on. The revolutionize applications of nanotechnology is being used successfully in manufacturing such as in electronic products, energy sectors, pharmaceutical sectors, medical sectors and so on. Among various applications of nanotechnology, more research carried out in medical field since nanotechnology can be seen as a boon as it helps in creating smart drugs. This smart drug helps to cure patients faster with fewer side effects where usage of traditional drugs has more side effects. Utilities of nanotechnology to biomedical sciences imply creation of materials and devices designed to interact with the body at sub-cellular scales with a high degree of specificity. This could be potentially translated into targeted cellular and tissue-specific clinical applications aimed at maximal therapeutic effects with very limited adverse-effects. Nanomedicine can offer impressive resolutions for various life threatening diseases. In the first half of the 21st century, nanomedicine should eliminate all common diseases of the 20th century, and all medical pain. It is also expected within the next few years for curing complicated diseases in early stages of diseases such as cancer, diseases of the cardiovascular system, the lungs, blood, neurological especially neurodegenerative diseases, diabetes, inflammatory /infectious diseases with the benefit of using nanotechnology. So nanotechnology in medical field is becoming an emerging research area. In this paper the evolution of nanotechnology, applications of nanotechnology in various fields are addressed. Among many applications of nanotechnology, nanotechnology in medical field has received more attention from researchers to find solutions to cure the complicated or incurable diseases efficiently with less cost and with minimum efforts. This paper focused on how nanotechnology helps the people in medical field to improve the medical services. Even though nanotechnology is being used successfully and giving solutions to unresolved problems it has to face some challenges and these challenges are discussed in this paper.

Key words: Nanomedicine, Nanotechnology, Neurodegenerative Diseases, Smart Drugs.

I. INTRODUCTION

Nanotechnology is the art and science of manipulating matter at the nanoscale (down to 1/100,000 the width of a human hair) to create new and unique materials and products with enormous potential to change society [1].As we know that our daily lives are depending on technology for everything around us. With technology everything has become easy now. Nanotechnology is a collective term referring to technological developments on the nanometre scale, usually 0.1-100 nm (nanometre). A nanometre is nothing but one-billionth of a meter which is visible with conventional microscope as very small. From figure. (1) We can see comparison of various microscopic organisms in nanoscale and nanodevices such as Dendrimers, Nanotubes, Quantum dots, and Nanoshells. Actually nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape &size at nanometerscale and another term nanoscience means it is the study of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a large scale [2].

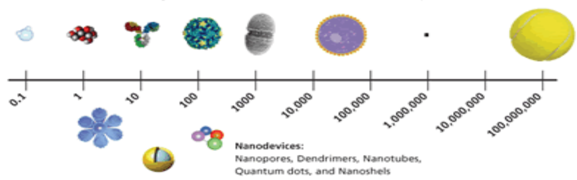


Fig: 1. various microscopic organisms in nanoscales and a list of nanodevices.

The origins of nanotechnology did not occur until 1959, but when Richard Feyman presented a lecture in the

American physical society annual meeting entitle "there's plenty of room at bottom", in his talk he presented ideas for creating nanoscale machines to manipulate, control image matter at the atomic scale. The term Nanotechnology was first coined by Tokyo Science University professor Norrio Taniguchi in 1974 [3]. The medical application of nanotechnology is called as nanomedicine, in the field of medicine the technology has developed with various aspects. Many researchers have worked in the timeline to develop nanotechnology, in various fields. This paper mainly focuses on applications of nanotechnology in various fields like Energy, Environment, food, textiles, agriculture, medical, quantum computers, optics, cosmetics etc., and deeply in medical application. The next following section discusses about application of nanotechnology in various fields.

II. APPLICATIONS OF NANOTECHNOLOGY

Nanotechnology is being successfully used in various fields because of its special features. Nanotechnology has put its roots in almost all fields like Energy, Environment, Food, Textiles, Agriculture, Medical, Quantum Computers, Optics, Cosmetics etc.,[4] In the field of medicine, the technology has developed with various aspects such as drug delivery, tissue engineering for the diagnosis of various diseases. It provides extraordinary opportunities not only to improve materials and medical devices but also to create new "smart" devices and technologies where existing and more conventional technologies may be reaching their limits. In the following subsection definitions related to new research areas and terms *i.e*., nanobiotechnology, nanomedicine, and nanodevices is presented and then some applications of nanotechnology in modern medicine will be discussed in more detail.[5] The figure. (2) Shows the various applications of nanotechnology.

Fig.2.Applications of Nanotechnology in Various Fields

A. ENERGY

There are many interesting ways that the energy is generated from steam of sunlight. In [4] Researchers have demonstrated that sunlight concentrated on nanoparticles, can produce steam with high energy efficiency. The "solar steam device" is intended to be used in areas of developing countries without electricity for applications such as purifying water [4]. This effectiveness is continued in making high efficiency light bulbs, electricity generated by windmills, generating electricity from waste heat and so on.,

B. ENVIRONMENT

There are many potential environmental benefits, the price of raw materials and energy coupled with the increasing environmental awareness of consumers, cleaning up oil spills through use of nanometerials, the radioactive waste cleanup in water, hydrogen production from sunlight makes artificial photosynthesis Artificial photosynthesis, using solar energy to split water generating hydrogen and oxygen, can offer a clean and portable source of energy supply as durable as the sunlight. It takes about 2.5 volts to break a single water molecule down into oxygen along with negatively charged electrons and positively charged protons. [5]

C. FOOD

Nanotechnology will provide new ways of controlling and structuring foods with greater functionality and value. Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packed Companies are using nanomaterials that will make a difference not only in the taste of food, but also in food safety, and also for the health benefits. Nanoparticles are very effectively used to selectively bind and remove the chemicals or pathogens. [6]

D. TEXTILES

Now a days, in textile industries, nanotechnology is used to do various services easily and efficiently in Figure. (3). Implemented how nanotechnology in textiles Such as water repellence, wrinkle resistance, computing and so

on, [7] the Figure. (4).also shows the repellence of water droplet. Nanotechnology is used to develop desired

Fig (3).Nanotechnology in textiles

textile characteristics such as high tensile strength, unique surface structure, soft hand, durability, water repellence, fire retardancy, antimicrobial properties.

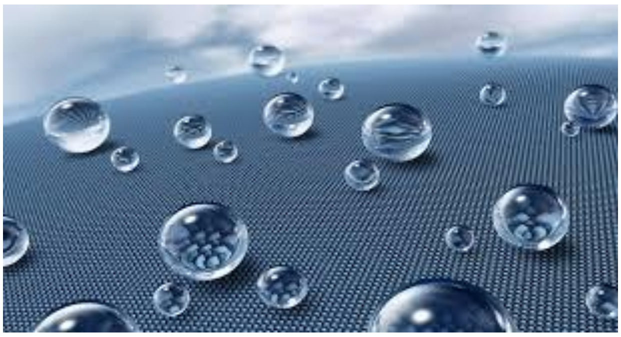


Fig (4).showing water droplet surface repellence

E. AGRICULTURE

Nanotechnology has the potential to bring about drastic changes in the agricultural industry. The development of new nanotech-based tools and equipment may help to increase efficiency and overcome challenges faced by the agricultural industry. [8] The agricultural sector will benefit greatly from nanotech-based tools to detect diseases in a rapid manner and also to improve the ability of plants to absorb nutrients and promote molecular treatment of diseases.

F. MEDICINE

Applications of nanotechnologies in medicine are disease diagnosis, drug delivery targeted at specific sites in the body, molecular imaging which intensively investigated and also some products undergoing clinical trials.[9]. The recent advances in nanotechnology will have an effective impact on disease prevention, diagnosis, and treatment. Nanomedicine refers to future developments in medicine that will be based on the ability to repair specific diseased cells, functioning in a similar way to antibodies in our natural healing processes using nanoparticles. Researchers are developing customized nanoparticles, where the size of molecules can deliver drugs directly to diseased cells in the body [10].

G. QUANTUM COMPUTERS

The field of quantum computing focuses on the development of computer technologies based on the principles of quantum theory which explains the behaviour and nature of matter and energy at the quantum level [11].Quantum computers can handle more than just binary information, which conventional computers operate on. Quantum computers can also handle data in between a 0 or 1 bit, implying that new types of calculations can be performed. [12]

H. OPTICS

Nano optics addresses the broad spectrum of optics on the nanometer scale covering technology and basic science.

The term "nano-optics", just like the term "optics", usually refers to situations involving ultraviolet, visible, and near-infrared light (free-space wavelengths from 300 to 1200 nanometres)[11]. “Optical sensing is very effective in sensing and identifying trace level gases, but uses laboratory devices that are very expensive and can’t be transported into the field”, said by Alan Wang, a photonics expert and an assistant professor in the OSU school of Electrical Engineering and computer. [13]

I. COSMETICS

Nowadays, nanotechnology is frequently used in many cosmetic products, such as moisturisers, hair care products, make up and sunscreen. The below Fig (5) shows the different cosmetics prepared by nanotechnology.[11] The two main primary uses of nanotechnology in cosmetics. Such as nanoparticles are used as UV filters and other is used for deliver particular components. Solid lipid nanoparticles and nanostructured lipid carriers are used in cosmetic industry for delivery which can replace liposomes and niosomes.

Care products, which apply nanotechnology

Fig 5.cosmetics by nanotechnology

III. APPLICATION OF NANOTECHNOLOGY IN MEDICAL FIELD

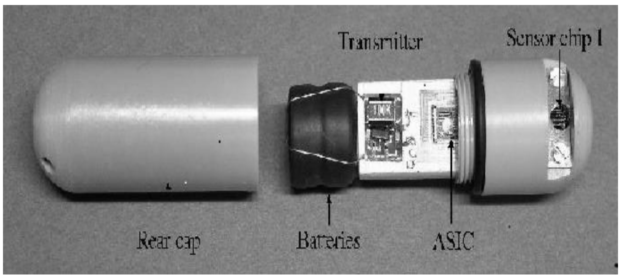
The use of nanotechnology in medical field offers many advantages with exciting possibilities. Nanotechnologies are new areas of research focusing on medical field particularly the modern medicine can benefit greatly. Now a day’s thus nanomedicine has become one of the main branches of nanotechnologies research. Currently it focuses on developing new methods of preventing diagnosis and treating various diseases [14]. Nanotechnology in medical application involves nanoparticles that is currently under development, Most of the research involves the use of manufactured nanorobots to make repairs at the cellular level is discussed in [15].these manufacturing is also referred as nanomedicine, actually nanomedicine is the treatment or repair of tissues and organs, within individually targeted cells. Nanomedicine typically combines use of molecular biosensors to provide control of treatment and repair. Biomedical nanotechnology presents revolutionary opportunities to fight against many diseases. This technology defects molecule associated with diseases such as cancer, diabetes mellitus, neurodegenerative diseases, as well as detecting microorganisms and viruses associated with infections, such as pathogenic bacteria, fungi, and HIV viruses. For example, in the field of cancer therapy, promising novel nanoparticles will respond to externally applied physical stimuli in ways that make them suitable therapeutics or therapeutic delivery systems.[16] The use of nanotechnology in many prospects of medicine are discussed below

A. NANOTECHNOLOGY IN DRUG DELIVERY

Drug delivery refers to approaches, formulation, technologies, and system for transporting a pharmaceutical compound in the body as needed to safely achieve its desired therapeutic effect [17].the most published use of nanotechnology in drug delivery under development is the use of nanoparticles to deliver drugs to cancer cells. Particles are engineered so that they are attracted to diseased cells, which allow direct treatment of those cells. This technique reduces damage to healthy cells in the body. There are a number of other ways that nanotechnology can make the delivery of drugs more efficient and potentially less [18]. The survey of nanomedicine applications in drug delivery introduces many techniques in treatment of cancer, Heart disease, Aging &other areas. Another important field of application for nanotechnology are biomaterials used for example in orthopedic implants or as scaffolds for tissue engineered products. Nanotechnology might yield nano-structured surfaces preventing non-specific protein adsorption. Control of surface properties at nanolevel was shown to increase the biocompatibility of the materials. For example let use consider the processes of Endoscopy earlier days and the advanced one. Endoscopy means the diagnostic procedure which involves the introduction of a flexible device into the lower or upper gastrointestinal tract for diagnostic or therapeutic purposes. Conventional endoscopes can be used to view only the first third of the small intestine. Require sedation of patient is an uncomfortable procedure. From Fig. (6) The endoscopy instruments that are used to trace the tract of intestine.

Fig.6.eqiupment used to do endoscopy

These problems of gastrointestinal tract for intestine are almost solved by introducing SMART DRUG. SMART DRUG is a substance that is claimed to enhance memory, concentration, or other mental functions. It targets specific cells or organs. These smart devices can be made accordingly, mostly they are implanted in the human body consists of Biosensors, Battery, control circuitry, Transmitters, drug reservoirs are shown in the Fig (7). The biosensors sense the substance to be measured, say insulin. Once this quantity falls below a certain amount required by the body, the pill releases the drug [15].



Fig(7). SMART PILL WITH TRANSMITTER, BATTERIES Etc

The working of this smart pill is as follows, the pill is intended to be swallowed like any normal pill. When it is in the body, the pill's sensors sample body fluids and pick up "meaningful patient data" such as temperature, dissolved oxygen levels and pH. The pill is expected to retrieve all data over a 12-hour period and disposed off, once excreted. This data is transmitted wirelessly to a card attached to the wrist of the individual and can show a view of the entire small intestine can aid in early detection of colon cancer.

B. NANOVACCINES.

Another broad application of nanotechnology is the delivery of antigens for vaccination. Mucosal immunity is extremely important in disease prevention but continues to be limited by both degradation of the vaccine and limited uptake [12]. Recent advances in encapsulation and development of suitable animal models have demonstrated that microparticles and nanoparticles are capable of enhancing immunization.

C. NANOTECHNOLOGY IN GENE DELIVERY.

Gene therapy is a recently introduced method for treatment or prevention of genetic disorders by correcting defective genes responsible for disease development based on the delivery of repaired genes. The most common approach for correcting faulty genes is insertion of a normal gene into a nonspecific location within the genome to replace a non-functional gene [9]. An abnormal gene could also be swapped for a normal gene through homologous recombination or repaired through selective reverse mutation, which returns the gene to its normal function. Three main types of gene delivery systems have been described: viral vectors, nonviral vectors and the direct injection of genetic materials into tissues using so-called gene guns. Viral vectors are attractive in terms of the scientific strategy exploiting the natural mechanisms [10]. However, such systems could suffer from the inherent difficulties of effective pharmaceutical processing and scale-up, and the possibility of the reversion of an engineered virus to the wild type.

Applications of nanotechnological tools in human gene therapy has been reviewed widely by Davis in[9], who described nonviral vectors based on nanoparticles (usually 50-500 nm in size) that were already tested to transport plasmid DNA. He emphasized that nanotechnology in gene therapy would be applied to replace the currently used viral vectors by potentially less immunogenic nanosize gene carriers. So delivery of repaired genes or the replacements of incorrect genes are fields in which nanoscale objects could be introduced successfully.

D. NANOPOWDERS

Nanopowders contain particles less than 100nm in size which is $1/10000^{th}$ thickness of a human hair. The physical, chemical and biological properties of such small particles allow industry to incorporate enhanced functionalities into products.

E. NANOROBOTIC

A new approach with advanced graphics imaging is represented for the problem of nano-assembly automation and its application for medicine. The problem under study concentrates its main focus on nanorobotic control design for molecular manipulation and the use of evolutionary agents as a suitable way to enable the robustness on the proposed model [20]. Biological-based robots can be diverted by microbes that can piggyback on its metabolism, and can even cause the engineered bio machine to perform some new or different function than was originally intended. Biological based robots may be found to be unpatentable for the pure fact that they are biologically based. Mechanical robots will have no such difficulty in receiving patents. It provides useful directions for further research and development of medical nanorobotic and suggests a time frame in which nanorobots may be expected to be available for common utilization in therapeutic and medical procedures. The use of nanorobots may advance biomedical intervention with minimally invasive surgeries, help patients who need constant body function monitoring, and improve treatment efficiency through early diagnosis of possibly serious diseases. Implantable devices in medicine have been used for continuous patient data acquisition. Patient monitoring can help in preparing for neurosurgery.

F. NANOROBOTS FOR DIABETES.

Nowadays patients with diabetes must take small blood samples many times a day to control their glucose levels. Such procedures are uncomfortable and extremely inconvenient. To solve this problem, the level of sugar in the body can be observed via constant glucose monitoring using medical nanorobotic.

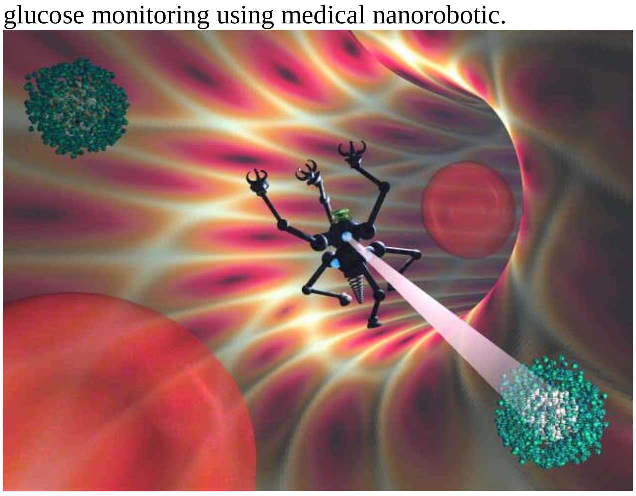


Fig 8.NanoRobot attacking the diseased area

G. DENDRIMERS

The dendrimers are perfect and monodispersed macromolecules with regular highly branched 3D architecture and offers controlled delivery and targeting. It possesses three components: Initiator core, interior layers and externally attached core. Figure(9) shows how dendrimers attacking cancer cells. Some of the dendrimers are poly amido amino (PAMAM) dendrimers, Poly propyleneimine, tecto dendrimers, multi-lingual dendrimers and chiral dendrimers. Dendrimers are used in microcapsules; nanodevices, and liposomes etc., Nanodevices targeted into tumour cells through h-foliate Receptors have been designed using dendrimers [1].

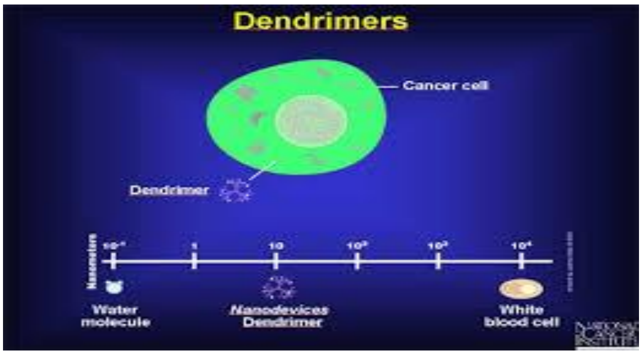


Fig.9.Dendrimers attacking cancer cells

H. QUANTUM DOTS.

Quantum dots are spherical nano-sized crystals. They can be made of nearly every semiconductor metal (e.g., CdS, CdSe, CdTe, ZnS, PbS), but alloys and other metals (e.g. Au) can also be used. Fig (10) shows the quantum dots in graphite. The prototypical quantum dot is cadmium selenide (CdSe). Quantum dots range between 2 and 10 nm in diameter (10 to 50 atoms). Generally, quantum dots consist of a semiconductor core, over coated by a shell (example: ZnS) to improve optical properties, and a cap enabling improved solubility in aqueous buffers [21].

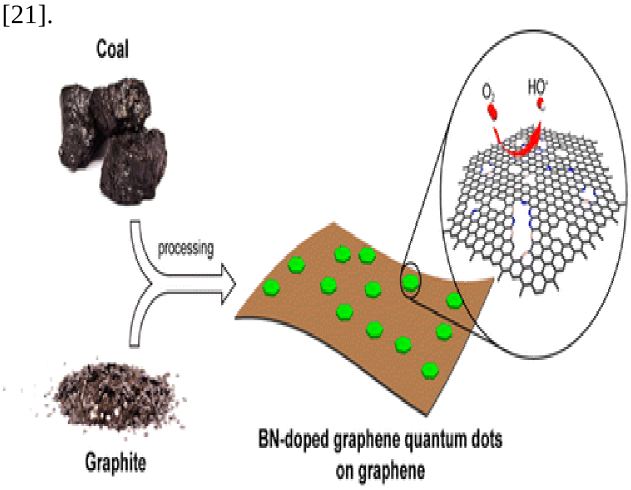


Fig.10.Quantum dots in graphite.

I. NANOSHELLS

Nanoshells have a core of silica and metallic layer. These Nanoshells can be linked to antibodies that can recognize tumour cells (PSMA). Once the cancer cells take them up, by applying a near infrared light that is absorbed by the Nanoshells, it is possible to create intense heat which selectively kills tumour cells and not the neighbouring healthy cells [22]. For example, gold encased Nanoshells have been used to convert light into heat, enabling the destruction of tumours by selective binding to malignant cells.

IV. CHALLENGES & EHICAL QUSTIONS OF NANOTECNOLOGY.

As impressive as nanotechnology might be there are also some potential disadvantages, there are valid arguments the use of nanomedicine, particularly around the issue of *toxicity*. Elements at these microscopic levels can exhibit different properties than they do normally. Furthermore every nanoparticle is unique and sometimes the effects or two of the same nanoparticles are not consistent. Thus, some nanoparticles might become dangerous for humans. It has been shown that nanoparticles that naturally occur in our body can have a serious effect on both our short term and long term health. Another disadvantage of nanotechnology is the enormous *financial costs* associated with it. There is the problem that nanomedicine will definitely be too expensive for the average citizen, at least at first. It raises a question of providing better access to medicine and infrastructure in less developed countries or to focus on improving key aspects of the health system and [23]. Finally, nanomedicine, like all technology, can also be used for malicious purposes. Much of the proposed technology and treatment that nanomedicine will bring can be used for purposes other than originally intended. This leads to problems of *ethics and privacy*. Nanorobots that could monitor the level of insulin in people in diabetes could also be misused by government and corporations trying to increase surveillance of citizens. Such technology can also be used for military purposes [24]. And where should we draw the line in the practical use of nanomedicine? To illustrate, if such technology allows us to heal people who have lost their vision or damaged their brain, either by an accident or through natural causes, should this technology be released to the general public, allowing people to have biotech implants that give them superior vision or mental abilities? Should this be extended to military purposes? If so, then to what extent? There are many moral and ethical dilemmas regarding nanomedicine that must be answered before this technology is put to.

CONCLUSION & FUTURE WORKS:

After we have taken you through a journey into the world of nanotechnology and nanomedicine, in which technology and medicine can intersect to improve humanity. Though the future is indeed truly difficult to predict, with so many uncertainties and unforeseeable factors, nanomedicine represents a technology of the future that can not only reshape the power of medicine but also potentially revolutionize the way we live our everyday lives.

With unique properties such as superior precision, strength, and malleability only existent at the nano level, nanostructures and nanoparticles indeed possess the ability to drastically increase the effectiveness of drug delivery and alternative disease treatments, providing doctors less risky methods to cure cancer and cardiovascular diseases. More detailed research and careful clinical trials are still required to introduce diverse components of nanobiotechnology in random clinical applications with success. Ethical and moral concerns also need to be addressed in parallel with

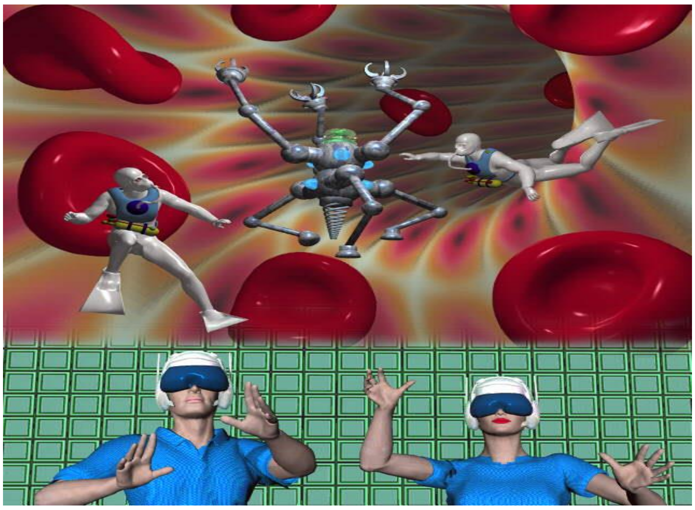


Fig.11.In Future medical applied nanotechnology.

The new developments.[25] Fig11.shows the future generation medical application of nanotechnology.

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