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NANOTECHNOLOGY: SMALLEST MULTI-TASKING WEAPON

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ABSTRACT

Nanotechnology, sometimes referred to general-purpose technology, is a new discipline that has opens the door to many fields. It is one of the leading scientificfic fields today since it combines knowledge from the fields of Physics, Chemistry, Biology, Medicine, Information technology, Molecular biology, Semiconductor physics, Micro-fabrication, Material science and Engineering. It has also excelled in the area of harvesting energy, microchip manufacturing, thin film technology.

Nanotechnology is the engineering and manufacturing of materials at the atomic and molecular scale.It is a technology, technique and process that involvesin the manipulation of matter at the smallest scale (from 1 to 100 nm). It is commonly refers to structures that are up to several hundred nanometers in size, developed by top-down or bottom-up approach.

Nanotechnology has significant impact on almost all industrial and social areas like computing and data storage, materials and manufacturing, health and medicine, energy and environment, transportation, national security, nanopowder, nanotubes, nanocarbons etc.

Nanotechnology make things small, light, cheap, better built, longer lasting, cleaner, safer, and smarter products for the home, communications, medicine, transportation, agriculture, electronics, biomaterials, energy production,robotics and for industry in general.

But their wastes make damages to human, agriculture and animal cells.

I. INTRODUCTION

Nanotechnology is the study of manipulating matter on an atomic scale which refers to the constructing and engineering of the functional systems at very micro level or at atomic level. It is defined as the study and use of structures between 1 nanometer and 100 nanometers in size. A nanometer is one billionth of a meter (10-9m); whereas the diameter of human hair is about 25,000 nanometers, to create new material that can be used at a very small scale.

Atoms and molecules stick together because they have complementary shapes that lock together, or charges that attract. A positively charged atom will stick to a negatively charged atom. As millions of these atoms are pieced together by nanomachines, a specific product will begin to take shape.

History: Dr. Richard P Feynman, US physicist and Nobel Prize winner, first ever presented ideas for creating nanoscale machines to manipulate, control and image matter at the atomic scale in 1959.

In 1974, Norio Taniguchi introduced the term 'nanotechnology' to represent extra-high precision and ultra-fine dimensions, and also predicted improvements in integrated circuits, optoelectronic devices, mechanical devices and computer memory devices.

The invention of the scanning tunneling microscope by Gerd Binnig and Heinrich Rohrer in 1981 provided the real breakthrough to image structures at the nanoscale.

In 1985 Harry Kroto, Robert Curl and Richard Smalley invented a new form of carbon called fullerenes ('buckyballs'), a single molecule of 60 carbon atoms arranged in the shape of a soccer ball.

Tools: The main tools used in nanotechnology are three main microscopes:-

1. Transmission Electron Microscope (TEM)
2. Atomic Force Microscope (AFM)
3. Scanning Tunneling Microscope (STM)

Approach:
TOP-DOWN APPROACH:These seek to create smaller devices by using larger ones to direct their assembly.It is the process of creating nanoscale materials by physically or chemically breaking down larger materials.
BOTTOM–UP APPROACH:These approaches utilize the concepts of molecular self-assembly or automatically arrange themselves into some useful conformation.It is cheaper than top-down methods.

Applications: The various applications of nanotechnology in different fields are as follows:-
(i) Health and Medicine
(ii) Agriculture
(iii) Computing, Data Storage and Quantum computers
(iv) Energy and Environment
(v) Materials and Manufacturing
(vi) Tissue engineering
(vii) Robotics
(viii) Filtration
(ix) Heavy industries
(x) Construction

Health and Medicine: Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology.

Cancer: In photodynamic therapy, a particle is placed within the body and is illuminated with light from the outside. The light gets absorbed by the particle and if the particle is metal, energy from the light will heat the particle and surrounding tissue. Light may also be used to produce high energy oxygen molecules which will chemically react with and destroy most organic molecules that are next to them (like tumors) without leaving toxic in body.

Procedure for Introducing Nanoparticles in the Body

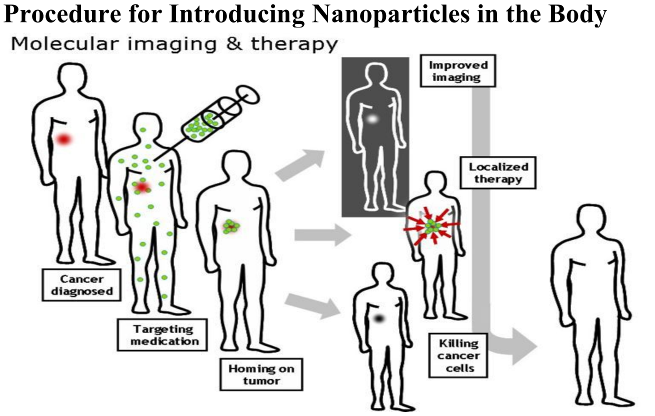

Fig – 01

- A cancer patient is injected with metallic nanoparticles, each with an antibody attached.
- The nanoparticles are then delivered by blood vessels into a malignant tumor.
- Each antibody attaches itself to a molecule on the surface of the cancer cell, and the nanoparticles are drawn into the cells.
- The patient is then exposed to the radio field to allow the controlled radiowaves to enter the body and heat the metallic nanoparticles.
- This results in the nanoparticles heating the cancer cells and killing them in seconds, all the while leaving the surrounding healthy cells completely undamaged.

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Drug delivery: Nanotechnology has been a boon for the medical field by delivering drugs to specific cells using nanoparticles. The overall drug consumption and side-effects can be lowered. An example can be found in dendrimers and nanoporous materials.

Computing, Data Storage and quantum computer: Future of ever increasing power of computing will belong to "spintronics": a nanoscale technology in which information is carried by the electron's intrinsic spin. Spintronic devices could offer higher data processing speeds, lower electric consumptionincluding, the ability to carry out quantum computations.

Displays: The production of displays with low energy consumption could be accomplished using carbon nanotubes (CNT). Carbon nanotubes are electrically conductive and due to their small diameter of several nanometers, they can be used as field emitters with extremely high efficiency for field emission displays (FED).

Quantum computers: Entirely new approaches for computing which enable the use of fast quantum algorithms. The Quantum computer has quantum bit memory space termed "Qubit" for several computations at the same time. This facility may improve the performance of the older systems.

Agriculture:
- Crop improvement
- Nanobiotechnology
- Soil management
- Plant disease diagnostics
- Efficient pesticides and fertilizers
- Water management
- Bioprocessing
- Post Harvest Technology
- Monitoring the identity and quality of agricultural produce
- Precision agriculture

Nanotechnology for *Crop Improvement*DNA has appealing features like its minuscule size, with a diameter of about 2 nanometers, its short structural repeat (helical pitch) of about 3.4–3.6 nm, and its 'stiffness', with a persistence length (a measure of stiffness) of round 50 nm.

Nanobiotechnology is an emerging area in microfabrication and biosystems. It provides the basic tools and technology for gathering information and designing innovative devices in diverse fields, particularly agriculture and medicine.

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Atomically Modified Seeds: Researchers "drilled" a hole through the membrane of a rice cell to insert a nitrogen atom that would stimulate the rearrangement of the rice's DNA. The goal is to develop varieties that can be grown all year long, with shorter stems and improved grain colour.

Soil Clean-Up: Anano clean-up method of injecting nano-scale iron into a contaminated site. The particles flow along with the groundwater and decontaminate en route, which is much less expensive than digging out the soil to treat it.

Military: Nanoparticles can be injected into the material on soldiers' uniforms to not only make the material more durable, but also to protect soldiers from many different dangers such as high temperatures, impacts and chemicals.Nanotechnology can improve soldiers' uniforms is by creating a better form of camouflage. Mobile pigment nanoparticles injected into the material can produce a better form of camouflage. These mobile pigment particles would be able to change the color of the uniforms depending upon the area that the soldiers are in. There is still much research being done on this self-changing camouflage.

Green nanotechnology: Means using nanotechnology to make current manufacturing processes for non-nano materials and products more environmentally friendly. It has a goal to produce nanomaterials and products without harming the environment or human health, and producing nano-products that provide solutions to environmental problems.

Tissue engineering: Nanotechnology can help reproduce or repair damaged tissue. It makes use of artificially stimulated cell proliferation by using suitable nanomaterial-based scaffolds and growth factors. For example, bones can be regrown on carbon nanotube scaffolds. Tissue engineering might replace treatments like organ transplants or artificial implants.

Energy: The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy and enhanced renewable energy sources.Nanotechnological approaches like light-emitting diodes (LEDs) or quantum caged atoms (QCAs) could lead to a strong reduction of energy consumption for illumination.Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of bandgaps.

II. EXCITING APPLICATIONS OF NANOTECHNOLOGY

Nanopowders: Nanopowders contain particles less than 100 nm in size. The physical, chemical and biological properties of such small particles give rise to a range of new and improved materials. For example, new medical nanomaterials are being developed, such as synthetic bone and bone cement, as well as drugs with improved solubility to allow lower dosing, more efficient drug delivery.

Membranes: Nanomembrane filtration devices that 'clean' polluted water, sifting out bacteria, viruses, heavy metals and organic material. Filtration techniques is based on the use of membranes with suitable hole sizes, whereby the liquid is pressed through the membrane. Nanoporous membranes are suitable for a mechanical filtration.

Carbon Nanotube:It is stiff as diamond. The estimated tensile strength is 200 Giga Pascal. Carbon Nanotube Transistors exploit the fact that nm- scale nanotubes (NT) are ready-made molecular wires and can be rendered into a conducting, semiconducting, or insulating state. Many potential applications have been proposedincluding conductive and high-strength composites; energy storage and energy conversion devices; sensors; field emission displays and radiation sources; hydrogen storage media; and nanometer-sized semiconductor devices, probes, and interconnect.

NanoRobotics:Nanorobots will be the next generation of nanomachines. Advanced nanobots will be able to sense and adapt to environmental stimuli such as heat, light, sounds, surface textures, and chemicals; perform complex calculations; move, communicate, and work together; conduct molecular assembly; and, to some extent, repair or even replicate themselves.

Buckyballs:Buckyballs, or Buckminsterfullerene are used in medical research to deliver drugs specifically to a particular molecule within the body. The way that they function is that they have only hexagonal and pentagonal faces, which easier to hydrogenate than benzene.It can also be used to treat cancer.

Implications:

Health and safety issues

- ✓ Nano-particles can get into the body through the skin, lungs and digestive system and can cause serious illness or damage human body andcell.
- ✓ Carbon Nanotubes could cause infection of lungs.
- ✓ Once nano-particles are in the bloodstream, they will be able to cross the blood-brain barrier.
- ✓ Extremely small fibers, so called nanofibers, can be as harmful for the lungs.

- ✓ Untraceable destructive weapons of mass destruction.
- ✓ Atomic weapons could be more accessible and destructive.
- ✓ The most dangerous Nano-application use for military purposes is the Nano-bomb that contain engineered self-multiplying deadly viruses that can continue to wipe out a community, country or even a civilization.

Social & Political issues

- ✓ Creates social strife through increasing wealth gap.
- ✓ Loss of jobs(in manufacturing, farming, etc).
- ✓ Advisability of increasing scope of the technology creates political dilemma

Environmental issues

- ✓ Nanopollution is created by toxic wastes from nanomaterial manufacturing
- ✓ Enhances Global warming in the long run

"Grey-goo"

- ✓ It is a hypothetical situation where self-replicatingnanorobots go out of control, and consume all matter on earth.

Hurdles:

- ✓ Mass Production/Throughput and Cost Constraints.
- ✓ Funding Requires Long-Term Investments.
- ✓ Intellectual Property Issues - Patent Office that is Overwhelmed and Under-Qualified.

III. SWOT ANALYSIS FOR NANOTECHNOLOGY

Strengths (S)

- More and more people are interested in this new technology.
- Government doesn't mind to invest money in this area.
- It has many different fields that can be investigated for the invention of new product so there is less likely to have competition.

Weaknesses (W)

- It will take a lot of time and money to research and develop products in this field.
- Today's technology does not provide enough resources to build these products.
- As it is a new technology and it involves a lot of manipulation.
- It may cause more harm to the human health system.
- Until it has been confirmed that it is 100% safe to use not everybody will try the product.

Opportunities (O)

- It is a new field so it opens the door to many new ideas and therefore potentially many new products.
- If these products come to the market, because of it direct effect in a short period of time people would be impressed.

Threats (T)

- Many countries are spending vast amounts on the R&D of this new field, therefore there would be a lot of competition in the future.
- Due to the fact that there is no current regulation there's the potential the products could be impacted hugely by regulation in the future.

IV. CONCLUSION

Nanotechnology gives us an ability to build large numbers of products that are incredibly powerful. Particularly in cancer diagnosis and treatment, promises to have a profound impact on health care. Many of the technologies involving nanoparticles for early detection of cancer and treatment are in preclinical stages. Nanotechnology

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applications in cancer detection and treatment have the potential to replace highly invasive conventional cancer detection and treatment, which often includes biopsies, irradiation, and painful therapies. Also it has wider uses in biotechnology, genetics, plant breeding, agriculture, and allied fields, etc.

A well-controlled manufacturing system can be widely deployed, allowing distributed, cheap, high-volume manufacturing of useful products and even a degree of distributed innovation. The range of possible nanotechnology-built products is almost infinite.

There are also considered many risk along with the opportunities discussed above. We have to work more to enhance these opportunities while decreasing the threats of risks associated with this technology.

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