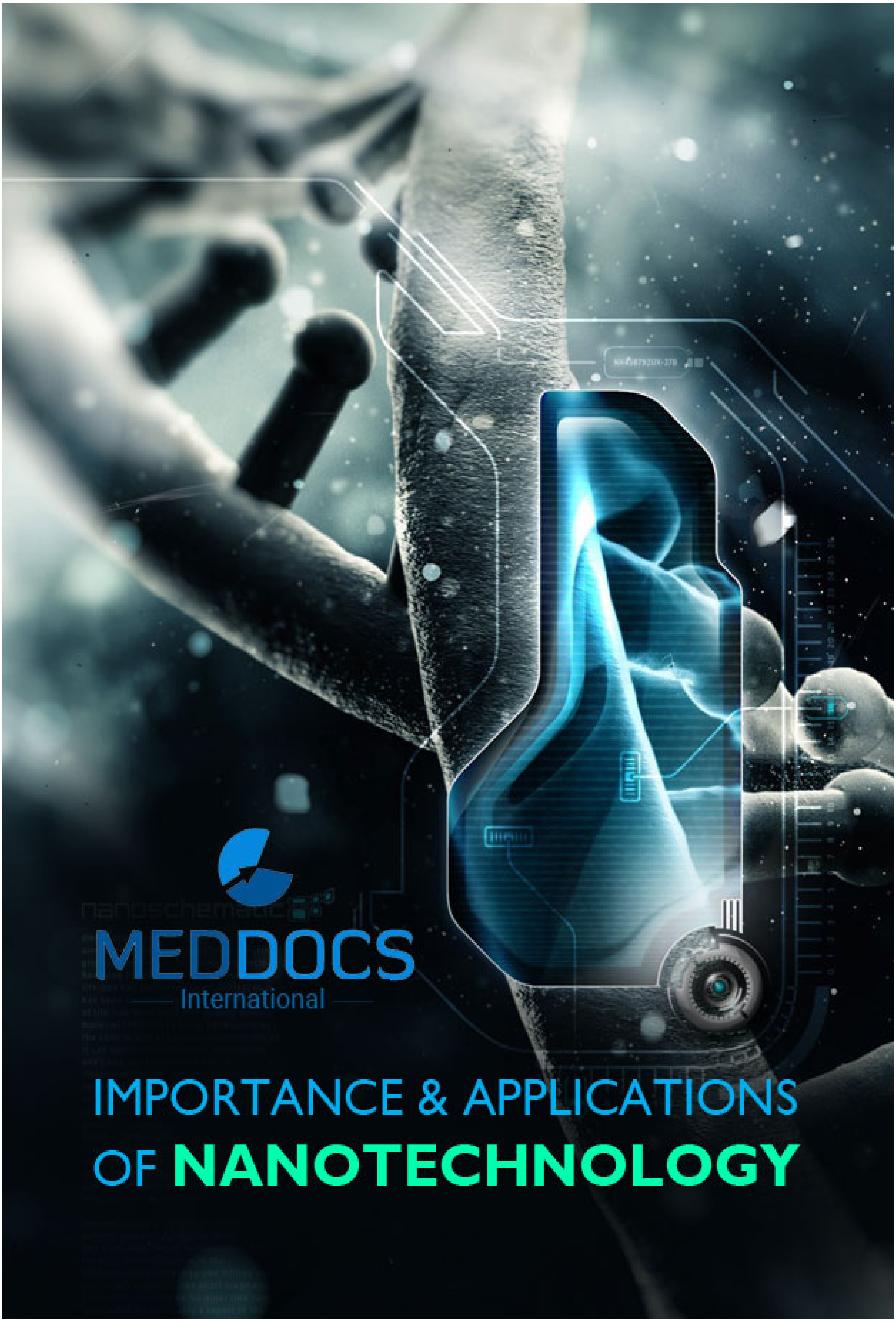


# IMPORTANCE & APPLICATIONS OF NANOTECHNOLOGY

# Nanotechnology: Applications, techniques, approaches, & the advancement in toxicology and environmental impact of engineered nanomaterials

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## Introduction

Nanoscience refers to the handling of materials, systems and devices at atomic, molecular and macromolecular level, whereas, nanotechnology is the cluster of techniques involved in design, synthesis, characterization and application of structures, materials, devices and systems by manipulating shape and size at nanometer scale. At nanometer level, individual molecules and interaction between them becomes important in comparison with the macroscopic properties of the material or device. Control at nanometer scale and manipulation of fundamental molecular structure permits to regulate the bulk macroscopic chemical and physical properties of the material and device [1]. The scale of dimensions is frequently <100 nm. The idea of nano-science is credited to physicist Richard Feynman in 1959, where he delivered a lecture at American Physical Society "There's plenty of room at the bottom - an invitation to enter a new field of physics" and he explored the ideas and benefits of manufacturing devices, and things on the very small scale. He anticipated the ideas that might be utilized to produce large-scale integrated circuits, gene sequencing, reading DNA molecules, and electron microscopy for writing enormous amounts of information in very slight bits. Many of his predictions are now well-established techniques in nanotechnology, although, he didn't coin the term nanotechnology [2].

Norio Taniguchi in 1974 used the term nanotechnology, while describing how the dimensional accuracy has improved with elapsing time. He was the first one to study development and advancements in machine technologies over three decades from 1940s to 1970s. He had foreseen the development of dimensional accuracies better than 100 nm by the era of late 1980s. He employed the term nanotechnology for these future developments [3]. Initially, physicists and engineers were the pioneers of nanotechnology. They developed nanotechnology by realizing the ideas of Feynman. He predicted the possibilities of developing technologies that might take, shuffle and rearrange an atom to make new chemical analogue. In 1981, two scientists at Zurich, developed scanning probe microscope and won Noble prize in 1986. In this microscope, a sharp metal head scans above the surface to visualize these atoms on surface. Eigler and his group explored the basics of physical and quantum mechanical phenomena using the same technique. In 1989, Eigler and his co-workers used the same technique to spell IBM on the surface of xenon atoms at temperature close to absolute zero [4]. Gimzewski worked on extreme nanotechnology, where he pushed single molecules around surfaces at room temperature using similar technology [5].

**Advancement in nanotechnology**

With the development in areas of materials science, chemistry and engineering over the previous few eras' nanotechnology has remained exploited in all fields where insignificant size plays crucial part in determining fundamental properties. They are being used from physics, engineering, and chemistry to biologicals and medicine. Nanoparticles of cadmium telluride are employed in the labelling of biological molecules with precision. Nanoparticles of titanium dioxide effectively block UV radiation and they are the main component of sun screens. In 1985, carbon-60 molecule was exposed by Harry Kroto, Richard Smalley and Robert Curl and they won the Nobel Prize for their work in 1996. In 1991, carbon nanotubes were discovered by Iijima. A type of nanotechnology 'Bottom-up nanotechnology' involves the self-assembling traits of biological systems, such as DNA molecules which control the organization and structure of carbon nanotubes [6].

**Nanotechnology in food processing**

Nontechnology has been implicated in food industry for the past decades to improve quality, taste and texture of foods, and to prevent them from pathogen infestations. Nanotechnology is employed to increase the shelf-life and improve the storage of food materials by preventing microbial infestations [7]. Nano-carriers are now used as delivery systems for food additives without disturbing the basic morphology of food. In nutraceuticals, an ideal delivery system (nano-carriers) should distribute the active compound precisely at specific rate on target place. Nanotechnology has become an integral part of food processing and food packaging with the advent in development of nano-polymers. Nano-sensors have been developed for the apprehension of contaminants, pathogens and toxic materials in food [8].

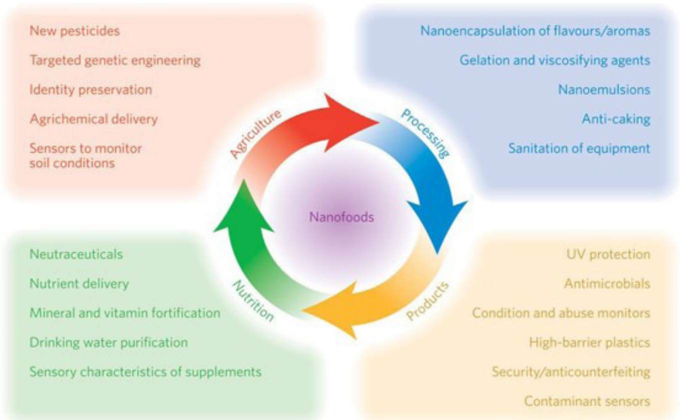


**Figure 1:** Nanotechnology in food processing and food packing [9].

In food industry and medicine, encapsulation of nanoparticles give better release and efficiency in addition to masking the odour and bitter taste. It controls the interactions between ingredients and the food matrix with controlled delivery of the active agents and its accessibility at specific rate [10]. Nano-encapsulation protects food ingredients from heat, moisture and degradation during various phases of processing, manufacturing and storage, it also increases compatibility of different compounds in the system [11]. Different polymer-based encapsulation and delivery systems have been developed for better bioavailability, conservancy of the active food components and aptitude to infiltrate deeply into tissues. It allows effectual distribution of the active component towards target point in body [12]. By nanotechnology food products have been improved in terms of texture, appearance, taste, nutritional value, and their shelf-life. Nanotechnology is responsible for significant modifications in food products as they improve the quality and enhance the taste of food. Nano-encapsulation has been broadly used for the release of desired flavour and its retention to deliver culinary balance. Encapsulation of cyanidin-3-*O*-glucoside in the inner cavity of recombinant soybean seed has resulted in improved thermal and photo stability [13]. Encapsulation of rutin with ferritin enhanced the solubility, and stability against heat and UV radiations [14]. Lipid-soluble bioactive compounds are formulated in nano-emulsions using natural food ingredients to enhance water-dispersion and bioavailability [15]. As compared with conventional methods nanoparticles improve the bioavailability of nutraceuticals. Silicon dioxide ($SiO_2$) is used as colouring agent in food items. $SiO_2$ nanoparticles are used as the carriers of flavours in food products [16].

Macromolecules in the body essential for cellular haemostasis such as lipids, vitamins, proteins and carbohydrates require optimum pH for their activity. In addition, they are sensitive to low pH environment. Encapsulation of these compounds helps them to resist acidic environment. Moreover, it allows them to integrate readily in food products. Nanoparticles-based capsules are formulated for significant benefits over conventional capsules [17]. Different techniques are employed in the process of nano-encapsulation to effectively deliver nutrients, proteins, and antioxidants and the other active compounds. Polymer based nanoparticles are appropriate for encapsulation of bioactive compounds to protect and transport the targeted delivery [18]. Furthermore, nano-encapsulation of bioactive components extend the shelf life of food materials either via reducing degradation process otherwise by preventing deprivation unless the product is transported towards target site. Nano-coatings are done on various food materials and they are found to be effective barrier against moisture and gas exchange. These coatings are also responsible for specific colour and flavours of food product. It also effectively delivers enzymes and antioxidants, hence increasing shelf-life of manufactured foods once the seal is opened [19]. Encapsulating functional components retards the chemical degradation process e.g. encapsulation of curcumin exhibited condensed antioxidant activity and it was found to be stable to pasteurization and at diverse ionic strengths [20].

**Nanotechnology and food packaging**

A good packaging material should consume permeability for gas and moisture in addition to strength compatibility [21]. Nano-based food packaging have numerous advantages over traditional packaging methods as they provide improved packaging with enhanced mechanical strength, antimicrobial films for pathogen detection, and barrier properties for safety status of food [22]. Nanocomposites are used to improve food packaging [23]. Organic compounds such as essential oils, organic acids, and bacteriocins are used in polymeric matrices as antimicrobial agents. However, they are extremely delicate to physical conditions. Nanoparticles of inorganic ions provide a potential antibacterial activity in low concentrations. Therefore, these nanoparticles are being used in antimicrobial food packaging. Antimicrobial packaging inhibits the growth of microbes that can be present on the surface of food. Moreover, different metals like silver and copper-based chitosan, and nanoparticles of metal oxide are already described to possess antibacterial property [24].

Nanocomposites and nanolaminates provide an effective barrier against extreme thermal and mechanical shock thereby, extending food shelf-life. Thus, nanoparticles offer nanoparticles with quality food with longer shelf-life. Many fillers are also being used for attaining improved polymer composites. Incorporating nanoparticles in polymers has permitted to develop additional resistant packaging by minimum cost [25]. Silicate and silica ($SiO_2$) nanoparticles, and chitosan gives polymer matrix stronger, fire resistance, and improved thermal properties [26]. Antimicrobial films are equipped by impregnating the fillers into the polymers with additional advantage due to the structural rectitude and barrier properties [27].

**Nanoparticles as nanosensors**

Nanomaterials offer the high level of sensitivity in food microbiology. Nanobiosensors are developed to detect microbes in processing of food material, plants and for the quantification of food ingredients, alarming customers and suppliers over the food safety status. Moreover, it acts as an indicator which that reacts to environmental changes in microbial contamination, storage rooms and in products degradation [28]. Various nanoparticles and nanofibers have possible applications to use as biosensors. Optical immunosensors have extremely complex detection systems. In these immunosensors, thin nano-films or sensor chips are loaded with specific antibodies, antigens, or protein molecules. These chips produce signals on detection of target molecules. Another immunosensor was established to detect the foodborne pathogens e.g. *E. coli.* Immunosensor is composed of dimethylsiloxane integrated with specialized antibodies immobilized on nanoporous alumina membrane which produce electrochemical impedance spectrum on detection of pathogen. Nanotechnology has influenced the detection techniques used for pesticides, pathogens and toxins [29].

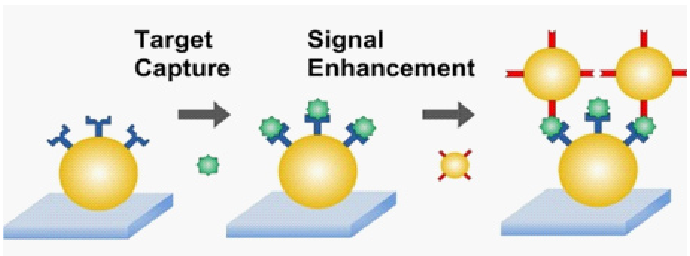


**Figure 2:** Nanoparticles as nanosensors [30].

Biosensors based on carbon nanotubes are popular because of their quick recognition, simplicity and cost efficiency. They are used to detect the microbes, waterborne toxins, and various tarnished products in food and beverages [31-32]. Small molecules are also detected by modified quartz crystal surfaces. It is modified with different functional groups, amines, lipids, enzymes and polymers [33].

**Nanomaterials in medicine**

In medicine such nano-materials are designed which interact at cellular level. They show interaction at molecular level with living cells and tissues. These nano-materials and devices are essential products of biomedical engineering, and they are used in medicine and physiology, through a high grade of useful precision. Therefore, they provide a degree of integration among technology and the biological system. Manipulation of drugs, active compounds and devices at nanometer scale, allows to control and alter the essential properties and bioactivity of the ingredients. Thus, they allow to control the solubility of drugs, controlled release, and targeted drug delivery [34].

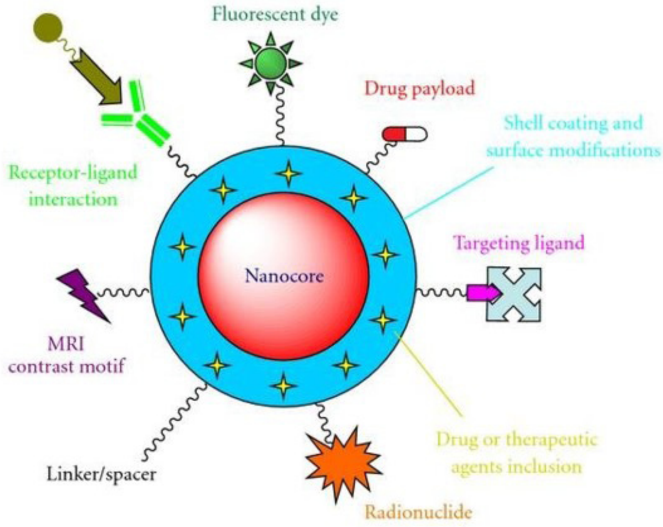


**Figure 3:** Multifunctional nanoparticle for molecular imaging, drug delivery and therapy [35].

Different applications of nano materials and nano-medicine comprise fluorescent biological labels, detection of amino acids, lipids and proteins, drug delivery, and other macromolecules, pathogen detection, probing of DNA structure, tumour identification and detection, and tissue engineering, MRI contrast enhancement and purification of biological molecule. Nanomachinery is crucial in designing of nano-medicine. Meticulous control and manipulation of nanomachinery in cellular environment results in better thoughtful of the cellular mechanistic studies in living cells. It also aids to develop innovative technologies towards the early finding and therapy of several diseases. Development of nano-medicine and advancement in biomedical engineering, provides a podium that effect nanoscale imaging, elucidating the molecular mechanisms inside the living cells [36]. Molecular imaging has become a very influential device to imagine molecular events underlying ailment state, often prior to its appearance. Adjunct of nanotechnology with molecular imaging offers a multipurpose stage for designing nanoprobes with remarkable potential and enhanced specificity, sensitivity and signalling capabilities to use as biomarkers in human diseases [37].

Nanoparticle renders molecular imaging by increased signal sensitivity, improved 3D resolution and capacity to spread data in biological systems at subcellular level. Simple magnetic nanoparticles serve as magnetic resonance imaging contrast enhancement probes. Magnetic nanoparticles provide novel stage by adding the other functional units, fluorescence tags, macromolecules and radionuclides. They are also used in the multimodal imaging, cellular trafficking and gene delivery. MRI with hybrid probes of magnetic nanoparticles is essentially used to perceive target cells, record gene delivery and protein expression [38]. Positron-Emission Tomography (PET) has higher detection sensitivity which allows the use of nanoparticles at low concentration. Furthermore, combination of the PET with Computed Tomography (CT), could map signals to atherosclerotic territories [39]. For molecular imaging a contrast agent is always required at target site, nanoparticles encapsulating the contrast agent is an emerging technique to deliver into the target site. In imaging methods with lower sensitivity, nanoparticles are used to provide signal amplification. They are used to carry the contrast agent into the tissues and at target area. Nanoparticles can deliver the drug in addition to contrast agent. It also allows to keep a track on the bio-distribution and therapeutic activity (theragnostic) [40]. Nanofiber-based scaffolds have advantage because of their high porosity, surface area and pore size distribution. These constraints are suitable for cell growth, division, attachment and proliferation. In addition, they offer a basis towards the optimization of electrospun nanofibrous framework in tissue-engineering.

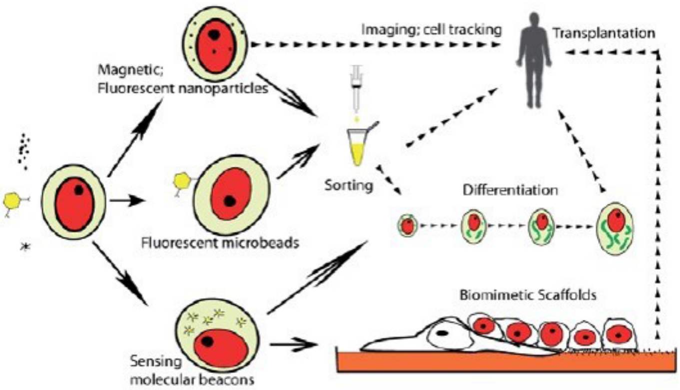


**Figure 4:** Nanotechnology and its applications in medicine [41].

### Tissue engineering

Regenerative medicine and tissue engineering techniques are used to restore and improve lost functions of tissues. These techniques showed the promising results in the past decades as compared to traditional therapy [42]. Nanotechnology is widely used in tissue engineering. As natural bone surface is not smooth, and it comprises features that are about 100 nm across. In the hip or knee prosthesis, nano-sized features on their surface minimize the probabilities of rejection. Moreover, they excite the making of osteoblasts.

### Nanomaterials for vascular tissue engineering

Due to increasing incidence of vascular diseases, demand for the use of nanomaterial has also raised. Vascular grafts with better efficiency for damaged blood vessels are much needed. As blood vessels have layered structure, with nanostructures nano-devices hold promise in treating vascular diseases [42]. In addition, they are also reported to inhibit incidence of thrombosis and inflammation, vascular cell adhesion and proliferation [43].

### Nanomedicine for neural diseases

With the advancement in nano-medicine, it is also used to heal damaged nerves and neural diseases and spinal cord injuries. Repairing spinal cord injuries and damaged nerves still pose a challenge in the face of modern-day medicine. The peripheral nervous system can regenerate itself as it can divide and proliferate via Schwann cells. Though, these cells are not present in central nervous system and nerves in CNS cannot heal themselves [44]. In brain and CNS astrocytes, meningeal cells and glial scar tissue are formed preventing axon growth and they inhibit neuron regeneration [42]. Therefore, CNS injuries are difficult to treat, and they cause more damage. Nano-devices for repairing neural tissue should be compatible with cells, and it should have excellent mechanical and electrical properties. Non-compatible materials fail to recover neuron growth and at they cause inflammation and infection. Without mechanical properties nano-devices do not last to regenerate neural tissue. Moreover, electrical properties control the behaviour of neurons thus allowing repair of neural tissue. Many nano materials have been developed for their use as nerve grafts to repair damaged nerves [45].

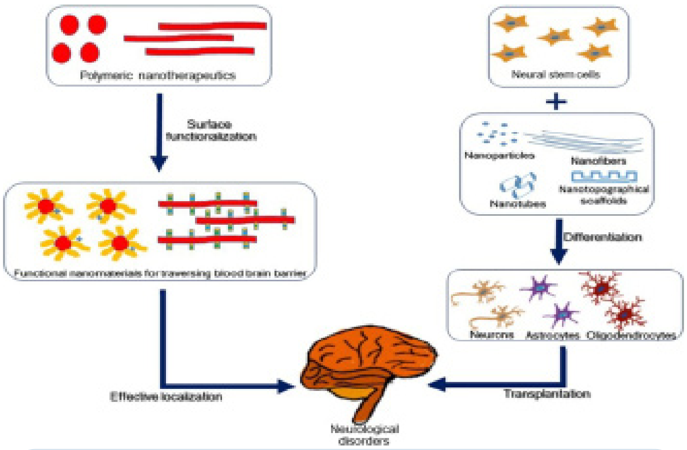


**Figure 5:** Nanotechnology approaches for neuronal diseases [46].

Silicon probes are also employed in neuro-prosthetic devices. The use of neuro prostheses is mainly limited due to the formation of glial scar tissue around the nanomaterial as well as due to the lack of compatibility and enough electrical and mechanical properties to promote nerve tissue repair. Although advents in nanotechnology provides the essential platform for the development of novel and enhanced neural tissue engineered products. The use of nanofibers and nanotubes provide better compatibility with brain cells and they also have better conductivity to boost neuron repair. Nanomaterials are also used in stem cell therapy for nerve repair and to overcome damage caused by brain injuries. Carbon nanotubes have excellent electrical conductivity in addition to strong mechanical properties. They also have similar nanoscale dimensions therefore they are used to guide axon regeneration in neural tissue injury [47]. Nanomaterials are also used in the regeneration of soft tissues. Although other treatments, and surgery are available to treat bladder cancer, nano-materials efficiently improve bladder tissue regeneration without having major adverse effects and risk factors associated with other treatment options [42].

### Cancer therapy

In cancer therapy, tumour cells are destroyed by atomic oxygen which is generated by laser. Such molecular oxygen is highly cytotoxic, and it destroys tumour cells efficiently. Dye used to produce atomic oxygen is occupied by cancer cells, and it only destroys the tumour cells which are exposed to the laser radiation without affecting the normal cells. To avoid adverse effects on normal cells, a porous nanoparticle is used to enclose the hydrophobic dye molecule which prevent it from spreading to other parts of the body [48].

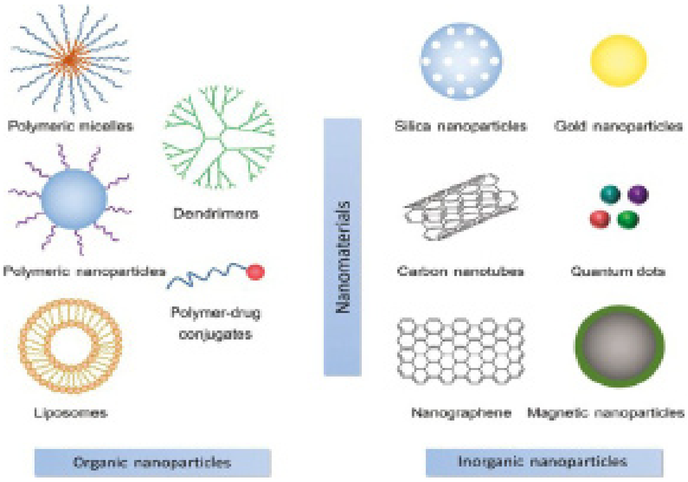


**Figure 6:** Different nanomaterials applied for cancer therapy [49].

### Multicolour optical coding in the biological assays

With the continuous growing research in genomics and proteomics, that assembles amassed amount of sequence data, the need for development of high throughput screening technologies is increased. Single quantum dots of semiconductors are employed instead of organic dyes for several bio-tagging applications. Fluorescent colours quantum dots are also combined in polymeric micro-beads. Optical bar coding of polymer particles in solution, is restricted by the amount of exclusive tags that could be produced and detected [50].

### Stem cells and nano-engineering

Nanotechnology offers the elementary grounds and roots for regenerative medicine. Nanomaterials are used for the controlled delivery of DNA molecules at target area, whereas, nanofibers direct and prepare the tissue for modification of the biosensors and nano-devices [51]. Embryonic and foetal stem cells, umbilical cord and adult stem cells are used for the generation of various therapeutically essential types of cell. These engineered cells are then processed for the therapy of various genetic and degenerative diseases. These disorders vary from age-related defects, immune system disorders, osteoporosis, heart failure, spine injury, liver damage, arthritis, muscular, vascular disorders, neuro degenerative diseases such as Alzheimer's and Parkinson's disease, and aggressive tumours [52].

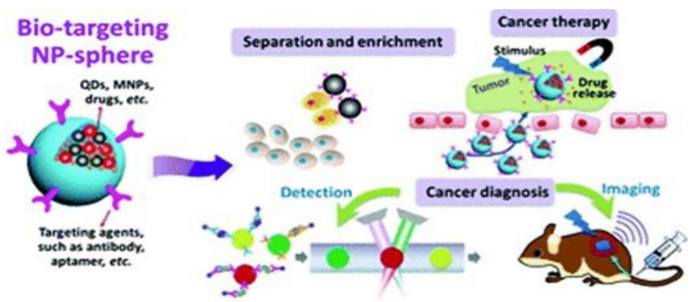


**Figure 7:** Nanoparticle application in cancer treatment [53].

stem cells are used as starting material for regenerative medicines. stem cells can generate all cell types and tissues with infinite growth morphology. stem cells have transformed the regenerative medicine's era and field. their role and involvement in cancer therapy are well established. for the alignment of different type of stem cells, modified nanoscale surfaces are designed. for instance, haematopoietic stem cells, embryonic stem cells and mesenchymal stem cells have been bio-engineered. $TiO_2$ nanotubes on the surface of rat mesenchymal stem cells with the spacing of around 15-30 nm delivers optimum conditions for integrin formation, clustering, induction of cell proliferation, cell differentiation and migration of stem cells into osteogenic lineages. Moreover, cell-based adhesion and growth is impaired on nanotubes which are >50 nm in sizes. Stem-cell nanotechnology in combination with imaging techniques at molecular level, controlled propagation and growth of stem cells has shown promising results in the therapy of several abnormalities and disorders. Nanomaterials are used for labelling of stem cells, gene delivery, cellular differentiation, and organ transplantation. There is still gap in deciphering the pathways underlying mechanism of interaction between nano-materials and stem cells [54]. In course of cardiomyoplasty, the mechanism of action of cell therapy limits the size of infarct wounds, it also recovers feasibility of myocardium and stimulates ventricular and diastolic functions [55]. Merging of biomaterial technology and stem-cell biology has enabled to capture the events taking part in the manufacture, and communication of molecules for the regeneration of tissues and organs in novel clinical treatments [56]. Tissue regeneration via transplanting progenitor cells with molecular imaging techniques are extensively used. Where Magnetic Resonance Imaging (MRI) suggests high resolution and efficiency. Despite the marvellous therapeutic potential of progenitor cells, there are many challenges in the way of stem cell therapy. The application of magnetic procedure suggests excessive potential for the tissue repair and regenerative medicine. Despite all the advancements there is a lot to understand why transplanted stem cells are being rejected [57].

### Manipulation of biomolecules and cells

Magnetic nanoparticles are also used for cell separation and probing. Mostly they are spherical in shape, while cylindrical nanoparticles could also be formed using metal electrode position to template of nanoporous alumina. Moreover, different ligands are attached selectively to various segments. E.g. porphyrins by carboxyl linkers and thiol are adhered to nickel and gold segments, respectively [58].

### Protein detection

Proteins are essential macromolecules in the body, with important functions. To identify protein-protein interaction gold nanoparticles are routinely employed in immunohistochemistry. Furthermore, surface-enhanced Raman spectroscopy is used for the recognition and characterization of single dye molecules. By merging these techniques in a single nanoparticle probe, the detection limit multiplexing capabilities of protein probes are improved [59].

### Nanotechnology in diagnostics

With the advent in the field of genomics and proteomics abnormalities and diseases are detected at the molecular level. Nanotechnology has enabled man to estimate gene expression and amount of RNA production in the diseased and normal tissues. DNA chips based on nanotechnology are widely used to check gene expression. These chips have an inert support which is responsible to carry out microarrays of 100-1000 of single-strand DNA molecules with various base sequences. Radioactive or fluorescent labelled DNA from a tissue sample can be identified based on its binding with base sequence onto the chip DNA [60]. The sequence of DNA molecules may also be established by drawing the sequences through nanopores in the membrane using an electric potential difference [61].

Labs-on-a-chip are used for analysing biopolymers and for manipulating cells. A nano-device known as PEBBLEs was developed to measure concentration of small ions and molecules in living cells [62]. Nanoparticles of perfluorohydrocarbons joint with a lipid layer are appropriate as an ultrasonic contrast agent.

Super paramagnetic iron oxide nanoparticles are also used therapeutically. Nanoparticles can also behave as active substance [63]. Inside the cancer cells, metal with nanoparticles are heated by near-Infrared (IR) Radiation or using rapidly vacillating magnetic field [64] to kill the cancerous cells. Silver nanoparticles have antiplatelet properties; thus, they have the potential to be used as future antithrombotic drugs.

Active grafts are transplants that consist of energy source like insulin or morphine pumps. Active implants are a type of targeted therapy where it goes directly to the target area as needed, and it may be monitored at different rates. Release of medicine in active implants is measured by biosensor that counter the physiological parameters [65]. Retinal implants to restore the normal vision are under the process of development. Various research groups are now working on neural prostheses that enable devices to be controlled by thoughts and will of a person wearing them. In neural prostheses, several chips are fitted with electrodes to the motor area of cerebral cortex. Here they work by registering the electrical signals connected with feelings and judgements. These prostheses are named as brain-machine edges [66]. Active transplants are indispensable products of micro technology; however, nanotechnology is playing an extremely significant role in their advancement and development. Research is focused on growing their function, complex with surrounding tissue, and biocompatible by surface modification. In case of retinal implants electrodes with a nanoporous surface are under development. This nanostructure rises the electrode's surface area, which is required for the proper signal transfer of electrodes to the tissues. An antiseptic layer made up of silver nanoparticles is previously in use for cochlear implants [67].

### Disinfection

Role of silver as a disinfectant is well established, but due to bacterial resistant use of silver is now renewed. Silver ions are responsible for antiseptic effect. They act by blocking the enzymes which are compulsory for the metabolism of oxygen. Moreover, they weaken the cell membrane and block the division of cell. In bacteria resistance against silver is not developed because of its diversity in mechanism of action. Silver nanoparticles are exceedingly effectively, because of huge contact area by the environment. Besides, they can be readily integrated with proteins and polymers. These nanoparticles may act as depots that repeatedly release silver ions [68]. Moreover, nanoparticles of titanium dioxide possess bactericidal effect. Under UV radiation, near water and oxygen molecules, these particles form free hydroxyl and per hydroxyl radicals, which then kill microorganisms. They can be used to assemble antiseptic surfaces which works in UV radiation. Fullerenes may also exhibit antimicrobial effect in light [69].

### Identification, logistics and security

Labels of Radio Frequency Identification (RFID) possess a microchip, with attached a radio antenna, being used for the information of the product, or the material to which it is adhered. This scanning device activates that chip with antenna and transmits the information to desired area. The information stored in the chip is employed to identify and for security reasons. These radio labels are extensively used in public places especially at care institutions and hospitals. Moreover, they are progressively used in the identification of patients and their samples in addition to bar codes. Furthermore, these labels are of size like grain of rice are accessible for skin implantation. The Food and Drug Administration (FDA) administration of US has permitted a RFID label for use in humans in 2004. Using these labels, patient history and record can be stored. Other than health care, these labels have found significant role in the food and agriculture technologies [70].

### Future directions

The multidisciplinary arena of nanotechnology and its applicability in discovering novel analogues and manipulation of available techniques may have probability to enhance health care. Nanotechnology has emerged as a powerful tool in modern day medicine in a relatively short time period. Therefore, nano-materials have entered in industrial production. Most of the applications of nanoparticle in medicine are focused on targeted drug discovery & delivery and gene therapy. In biological sciences, nanoparticles are substituting organic dyes which necessitate high photo-stability and innumerable abilities. There are few developments to the remote-control functionality of nano-probes, like magnetic nanoparticles being used in removal of tumours from the body with the release of drug or destroying the surrounding area to get rid of tumour. The main tendency in future development of nano-materials is to make them flexible for countless uses by control of signals emitted and hereby revolving them into nano-devices. In near future, nanotechnology will embellish a critical tool against severe and infectious diseases. Moreover, another future perspective involves the catalysis of biologically inspired nano - biomaterials and their development. In this way, the functional catalysis will stimulate the capabilities of natural tissues and organs. Current trends in nanotechnology have developed to enhance the quality of human life. Integrating the interactions of tissue and cell-biomaterial and the cell-nano-topography at nanoscale is the major clinical goal of nano-medicine.

## Conclusion

The role of nanotechnology, besides food packaging and processing, cancer therapy, in regenerative medicine and etc, may gain long term visibility to contribute in a competitive and innovative methods. The improvement in the food system by enhancing the nutritional values and safety of food products. The products like contaminant sensors, high barrier plastic, antimicrobials and UV protections can be good contribution of nanotechnology. In agriculture, novel pesticides, agrochemical delivery, sensor to monitor soil condition and targeted genetic engineering are associated with nanotechnology. Moreover, the nanosensors for food characterization, water purification, mineral and vitamin fortification and nutraceutical & nutrient delivery are the contributions of nanotechnology towards nutrition. The advancement will overcome the existing challenges which are associated with medicine and food industry. This innovation will affect positively in the industry and healthcare. We need to comprehend further about the use of environmental and medical impacts of nano-particles. Nanotechnology may offer us a wide variety of proficiencies and these may be utilized in reasonable and thoughtful way.

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