

# NANOTECHNOLOGY AND ITS APPLICATIONS

## Abstract

Nanotechnology is currently the most demanding technology which is affecting almost every part of our daily life in a positive accept. Nanotechnology is science, engineering and technology conducted at nanoscale. Nanotechnology deals with the application of nano-sized particles in the range of 1 to 100 nm, and due to their sizes, they exhibit unique properties which enhance a wide range of utility in various field of application. Nanotechnology is helping to considerably improve, many sectors: information technology, homeland security, medicine, transportation, energy, food safety, and environmental science, among many others. In almost every field Nanotechnology's are used. This Paper mainly focused on the various applications and technology of Nanotechnology which is used world-wide by the people.

**Keyword:** Nanotechnology, Science, Medicine, Nanoscale

## Authors

### **Sandhya Jaiswal**

Department of Pharmaceutics  
Chandigarh College of Pharmacy  
IKGPTU, Landran, Mohali, Punjab, India

### **Shilpa Kumari**

Department of Pharmaceutics  
Chandigarh College of Pharmacy  
IKGPTU, Landran, Mohali, Punjab, India

## I. INTRODUCTION

The word "nanotechnology" was first defined in 1974 by Norio Taniguchi of Tokyo University of Science. Nanotechnology, abbreviated as 'nanotech', is the study of controlling problems at the atomic and molecular scale.<sup>1</sup> The term nanotechnology comes from a combination of two words: the Greek prefix nano (meaning one billion) and the word "technology". Nanotechnology is the study of small structures. Therefore, nanotechnology or nanoscale technology is generally considered to be 0:1 m or below 100 nm. A nano-meter is one billionth of a meter and is about 100,000 times smaller than the diameter of a human hair.<sup>2</sup> It is one of the most important fields of science that has gradually established itself with new research and valuable applications in the last two decades. Not surprisingly, expenses on nanotechnology research are substantial. The National Nanotechnology Initiative (NNI) spends more than \$1 billion a year, and the President's 2008 NNI budget was \$1.5 billion. However, the progress of this research is mainly due to the instant benefits from high-quality products.<sup>3</sup> Nanotechnology can be the solution to the problems related to the basic needs and desires of people for a sustainable lifestyle. Basic human needs are food, water, energy, clothing, shelter, health and a clean environment. Thoughts on living a better life include understanding and using computers, such as space travel and increased life expectancy. After nearly three years of uninterrupted efforts by scientists and engineers, great work has been done in food technology, clean water, automobiles, energy storage, cosmetics, fabrics, appliances and more. Nanotechnology involves the research and development of technology, at the atomic, molecular or supramolecular level, in the range of about 1-100 nanometres, we get an idea of the phenomenon and composition.<sup>4</sup> Nano-technology is considered a new technology, with great potential for many applications, as it can achieve high quality products and create new products with new features and functions. Nanotechnology has become a worldwide technology with the potential to affect all aspects of human civilization today. In addition to being used in many sectors, information and communication technology, biology and biotechnology, medicine and medical technology, metrology etc. The main applications of nanoscience and nanoengineering lie in the pharmaceutical, cosmetic and functional industries, food, chemical engineering, efficient materials, electronics, precision mechanics, optics, power generation and environmental science.<sup>5,6</sup>

Nanotechnology is an emerging and dynamic field with more than 50,000 nanotechnology articles published annually worldwide in recent years and more than 2,500 patents filed in major patent office such as the European Patent Office.<sup>7</sup> New materials and new designs can make products more efficient. Nanotechnology is used to create structures, devices, and systems with properties and performance as the size decreases, increases in volume, and the material undergoes an unusual physical and chemical effect known as the quantum size effect. Computers are built with nanoscale components, and improvements in performance depend on the reduction of these sizes.<sup>8</sup> This means that the particle size of nanoscale materials can be different from larger materials. Using these bits of information, scientists fine-tune shape and size at the nanoscale to design and manufacture materials with far-reaching effects. Nanomaterials with special properties such as nanoparticles, carbon nanotubes, fullerenes, quantum dots, quantum wires, nanofibers and nanocomposites could find new applications. Products containing engineered nanomaterials are already on the market. Today's products are numerous and include metals, ceramics, polymers, smart textiles, cosmetics, sunscreens, electronics, paints and varnishes. However, new methods and tools should be developed to increase our knowledge and experience about their products. As

a precaution, the health benefits and environmental effects of nanomaterials should be studied.<sup>9</sup>

1. **History:** Expansion in nanotechnology commenced in 1958.

**Table 1: summarizes the various stages of development.**<sup>10</sup>

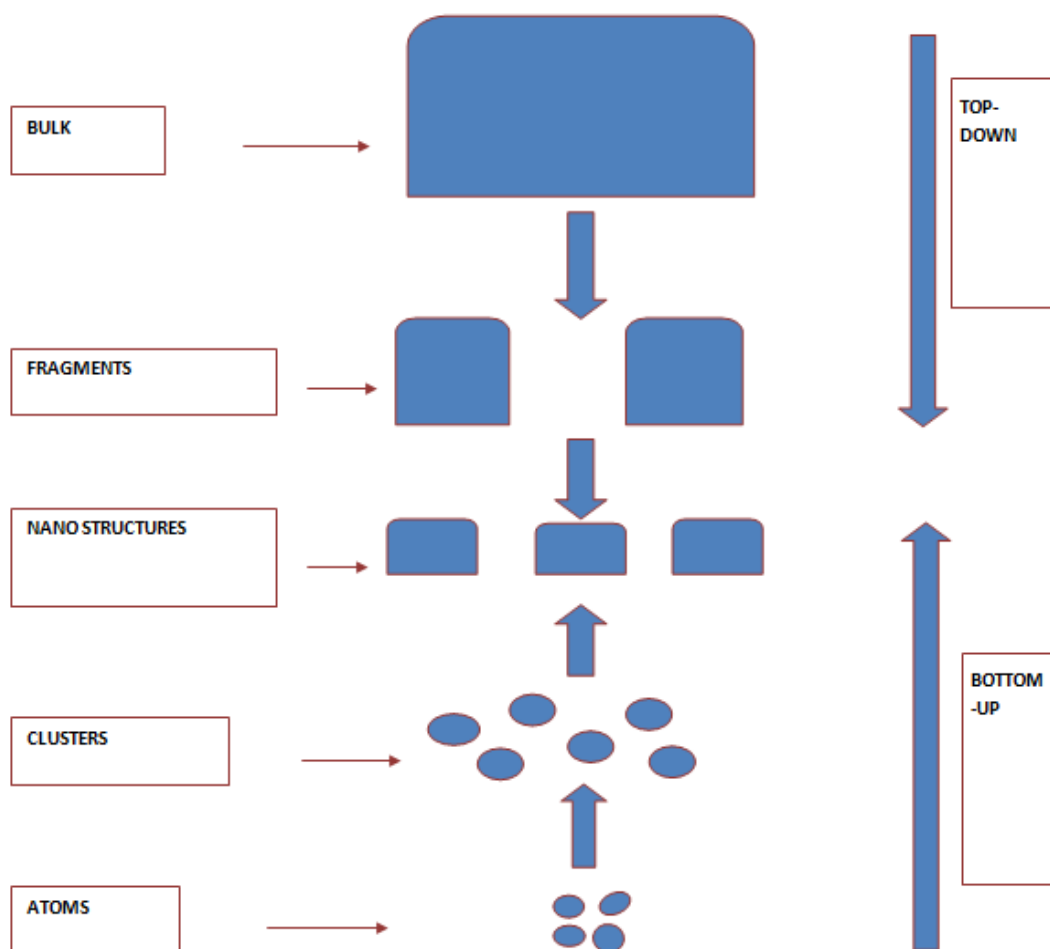
Yrs.	Expansion in the Nano-technology
1959	The concept of nanotechnology originated in a lecture by <b>physicist Richard Feynman</b> .
1974	The word "nanotechnology" was primarily used by <b>Norio Taniguchi</b> , a professor at Tokyo University of Science.
1981	STMs (Scanning Tunnelling Microscope) and atomic force microscopes were invented by <b>Feynman</b> .
1986	<b>K. Eric Drexler's</b> first book published on the creation of the nanotechnology engine.
1989	<b>IBM logo</b> was prepared through distinct atoms.
1991	S. Iijima revealed <b>Carbon Nano-tube</b> initially.
1999	1st Nano medicine book by R. Freitas " <b>Nano medicine</b> " was published.
2000	The first of the ' <b>National Nanotechnology</b> ' Programme.
2001	<b>Feynman</b> received the Prize in 'Nanotechnology' for his development of the theory of nanoscale electronic devices and for the synthesis and characterization of carbon nanotubes and nanowires.
2002	The Nanotechnology Award was given to <b>Feynman</b> for enabling the self-assembly of new structures using DNA and improving our ability to model molecular system.
2003	The Prize for Nanotechnology is awarded to <b>Feynman</b> for the integration of single-molecule bio motors with nanoscale silicon devices.
2004	The first Advanced Nanotechnology Policies <b>Conference</b> was held. The first Center for Nanomechanical Systems opens, <b>Feynman</b> receiving the nanotechnology award for the creation of stable protein structures and the creation of new enzymes with revolutionary functions.
2010	<b>3D nano-systems</b> such as state-changing robots, 3D networks, and nano-devices during practice were prepared.
2011	The era of <b>molecular nanotechnology</b> has commenced.

2. **Different Generations of Nanotechnology:** So far, nanotechnology has passed through four generations.<sup>11</sup>

- **First Generation of Nano-Technology:** This is called passive nanostructure. Applications include dispersive and contacting nanostructures (such as aerosols, colloids, coatings, nanoparticle reinforced composites, nanostructured metals, polymers and ceramics).
- **Second Generation of Nano-Technology:** Refers to active nanostructures. Applications include biological functions, health, physicochemical functions (such as 3D transistors, amplifiers, actuators, adaptive structures).

- **Third Generation of Nano-Technology:** These are called nano-systems. Applications include robotics, assembly: 3D networks and new systems.
- **Fourth Generation of Nano-Technology:** They are called molecular nano-systems. Some of the applications include molecular design, atomic design and emerging projects. Fourth generation nanotechnology often involves the design and manufacture of nano-computers.

3. **Approaches:** Manufacturing processes are divided into two broad categories:



**Figure 1:** Tops down and bottoms up approaches

- **Top-down Method:** This method implies that the nanostructures are formed by removing of crystal faces already present onto the substrate.
- **Bottom-up Method:** This method implies that the nanostructures are formed by stacking atoms in the substrate on top of each other, which leads to crystal faces, which in turn leads to stack on top of each other those consequences the manufacture of nanostructures.<sup>4</sup>

#### 4. **Nanomaterials:** Depending on the material, nanoscale materials can be divided into 4 groups:

- **Carbonbased Nanomaterials:** Depending on the type of carbon the nanomaterials contain, structures such as tubes, spheroids or spheres can be found. Carbon-based nanomaterials include fullerenes, carbon nanotubes, graphene and its derivatives, graphene oxide, and carbon nanomaterials as quantum dots. Graphene is the most studied nanomaterial in the last decade; preparation of graphene includes Liquid phase exfoliation, chemical vapour deposition, CNT melting, and epitaxial growth. Other Carbon-based nanomaterials are produced by arc discharge, CVD, and Laser ablation.
- **Inorganicbased Nanomaterials:** Mostly they are metals and metal oxide nanoparticles and nanoscale materials. Inorganic nanomaterials include Metal nanoparticles (Gold nanoparticles), quantum dots, superparamagnetic metaloxide nanoparticles, paramagnetic ions. Synthetic methods include deposition, template assisted spinning, electrospinning, sol-gel methods and CVD.
- **Organicbased Nanomaterials:** This category includes nanoparticles made mostly of organic matter and does not include carbon inorganic-based nanoparticles. Organic nanomaterials include dendrimers, micelles, liposomes, ferritin. Most organic nanomaterials occur naturally and some are produced by chemically.
- **Composite Based Nanomaterials:** Composite-based nanomaterials are various structures that combine nanoscale 1-phase nanoparticles with other nanoparticles attached to large materials or multiple bases. Nanocomposites, can be divided into four types; (a) Ceramic matrix nanocomposites including part of the metal and nitride, boride, silicide products. (b) Metal matrix nanocomposites, including mainly carbon nanotube metal matrix nanocomposites. (c) Polymer matrix nanocomposites. (d) Magnetic nanocomposites.

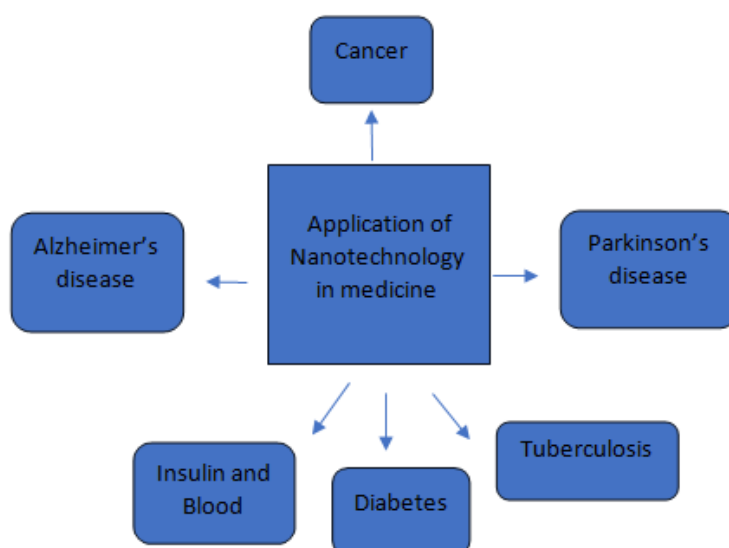
#### 5. **Development of Nanotechnology**

- **Nanomanipulators:** The key concept in nanotechnology is the use of underlying processes to create objects. Rather than transforming bulk materials into desired objects, the underlying process finds a new way of combining atoms into objects. The first step in the underlying technology is to gain the ability to control individual atoms on demand at the nanoscale. Therefore, the development of a nanomanipulator, a tool for manipulating nanomaterials, is considered important for the advancement of nanotechnology. The first nanoscale imaging was done with the electron microscope developed by M. Knoll and E. Ruska in 1931.<sup>12</sup> Later in 1981 G. Binnig and H. Rohrer invented the Scanning Tunneling Microscope (STM) which can see individual atoms, and won the Nobel Prize.<sup>13</sup> The success of the microscope led to the development of other scanning probe microscopes (SPM) including the atomic force microscope (AFM). Researchers use a nanomanipulator to study the mechanical and electrical properties of carbon nanotubes.<sup>14</sup> Nano manipulators are now available commercially.

- **Nanofabrication:** It is a collection of technologies used to create micro-devices. Microfabrication is a term that describes the manufacturing processes of micron size or smaller. For example, the manufacture of ICs (Integrated circuits). Nanofabrication or micro fabrication technology began in the microelectronics industry, where most devices are made from silicon wafers. Nanofabrication approaches can be divided into two groups: a) top-down approach and b) bottom-up approach.<sup>15</sup> A top-down method that has been used in the electronics industry is photolithography. Photolithography is the process of changing the geometry of the mask to the surface of the silicon wafer by exposing it to ultraviolet light through a lens. The computer industry uses this technique to manufacture microprocessor chips. A modification can be made by using electronbeam lithography, a technique for producing thin models of polymer films with electric light.<sup>16</sup> In contrast, those in the bottom-up approach is truly representing a new style of technique. This method is used to assemble atoms or molecules into nanostructures. A recent invention using the bottom-up method was the discovery of carbon nanotubes by S. Iijima of NEC in 1991.<sup>17</sup> A carbon nanotube is a carbon tubular material that is measured on the nanometre scale.
  - **Nano Computers:** Perhaps the first achievement of nano computer research was perhaps the development of the single electron tunnelling (SET) transistor in 1985 by D. Averin and K. Likharev.<sup>17</sup> Later in 1987, T. A. Fulton and G. J. Dolan of Bell Laboratories made single-electron transistors and found quantum energy and electrical interference when the transistors worked.<sup>18</sup> With the advancement of nanofabrication technology, researchers have successfully fabricated electronic devices such as transistors, diodes, relays and logic gates with carbon nanotubes.<sup>19,20</sup> The next step is to provide a connection between the components. With the advancement of nano fabrication technology, the silicon-based nano computers will be closer to reality. Another approach to nanocomputers is DNA computation. Researchers believe that, in addition to silicon-based nanocomputers and DNA computers, quantum computers will be another effective way to circumvent the limitations of classical computers.<sup>21</sup>
  - **Nanorobots:** A nano assembler or nanorobot vision is a device with robotic arms, motors, sensors and computers, all to control behaviour at the nanoscale. In 1992, Drexler's book 'Nano system' described the possibility of mechanical devices for nanorobots.<sup>22</sup>
- 6. Applications of Nanotechnology:** Nanotechnology has become the talk of the scientific community from the time it bloomed in the 2000s. Nanotechnology has found various daily life and industrial applications already and many major applications are yet in research and development. It is not wrong to say that Nanotechnology has taken the technological world by storm. Nanotechnology has been reported to be effective in many fields, and some of the various applications of nanotechnology are summarized below.<sup>23</sup>
- **Nanotechnology in Medicines:** Nanomedicine is a new field of science and technology. Dealing with biomolecules at the nanoscale, nanotechnology expands the scope of research and applications.<sup>24</sup> The interaction of nanodevices with biomolecules can be understood both in the cellular environment and in the human brain. Nanotechnology has the greatest impact in medicine. One application of nanotechnology currently under development in medicine involves using NPs to

deliver drugs, heat, light or other properties to certain cells, such as cancer cells. The product has been carefully designed to attract infected bacteria so that they can be treated directly. This process minimizes damages to healthy cells in the body and enables early diagnosis of the disease. For example, NPs have been developed that deliver chemotherapeutic drugs directly to cancer cells. Even today, many diseases such as diabetes, cancer, Parkinson's disease, Alzheimer's disease, heart disease and multiple sclerosis, and many other serious or infectious disease such as HIV cause many serious and complex diseases that cause serious illness. Nanomedicine is the application of nanotechnology in health and medicine. Nanomedicine uses nanomaterials and nanoelectronics biosensors. In the future, nanomedicine will benefit from molecular nanotechnology. The medical application of nanoscience has many possibilities and benefits for all people. With the help of nanomedicine, early diagnosis and prevention, advanced diagnosis, treatment and follow-up are made. By using some nanoscale particles as markers, bacteria can be processed quickly and tests become easier and more flexible. Genes sequencing has become more efficient with the production of nanodevices, such as gold nanoparticles, which can be used to identify genetic diseases in samples when tagged with short DNA fragments. With the help of nanotechnology, damaged tissue can be regenerated or repaired. So-called artificial stimulatory cells are used in tissue engineering, which can be transplanted into organs or plant tissues. Advanced biosensors with new functions can be created with the help of carbon nanotubes. These biosensors can be used in astrobiology and provide clues to life history studies. The technology has also been used to develop cancer tests. Although the carbon nanotube is inert, it can work with probe molecules at the tip. Their research used AFM as an experimental platform.<sup>25-28</sup>

- Probe molecules based on the properties of Island leukemic cells.
- The electric current produced by the hybridization will reach the IC chip through the CNT electrodes.
- Prototype Biosensor Catheter Development



**Figure 2:** Application of Nanotechnology in Therapeutics

- 7. Cancer:** Nanoparticles are useful in oncology, especially imaging, due to their small size. Nanoparticle such as quantum dots with quantum confinement properties such as size-turned light emission can be used with magnetic resonance imaging to create specific images of tumor regions. Compared to organic dyes, nanoparticles are brighter and need light for their excitation. Therefore, the use of fluorescent quantum dots can produce similar images at lower cost than organic dyes used as contrast agents. But quantum dots are often made of highly toxic materials. Nanoparticles have the unique feature of high surface area/volumeratio, which enables many functional groups to bind to nanoparticles of small size between 10 and 100 nm allow tumors to exploit tumors as they do not have lymphatic drainage. Multifunctional nanoparticles could be designed to capture, screen and treat tumors in future cancer treatments. Nanowires are used to prepare diagnostic devices that can detect proteins and other biomarkers left by cancer cells and detect and diagnose cancer from patients' blood at any stage.<sup>29-31</sup>

Nanotechnology based drug delivery is based on three phenomena:

- Effective encapsulation of the drug
- Delivery of the drug to the target site of the body
- Successful drug availability in body.

## II. THE APPLICATIONS OF VARIOUS NANOSYSTEMS IN CANCER THERAPY ARE SUMMARIZED AS FOLLOWS<sup>32</sup>

Carbon nanotubes are 0.5-3 nm in diameter and 20-1000 nm in length, which are used to detect DNA mutations and detect protein biomarkers. Carbon nanotubes are simple cylinders containing aromatic hydrocarbon rings and are used in biology as sensors for DNA and super molecular activity. Together, they are used as diagnostic tools for the differentiation of proteins in body fluids and as vehicles for the delivery of drugs, immunogens and supermolecules.

Dendrimers with dimensions below 10 nm can be used for controlled drug release and different shapes. Dendrimers are organic compounds with branches surrounding a nucleus, which can vary in size and shape as needed. In recent studies, DNA- coupled polyamidoamine dendrimer clusters have been prepared for specific targeting of cancer cells. The structure of the dendrimers allows multiple additions of photoprobes. It will be used together as a commercially useful tool for cancer diagnosis.

Nanocrystals with a size of 2-9.5 nm can improve the structure of poorly soluble drugs and populate the breast cancer marker Her2 on cancer cells.

Nanoparticles, 10-1000 nm in size, are used as contrast agents for MR and ultrasound images as well as precursor of drug delivery, penetration and apoptosis, angiogenesis.

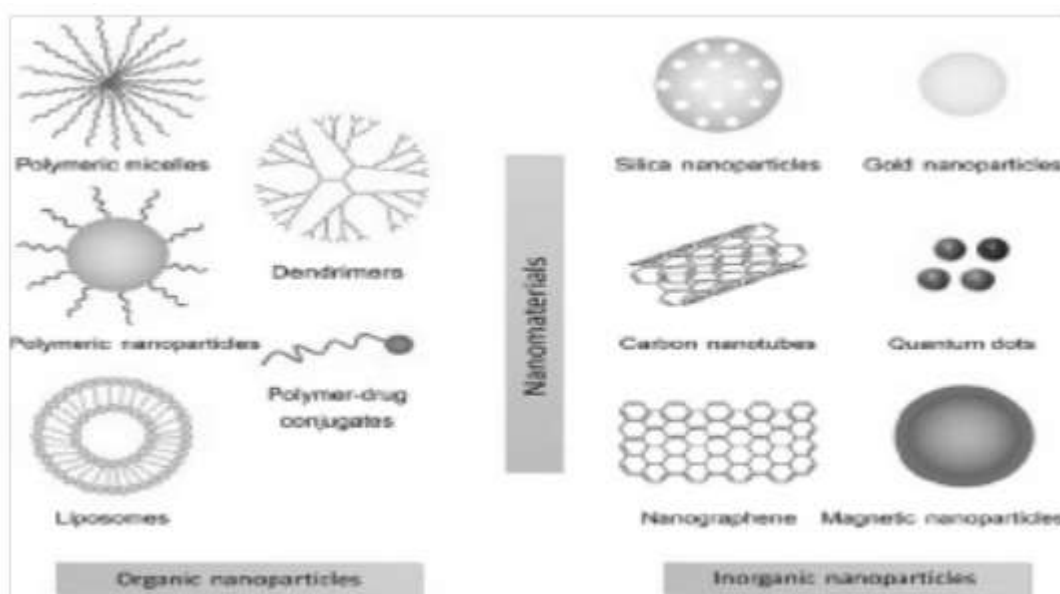
Nano shells have found applications in tumour-specific imaging and thermal ablation of deep tissue.

Nanowires can be used for protein biomarker detection, DNA mutation detection and gene expression detection.



Quantum dots with a size of 29.5 nm can facilitate optical detection of genes and proteins and identification of cells, and tumours in animal models. Quantum dots are semiconductor NPs that, when selected, emit light in selected when exposed to light. The colour of their light depends on the size of the nanoparticle. When quantum dots are illuminated by actinic rays, many electrons receive enough energy to be removed from atoms. This ability causes quantum dots to move around the nanoparticles, creating electrical currents when electrons are not involved in moving through the fabric and generating electricity.

In cancer treatment, tumour cells are destroyed with atomic oxygen produced by laser light. This molecular oxygen has strong cytotoxicity and can destroy tumour cells. The colour used to produce atomic oxygen is taken from cancer cells and only destroys cancer cells exposed to laser radiation, leaving their cells unaffected. To avoid adverse effects on the normal body, porous nanoparticles are used to surround hydrophobic dye molecules and prevent their diffusion to other parts of the body.<sup>33</sup>



**Figure 3:** Different nanomaterials applied for cancer therapy<sup>34</sup>

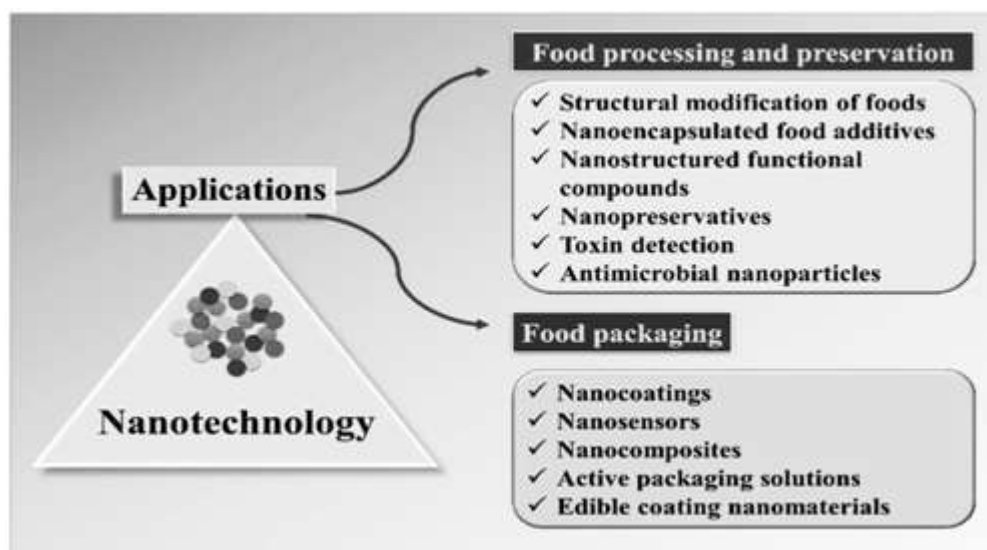
These treatments focus on the power of nanotechnology and the voracious tendency of cancer cells to eat anything they see, including drug-loaded NPs. The colour used to produce atomic oxygen is taken from cancer cells and only destroys cancer cells exposed to laser radiation, leaving their cells unaffected. To avoid adverse effects on the normal body, porous nanoparticles are used to surround the hydrophobic dye molecules, preventing them from spreading to other parts of the body.

**1. Nanotechnology in Diabetes:** Diabetes is one of the most important diseases of today's civilization. It is known as a chronic disease and occurs when the exocrine glands cannot produce enough blood sugar or the body cannot use the insulin it produces. The most common treatment of combat polygenic diseases involves administering hypoglycaemic drugs directly into the patient's bloodstream by injection. Treatment of polygenic diseases is usually carried out as follows:

2. **Development of oral Hypoglycemic agents:** Insulin is produced by the exocrine gland to control aldohexose levels in the body. Oral method is accepted as a convenient and comfortable method for the treatment of polygenic disease. Chitosan NPs are impregnated with hypoglycaemic agents that can increase intestinal absorption of supramolecules.
3. **Artificial Exocrine Gland (Pancreas):** The first plan for the production of exocrine gland was made in 1974. Its formula is simple: The amount of aldohexose in the blood is measured again with the contact control device; this information is entered in a small interface, the amount to be calculated and the number of hypoglycaemic agents that must be taken into the blood from a small reservoir. A different method to adjust aldohexose levels uses tiny silicon device containing tumour cells from animals. The box is surrounded by a fabric with a specific nanopore size.
4. **Nanopumps:** Nanopumps can be powerful tools with many applications in the medical field. Main uses of pumps are to deliver hypoglycaemic drugs into the blood. The pump injects a hypoglycaemic drug into the patient at a rate equal to the patient's blood sugar. The pump has the convenience of injecting a small amount of medication over an extended period of time.<sup>4</sup>
5. **Nanotechnology in Detection of Insulin and Blood Sugar:** Another important use of nanotechnology is to clarify blood sugar levels to determine the health of insulin producing cells in the body, which can be earned through the following ways:
  - **From Microphysiometer:** Microphysiometer is an advanced tool for measuring real-time conditions on a very small scale (e.g., micrometres). The tiny biometer is made of carbon nanotubes, but the new device regularly monitors endocrine levels based on activity (i.e., the number of radiations sent) when insulin changes in the presence of aldohexose. When cells produce too many endocrine molecules, the endocrine molecules in the device will increase and vice versa, the endocrine concentration will be seen over time.
  - **From Sensors:** One of the best strategies for monitoring endocrine and blood glucose levels are the use of synthetic glycol beads coated with fluorescent molecules. In this method, the beads are injected subcutaneously and remain in the ECF. When aldohexose in the ECF drops to dangerous levels, aldohexose remove the fluorescent molecule and produce a glow. Devices that use microchips are also being developed to regularly monitor vital body parameters such as heart rate, body temperature, and blood sugar. The chip will be implanted under the skin and will send signals that can be tracked continuously.<sup>4</sup>
6. **Nanotechnology in Neurodegenerative Disorders:** One of the most important applications of nanotechnology is the treatment of neurodegenerative disease.<sup>35</sup> Various nanocarriers such as dendrimers, nanogels, nano-emulsion, liposomes, polymer nanoparticles, SLNs and nanosuspension have been investigated for the delivery of CNS therapy. Delivery of nanodrugs has been achieved in various in vitro and in vivo models of BBB endocytosis or transcytosis has been shown to be effective in the treatment of central nervous system diseases such as Alzheimer's disease, HIV encephalopathy and early ischemic. Stroke progression in

systemic disease. Nanomedicine can be further developed by increasing blood-brain barrier permeability and reducing its neurotoxicity.

7. **Parkinson's Disease:** This could improve current treatment for Parkinson disease. Parkinson's disease is the second most common neurodegenerative disease after Alzheimer's disease, affecting one in 100 people over the age of 65. Current treatments aim to improve the patient's ability to function for as long as possible without altering the neurodegenerative process.
8. **Alzheimer's Disease:** More than 35 million people worldwide have Alzheimer's disease, the most common form of dementia. Nanotechnology has important applications in neurology. This process is done by enabling early diagnosis and treatment of AD through the design and architecture of many NPs regions that are very specific to brain capillary endothelial cells. Nanoparticles have a high affinity to disperse amyloid- $\beta$  ( $A\beta$ ) data, thus potentially causing a "stinging effect" and improving AD conditions. In vitro diagnosis of AD has advanced thanks to ultra-sensitive NP-based biomaterials and antibodies and scanning tunnelling microscopy techniques that can detect  $A\beta$ 1-40 and  $A\beta$ 1-42.<sup>36</sup>
9. **Tuberculosis Treatment:** Tuberculosis (TB) is a deadly disease. Long treatment times and burdens can affect patients' quality of life and contribute to the development of multidrug resistance (MDR). Pediatric first-line drug is not yet commercially available. New antibiotics can be developed to prevent resistance, shorten the duration of treatment, and reduce the number of antibiotics. Advances in nano delivery systems to encapsulate and release drugs against tuberculosis could lead to the development of better and cheaper TB drugs.



**Figure 4:** Application of Nanotechnology in Food

- **Nanotechnology in Food:** Nanotechnology has also opened its wings to the food industry. Similarly, nanomaterials produced by different companies not only enhance the taste of food, but also take care to ensure that food is safe. Food experts believe

that only nano-meter technology can better guarantee the health benefits of food.<sup>37</sup> Nanotechnology has become popular in electronics, robotics, medicines and many other fields. However, it is not much known in the food industry compared to other areas. The most important applications in this field are food processing, food packaging, food storage, food quality monitoring etc. various types of sensors have been designed to detect the presence of bacteria, water seepage, carbon monoxide, colour change, Ph change, odour or temperature.

- **Food Processing:** Few years ago, technology was not used in the food industry to improve the quality, taste and texture of food and protect from disease. Nanotechnology is used to extend the shelf life of food products and improve storage by preventing microbial contamination.<sup>38</sup> Nanocarriers are currently used as a delivery system for food supplements without affecting the structure of the food. In nutraceuticals, an optimal delivery system must distribute the compound at specific rate exactly at the target location. With the development of nanopolymers, nanotechnology has become an important part of food processing and packaging. Nano sensors have been developed to detect bacteria, viruses and toxins in food.<sup>39</sup>In the food and pharmaceutical industry, encapsulation of nanoparticles can provide better release and function, as well as masking odours and bitter tastes. It controls the interaction between the ingredients and the food matrix by controlling the distribution of active substances and their presence in certain proportions.<sup>40</sup> Nanoencapsulation protects food ingredients from heat, moisture and spoilage at various stages of processing, production and storage, and also improves the relationship between different compound in the body.<sup>41</sup> Different polymer-based encapsulation and delivery system have been developed for better bioavailability, retention of active ingredients, and ability to penetrate deep into tissues. It ensures the distribution of active ingredients into body contents.<sup>42</sup> Thanks to nanotechnology, the texture, appearance, taste and shelf life of foods have been improved. Nanotechnology has changed food quality as it improves the quality of food and improve the flavour. Nanoencapsulation is widely used to release desired properties and preserve them for culinary purposes. Encapsulation of anthocyanin-3-O-glycoside in the lumen of recombinant soybean seeds can improve thermal and photostability.<sup>43</sup> Encapsulation of rutin with ferritin increases solubility and stability against heat and UV radiation.<sup>44</sup>Oil-soluble bioactive compounds have been formulated in nano-emulsion using natural ingredients to improve water dispersibility and bioavailability.<sup>45</sup> Nanoparticles increase the bioavailability of nutraceuticals compared to conventional methods. Silicon dioxide is used as a colorant in foods. SiO<sub>2</sub> nanoparticles are used as flavouring agents in foods.
- **Food Packaging:** In addition to the relationship between strength, good packaging should also consider gas and moisture permeability. Nanoscale food packaging has many advantages over conventional packaging as they provide better packaging with improved materials, antibacterial films for disease detection, and food safety barriers. Nanocomposites are used to improve food packaging. Organic compounds such as essential oils, organic acids are used as antibacterial agents in polymer matrices. However, they are less harmful to the body. Inorganic ionic nanoparticles have anti-inflammatory properties at low concentrations. Therefore, these NPs are used in antimicrobial food products. Antimicrobial packaging prevents bacterial growth on

food. In addition, NPs of different metals such as silver-based chitosan and copper-based chitosan, as well as metal oxides, have been reported to have antibacterial properties.<sup>46,47</sup>

- **Nanotechnology in Electronics:** Nanoelectronics is a step towards the electronic world. Nanoelectronics are characterized by the use of nanotechnology for electronic devices. Novel nano scale electronic devices might soon help attain quantum computers, or a completely novel type of supercomputer that can learn and resolve problems alike a human brain. The term includes many compounds, materials, and devices that share a single similarity, which is only their small size and thus the quantum-mechanical synergy of atoms that needs to be studied in detail. Most of these materials include hybrid molecules/semiconductors, 1D nanotubes/nano wells (e.g., silver nanowires/ carbon nanotubes) or advanced molecular engineering nanoelectronics:

#### 4 Graphene transistors

- High-density memory devices
- Quantum computers
- CNT-Based Nano sensors
- OLED Display

Cadmium sulfide (CdS) is an electronic semiconductor that has attracted much attention due to its wide visible wavelength emission range. CdS nanoparticles, approximately 3-10nm in size, have 10nm in size, have been successfully prepared by the precipitation methods of chemical and green methods. It is reported that the size of EDTA-coated CdS NPs is 1.88nm, the size of *Guria japonica* leaf extract-coated CdS NPs is 1.79nm, the conductivity of EDTA-coated and NI-doped CdS nanoparticles is 1, 24 and 0.68, respectively.<sup>48</sup>

- **Nanotechnology in Environmental Sector:** Nanotechnology can help develop green technologies that reduce environmental pollution. Sensors and solutions using nanotechnology can now detect and analyse chemical and biological substances in air, water and soil with greater precision than before. Catalysis and purification processes of products are two popular examples where nanotechnology comes into play. These sources provide new products with functional and chemical properties: for example, nanoparticles with specific chemical compounds (ligands) or optical properties. In this sense, cosmetics is actually nanoscience. In the short term, chemical synthesis will provide new kinds of “nanomaterials”, and in the long term, excellent process such as “self-assembly” will provide time- and energy-saving methods. Thus, the chemical composition includes elements, polymers etc. it provides a platform for nanotechnology by combining with groups and nanoparticles. A continuous mobile phone has been developed to help firefighters monitor the air quality around fires. For the environment, many applications of nano technology have been successfully implemented at a scale. However, most of these applications require performance and safety validation in the field.<sup>49</sup> Nanotechnology is nowadays utilized in dealing with the impurity into ground water. Since clean drinking water is needed, this special technology has started to play an important role in eliminating environmental pollution. Again, the development of nano fabrics paper towel into the market has

shown that nanotechnology is used. Use less time in the ground water treatment process than conventional methods.<sup>50</sup>

- **Nanotechnology in Transportation:** The nanotechnology empowered lightweight ingredients have decreased the heaviness of jet aircraft to a substantial level, thus fading their fuel feasting as well. Also, according to the scientist and researchers in NASA, although the utilization of nano material would enhance the mission consistency alike not ever. As per the statement made by Allied Market Research (ARM), the marketplace of nano material has market of nanomaterials has development in the last few years. The market worth of \$14,741.6 million in 2015 is expected to outreach \$55,016 million by 2022.<sup>25</sup>
- **Nanotechnology in Space:** Nanotechnology could be the key to greater efficiency. Advances in nanomaterials have led to lightweight solar sails and cables for space elevators. These advances could reduce the cost of reaching orbit and space travel by reducing the amount of rocket fuel needed. Additionally, the combination of new materials with nano sensors and nanorobots could improve the performance of airplanes, improve the performance of airplanes, spacesuits and devices used to explore planets and moons, making nanotechnology an important part of the “final frontier”. 51 Scientists are investigating the following applications of nanotechnology in spaceflight:
  - Use materials made of carbon nanotubes to reduce the weight of the aircraft below during maintenance or retrofit.
  - Use carbon nanotubes to make the cables needed for the space elevator; this system is a system that will reduce the cost of objects entering orbit.
  - Use a nano sensor network to search for water or other substances in large areas of planets like Mars.
- **Nanotechnology in Drug Delivery System:** Currently, 95% of new treatment modalities are designed with poor pharmacokinetics and less biopharmaceutical properties.<sup>52</sup> There is no treatment that can deliver drugs and disperse drug molecules for the workplace without aide effects or pain. The nanotechnology has overcome this problem. The size of nanomedicine allows it to be injected without blocking the needle and capillaries, enabling targeted drug delivery and medical imaging.<sup>53</sup> Therefore, nano liposomes, micelles, nanoemulsions, nanogels are used for this purpose.

### III. CONCLUSION

Nanoscience refers to science and discipline, and nanotechnology refers to products of science and discipline, including control architecture, management and incredibly small design problems. Nanotechnology has revolutionized human life and promoted human development in many ways. The use of nanotechnology has many benefits, and the technology has many different approaches. Nanotechnology can give us many possibilities that can be used through thinking and imagination. Nanotechnology will continue to improve humanity and improve the environment in many ways. In addition, nanotechnology and nanomaterials are a rapidly growing field of research that can use new products of nanoscale

materials for economic benefits, and there are many inventions that can change the life value and life value of nanomaterials. Build infrastructure and create the new world of the future.

## REFERENCES

- [1] Rao MC, Ravindranath K. Insight into Nanotechnology and Applications of Nanomaterials in INTERNATIONAL JOURNAL OF ADVANCES IN PHARMACY, BIOLOGY AND CHEMISTRY, IJAPBC – Vol. 2(1), Jan-Mar 2013 ISSN: 2277 - 4688
- [2] Rajak A. Nanotechnology and its application. J. Nanomed. Nanotechnol. 2018;9(3):1000502.
- [3] Chadha S. Nanotechnology and its Application. International Journal of Agriculture and Food Science Technology. 2013;4(10):1011-8.
- [4] Singh A, Suki M, Sharma R, Ingle P. Applications of Nanotechnology: A Review. IJARCS. 2020; 7:16-32.
- [5] Nikalje AP. Nanotechnology and its applications in medicine. Med chem. 2015 Mar;5(2):081-9.
- [6] Gupta SK. Study of nanotechnology and its application. Journal of Physics & Optics Sciences. 2020;2(1).
- [7] Shrivastava S, Dash D. Applying nanotechnology to human health: revolution in biomedical sciences. Journal of Nanotechnology. 2009 Jan 1;2009.
- [8] Deb KD, Griffith M, De Muinck E, Rafat M. Nanotechnology in stem cells research: advances and applications. Frontiers in Bioscience-Landmark. 2012 Jan 1;17(5):1747-60.
- [9] Özdemir O, Kopac T. Recent Progress on the Applications of Nanomaterials and Nano-Characterization Techniques in Endodontics: A Review. Materials. 2022 Jul 22;15(15):5109.
- [10] Gupta SK. Study of nanotechnology and its application. Journal of Physics & Optics Sciences. 2020;2(1).
- [11] Tomar K. Nanotechnology: recent developments, applications, risk and techniques. International Journal of Engineering Science. 2017 Jul;14264.
- [12] Schiemann G. Nanotechnology and nature: On two criteria for understanding their relationship. In Nanotechnology Challenges: Implications for Philosophy, Ethics and Society 2006 (pp. 73-94).
- [13] Drexler KE. Machine-phase nanotechnology. Scientific American. 2001 Sep 1;285(3):74-5.
- [14] Falvo MR, Clary GJ, Taylor R2, Chi V, Brooks Jr FP, Washburn S, Superfine R. Bending and buckling of carbon nanotubes under large strain. Nature. 1997 Oct 9;389(6651):582-4.
- [15] Roukes M. Plenty of room, indeed. Scientific American. 2001 Sep 1;285(3):48-57.
- [16] Rai-Choudhury P, editor. Handbook of Microlithography, Micromachining, and Microfabrication: Micromachining and Microfabrication. IET; 1997.
- [17] Iijima S. Helical microtubules of graphitic carbon. nature. 1991 Nov 7;354(6348):56-8.
- [18] Fulton TA, Dolan GJ. Observation of single-electron charging effects in small tunnel junctions. Physical review letters. 1987 Jul 6;59(1):109.
- [19] Lieber CM. The incredible shrinking circuit. Scientific American. 2001 Sep 1;285(3):58-64.
- [20] Reed MA, Tour JM. Computing with molecules. Scientific American. 2000 Jun 1;282(6):86-93.
- [21] Gershenfeld N, Chuang IL. Quantum computing with molecules. Scientific American. 1998 Jun 1;278(6):66-71.
- [22] Drexler KE. Nano systems: molecular machinery, manufacturing, and computation. John Wiley & Sons, Inc.; 1992 Nov 1.
- [23] Solomon A. The emergence of nanotechnology and its applications. Res. J. Nanosci. Eng. 2018; 2:8-12.
- [24] Boisseau P, Loubaton B. Nanomedicine, nanotechnology in medicine. Comptes Rendus Physique. 2011 Sep 1;12(7):620-36.
- [25] Friedersdorf LE. Developing the workforce of the future: how the national nanotechnology initiative has supported nanoscale science and engineering education in the United States. IEEE Nanotechnology Magazine. 2020 Jun 5;14(4):13-20.
- [26] Nikalje AP. Nanotechnology and its applications in medicine. Med chem. 2015 Mar;5(2):081-9.
- [27] Zaib S, Iqbal J. Nanotechnology: Applications, techniques, approaches, & the advancement in toxicology and environmental impact of engineered nanomaterials. Importance & Applications of Nanotechnology. 2019;8.
- [28] Rakesh M, Divya TN, Vishal T, Shalini K. Applications of nanotechnology. Journal of Nanomedicine & Biotherapeutic Discovery. 2015 Jan 1;5(1):1.
- [29] Nie S, Xing Y, Kim GJ, Simons JW. Nanotechnology applications in cancer. Annu. Rev. Biomed. Eng. 2007 Aug 15; 9:257-88.
- [30] Zheng G, Patolsky F, Cui Y, Wang WU, Lieber CM. Multiplexed electrical detection of cancer markers with nanowire sensor arrays. Nature biotechnology. 2005 Oct 1;23(10):1294-301.

- [31] Loo C, Lin A, Hirsch L, Lee MH, Barton J, Halas N, West J, Drezek R. Nanoshell-enabled photonics-based imaging and therapy of cancer. *Technology in cancer research & treatment*. 2004 Feb;3(1):33-40.
- [32] Nahar M, Dutta T, Murugesan S, Asthana A, Mishra D, Rajkumar V, Tare M, Saraf S, Jain NK. Functional polymeric nanoparticles: an efficient and promising tool for active delivery of bioactives. *Critical Reviews™ in Therapeutic Drug Carrier Systems*. 2006;23(4).
- [33] Roy I, Ohulchanskyy TY, Pudavar HE, Bergey EJ, Oseroff AR, Morgan J, Dougherty TJ, Prasad PN. Ceramic-based nanoparticles entrapping water-insoluble photosensitizing anticancer drugs: A novel drug-carrier system for photodynamic therapy. *Journal of the American Chemical Society*. 2003 Jul 2;125(26):7860-5.
- [34] Qing Z, Li Z, Hong Wu. Nanomaterials for cancer therapies. *Nanotechnol Rev*. 2017; 6:473-96.
- [35] Wong HL, Wu XY, Bendayan R. Nanotechnological advances for the delivery of CNS therapeutics. *Advanced drug delivery reviews*. 2012 May 15;64(7):686-700.
- [36] Brambilla D, Le Droumaguet B, Nicolas J, Hashemi SH, Wu LP, Moghimi SM, Couvreur P, Andrieux K. Nanotechnologies for Alzheimer's disease: diagnosis, therapy, and safety issues. *Nanomedicine: Nanotechnology, Biology and Medicine*. 2011 Oct 1;7(5):521-40.
- [37] Kamat PV. Dominance of metal oxides in the era of nanotechnology. *The Journal of Physical Chemistry Letters*. 2011 Apr 7;2(7):839-40.
- [38] Pradhan N, Singh S, Ojha N, Shrivastava A, Barla A, Rai V, Bose S. Facets of nanotechnology as seen in food processing, packaging, and preservation industry. *BioMed research international*. 2015 Oct;2015.
- [39] Bratovčić A, Odobašić A, Čatić S and Šestan I. Application of polymer nanocomposite materials in food packaging. *Croatian Journal of Food Science and Technology*. 2015; 7: 86-94.
- [40] Duncan TV. The communication challenges presented by nanofoods. *Nature Nanotechnology*. 2011 Nov;6(11):683-8.
- [41] Ubbink J, Krüger J. Physical approaches for the delivery of active ingredients in foods. *Trends in Food Science & Technology*. 2006 May 1;17(5):244-54.
- [42] Weiss J, Takhistov P, McClements DJ. Functional materials in food nanotechnology. *Journal of food science*. 2006 Nov;71(9): R107-16.
- [43] Lamprecht A, Saumet JL, Roux J, Benoit JP. Lipid nanocarriers as drug delivery system for ibuprofen in pain treatment. *International journal of pharmaceutics*. 2004 Jul 8;278(2):407-14.
- [44] Zhang T, Lv C, Chen L, Bai G, Zhao G, Xu C. Encapsulation of anthocyanin molecules within a ferritin nanocage increases their stability and cell uptake efficiency. *Food Research International*. 2014 Aug 1; 62:183-92.
- [45] Yang R, Zhou Z, Sun G, Gao Y, Xu J, Strappe P, Blanchard C, Cheng Y, Ding X. Synthesis of homogeneous protein-stabilized rutin nanodispersions by reversible assembly of soybean (Glycine max) seed ferritin. *RSC Advances*. 2015;5(40):31533-40.
- [46] Couch LM, Wien M, Brown JL, Davidson P. Food nanotechnology: proposed uses, safety concerns and regulations. *Agro. Food Ind. Hitech*. 2016 Jan 1; 27:36-9.
- [47] Mihindikulasuriya SD, Lim LT. Nanotechnology development in food packaging: A review. *Trends in Food Science & Technology*. 2014 Dec 1;40(2):149-67.
- [48] Pooja S, Preeti J. Synthesis and Characterization of CdS Nanoparticle and Measurement of Conductivity of Different Sample. *Int. J. Res. Chem. Environ*. 2015 Oct;5(4):22-5.
- [49] Mobasser S, Firoozi AA. Review of nanotechnology applications in science and engineering. *J Civil Eng Urban*. 2016 Jul 25;6(4):84-93.
- [50] Blonder R, Sakhnini S. Teaching two basic nanotechnology concepts in secondary school by using a variety of teaching methods. *Chemistry Education Research and Practice*. 2012;13(4):500-16.
- [51] Patil DP, Pardeshi PR, Shaikh RA, Deshmukh HM. Applications of Emad Sara transform in handling population growth and decay problems. *International Journal of Creative Research Thoughts*. 2022 Jul;10(7): a137-41.
- [52] Brayden DJ. Controlled release technologies for drug delivery. *Drug discovery today*. 2003 Nov 1;8(21):976-8.
- [53] Genther-Yoshida P, Casassa MP, Shull RD, Pomrenke GS, Thomas IL, Price R, DOE BV, John RR, Lacombe A, Murphy E, Venneri S. National Science and Technology Council Committee on Technology the Interagency Working Group on Nanoscience, Engineering and Technology September 1999, Washington, DC About the National Science and Technology Council.