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Review article

Nanotechnology: Prospective Future for the Medical Field

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ABSTRACT
Nanotechnology is a modern technology and has many applications that include the manufacture of molecules or particles in the range of the nanoscale. Nanotechnology from the Greek word nano, meaning "dwarf". Nanoparticles are defined as single particles whose dimensions do not exceed 100 nanometers. The unique properties and features of nanoparticles are due to their small size, in addition to their chemical composition and surface structure. Different materials at the nanoscale lead to the development of new properties in industrial products, resulting in a real and impressive increase in industrial and medical applications. In this review, we will learn about this technology, its history, and the characteristics and shapes of nanoparticles. The focus will be on the application of nanotechnology in medicine, particularly in engineering living tissues with nanoscale scaffolds that simulate the functions of the extracellular matrix (ECM) to promote tissue recovery, replacement, and regeneration. It turns out that stem cells attached to a scaffold are more successful in adapting to their environment and performing the task of regeneration. The nerve endings in the body are attached to the scaffolding by weaving between the openings. This will cause them to act as a bridge to connect the cut sections. Over time, the scaffolds will dissolve and exit the body safely, leaving intact nerves in place. Some of the successfully used scaffolds are briefly identified, such as bone scaffolds, cardiac muscle scaffolds, and spinal cord engineering.

Introduction
Science is a vast, deep sea, and the wheel of science is constantly progressing and never stops to find new things every day in various scientific fields, and there is no doubt in it, nanotechnology has become the subject and focus of modern science and has become at the forefront of the most important fields in physics, chemistry, biology, etc. [1]. “Have you ever wondered what a person would be able to do if he controlled a single atom and moved it freely and easily?” This was stated by the scientist Feynman when he announced the emergence of a modern technology called nanotechnology [2].
Scientists have predicted a promising future for this technology, which actually began in 1990 [2], in which industrialized countries are now pumping millions of dollars into its development. Japan’s funding to support nanotechnology research by 2005 has reached one billion US dollars. In the United States, there are 40,000 American scientists who have the ability to work in this field, and it is estimated that the US budget provided for this science is one trillion dollars until 2015 [3]. What is this science that is expected to conquer the world with its applications that border on imagination? Nanotechnology is the fifth generation that appeared in the world of electronics and was preceded by the first generation that used lamps, including the television, the second generation that used the transistor device, then the third generation, which used integrated circuits (IC), which are very small piece that reduces the size of many electronics. These ICs increased devices’ efficiency and enlarged their functions.
The fourth generation came using microprocessors, which brought about a tremendous revolution in the field of electronics by producing the personal computer, and silicon computer chips that have brought about progress in many scientific and industrial fields [4]. So what about the fifth generation? This has become known as nanotechnology. The word “nano” in English refers to everything small in size, microscopic in size. This phrase literally means techniques that are manufactured on a nanometer scale. Nanoscience is the study of the basic principles of molecules and compounds whose size does not exceed 100 nanometers. A nanometer is a unit of measurement equal to 10^{-9} meters (m). The nanometer is the most accurate metric unit known to date, and its length is one billionth of a meter, i.e., a 10^{-6} millimeter (10^{-6} mm), which is equivalent to ten times the atomic measurement unit known as the angstrom, and the nano size is about 80,000 times smaller than the diameter of a hair [5]. Generally, the term “nanotechnology” has begun to spread in the field of electronics. There is a wide range of measurements, 1-100 nanometers (1-100 nm),

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that nanotechnologies also deal with. Moreover, the atomic assemblies consisting of a range may reach from 5 to 1000 atoms. These atomic dimensions are considered very small and precise compared to living cells or bacterial cells [6].
Nanoscience is not concerned with living sciences and organisms, but rather the interests of nanotechnology focus on the science of matter and its properties. It is related to other branches of matters and their research at the micro and small levels, including: physical and mechanical sciences, in addition to chemical and biological engineering [7]. The principle of this technology depends on capturing extremely small atoms of any substance, manipulating them and moving them from their original positions to the other places and then combine them with atoms of other materials to form a crystalline network in order to obtain nano-dimensional materials with distinct properties and high performance [8], but the question is how can we benefit from this technology in the future and can it meet all human needs at all times? Will they become more popular when they enter the service of humanity in matters of life? Such a review was undertaken to find out: The history of nanotechnology and the research of some scientists in the twentieth century on it, the principles that characterize nanotechnology, the shapes of nanomaterials, the applications of nanotechnology at present, the applications of nanotechnology in medicine, and Tissue engineering using nanotechnology (nanoscaffold).

History of Nanotechnology

The use of nanotechnology is very ancient and dates back to the Greek civilization and the Chinese civilization in the manufacture of glass. Perhaps the Greek vase - which changes color depending on the angle of light - is one of the oldest applications of this technology and was made with gold nanoparticles mixed with glass [9]. The Damascus sword, known for its hardness and flexibility, is one of the oldest applications of nanotechnology, as a team headed by Peter Paufler, a researcher in materials science at the Technical University of Dresden in Germany, conducted research indicating that carbon nanotubes were found in the designs of Damascus swords [10]. It's steel specially made in India, and it is called “wootz”. The German researcher studied pictures of Damascus swords that he took with an electron microscope, and his team found that the nano-structures of tubes of the same size inside this steel are similar to the carbon nanotubes that modern technology designers employ to create durable products [10]. The last-mentioned applications are old in the nanotechnology field.
As the American physicist Richard Feynman gave a lecture entitled “There's Plenty of Room at the Bottom” in 1959 before many others, he was wondered, “What would scientists do if they were able to control the movement of a single atom and rearrange it as it should?”, he also described a new field that deals with individual atoms and molecules to create precise materials and machines with distinctive properties, and this was the beginning of the announcement of a new field that was later known as nanotechnology [11]. In 1974, the Japanese researcher Noria Taniguchi launched the term (Nanotechnology) to express methods for manufacturing extremely small mechanical and electrical elements with high precision [12]. In 1976, the Palestinian physicist Munir Nayfeh developed a laser method called resonant ionization to detect individual atoms, and measured it with the highest levels of precision and control, monitoring a single atom out of millions of atoms and revealing its identity for the first time in history. This method sensitizes atoms with a color-specific laser, ionizes them, and then senses the dye charges [13].
In 1981, Swiss researchers Gerd Bing and Henrik Rohr invented the scanning tunneling microscope. This microscope enabled scientists for the first time to deal directly with atoms and molecules, to photograph, and to move to form nanoparticles [14]. In 1986, Eric Drexler mentioned the imagined dangers of nanotechnology in his book “Engines of Creation.” he hypothesized that nano-vehicles that can copy themselves cannot limit their spread. He also explained the basic ideas of nanotechnology, which is the ability to manufacture any material by assembling its atomic components one by one [15]. In 1991, the Japanese researcher Sumio Iijima discovered carbon nanotubes, which are cylinders of carbon, several nanometers in diameter, with distinct electronic and mechanical properties, making them important for making materials [16]. In 1992, the scientist Munir Nayfeh wrote with atoms the smallest handwriting in history, the letter “P”, and in front of it is a heart, a symbol of love for Palestine.
It has spread in major scientific fields and international news agencies. A scanning tunneling microscope was used for this, and the benefit of this drawing of atoms is that it was able to control the tiny atoms and arrange them as he pleases [17]. In 2005, a year that saw the creation of nanowires, integrated circuits with transistors only 50 nanometers across, and the launch of nanotrousers – ordinary cotton trousers treated with nanoparticles of stain-resistant chemicals [18]. In 2020, a team led by Prof. Vinayak Dravid created a ‘multipurpose sponge’ with a nanocomposite coating that can selectively absorb more than 30 times its weight in oil without harming marine life. Further research has led to membranes that can be tuned to safely capture and remove phosphates, heavy metals, and micro/nanoplastics from the environment, and the journey of nanotechnology on the way [19].

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Principles that distinguish nanotechnology
Several principles distinguish nanotechnology from our known technologies, which is why scientists are interested in getting to this nano size, and what is the benefit of this technology, and why do we need to reach this precise size (which is the question posed by the physicist Richard Feynman and answered by the Palestinian scientist Munir Nayfeh. Initially, the ability to control the movement of individual atoms and rearrange them, this principle brings the ability to build any matter in the universe because the atom is the building unit for everything. Secondly, physical and chemical properties of matter at the nanoscale are different from the properties of the same material in normal size, which enables discovering distinctive properties of materials that can be used in many ways, inventions, and applied fields. Then, nanotechnology is based on the principles of physics, chemistry, biology, electrical and electronic engineering, this gather sciences and encourages researchers regardless of their scientific specializations to enter into their field and cooperate among themselves.
The possibility of controlling atoms in making materials and machines and purifying them from impurities and getting rid of them of defects gives nanotechnology a good advantage, in which properties of materials and machines become better, they are smaller and lighter, stronger, faster, cheaper, and less energy consuming. Lastly, nanotechnology depends on scientific research that has the potential to apply them to inventions and useful uses, such as science fiction turned into reality.

Properties of nanomaterials
Nanomaterials represent a distinct class of advanced materials characterized by grain dimensions ranging between 1 and 100nm. Their nanoscale size imparts unique properties that differ significantly from those of bulk materials, positioning them as foundational building blocks of twenty-first-century technologies. Depending on their source and composition, nanostructured materials may be organic or inorganic, natural or manufactured, and their performance is strongly influenced by particle size, shape, composition, aggregation, distribution, and confinement effects. From a mechanical perspective, reducing grain size enhances hardness and stress resistance, while ceramics at the nanoscale exhibit durability not observed in conventional ceramics. Thermal properties are also altered; for example, the melting point of gold decreases by approximately 500 °C when grain diameters are reduced to the nanoscale. Magnetic behavior is similarly affected, with smaller nanoparticles exhibiting stronger magnetism due to increased surface area and active atoms.
Electrical properties benefit from enhanced conductivity and capacity, enabling applications in micro-sensors and high-performance electronic chips. Chemically, homogeneous nanoparticles of uniform size display increased reactivity, which is critical for catalysis and other surface-driven processes. The reasons underlying these property differences are multifaceted. Particle size at the nanoscale alters optical, electrical, and mechanical behavior, as seen in silicon, which shifts from opaque in bulk form to radiating blue or red light depending on nanometer dimensions. Particle shape—whether spherical, tubular, or hexagonal—further influences performance.
Composition, aggregation state, and distribution of atoms or molecules within particles also play decisive roles, with uniform distributions yielding stable properties and irregular distributions leading to instability. Finally, quantum confinement effects restrict electron movement to one or two dimensions, producing novel electrical and optical phenomena. Together, these factors explain why nanomaterials exhibit extraordinary mechanical strength, altered thermal thresholds, enhanced magnetism, superior electrical conductivity, and heightened chemical reactivity, making them indispensable to modern science and technology.

Forms and shapes of nanomaterials
Nanomaterials encompass a wide range of forms, each distinguished by its composition, geometry, characteristic dimensions, and specific applications. They can be classified according to shape into several major categories. Quantum dots are three-dimensional semiconductor nanostructures with diameters between 2 and 10 nm, corresponding to aggregates of tens of atoms, and they exhibit unique optical properties due to quantum confinement. Fullerenes, first discovered in 1985, are spherical carbon molecules composed of 60 atoms (C_{60}), resembling a football, and have given rise to an entire branch of chemistry with thousands of derivatives, some of which display superconductivity.
Closely related are carbon nanospheres, or "nano-balls," which often have hollow interiors and layered structures resembling onions, with diameters that may reach hundreds of nanometers. Nanoparticles, although a relatively new term, have existed naturally and in manufactured materials for centuries. They are aggregates ranging from a few atoms to millions, typically less than 100 nm in diameter, and their electronic and optical properties change dramatically at the nanoscale. Depending on dimensionality, they may form quantum wells, wires, or dots, each with distinct confinement effects. Nanotubes, formed from

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carbon or inorganic oxides, are cylindrical structures with diameters of 1–100 nm and lengths up to 100 micrometers (um). They exhibit exceptional strength, hardness, and conductivity, though properties vary with composition and morphology.

Nanofibers, with their high surface-to-volume ratios, provide remarkable mechanical properties such as tensile strength and hardness, though challenges remain in controlling alignment and continuity. They are increasingly used in biomedical applications, including tissue engineering, wound healing, and drug delivery, as well as in aerospace and defense. Nanocomposites are bulk materials enhanced by the incorporation of nanoparticles, which significantly improve mechanical, electrical, thermal, or optical properties even at low volume fractions. Nanowires, with diameters below one nanometer and extreme length-to-width ratios, are one-dimensional materials that exhibit quantum confinement and unique electronic behavior. They are synthesized in laboratories through various techniques and hold promise for future applications in nanoscale electronics and computing. Together, these diverse forms illustrate the breadth of nanomaterials, each offering distinctive structural features and functional advantages that underpin their growing role in advanced technologies.

Applications of nanotechnology

The applications of nanotechnology are wide-ranging and include many industrial, military, medical, agricultural, and other fields. For example, a wide range of raw materials is improved to produce a change in the physical properties of the micro or nano sizes. Nanoparticles, for example, benefit from a significant increase in surface area to volume ratio. And from their optical properties, including fluorescence, it becomes a function of the particle diameter. When incorporated into a bulk material, nanoparticles greatly affect the mechanical properties of the material, including hardness or ductility. For example, conventional polymers can be reinforced by using nanoparticles in new materials that may be used as lightweight alternatives to metals. As a result, the net utility of nanoparticles can be expected to increase. These nano-reinforced materials will reduce the associated weight, increase stability, and improve functionality. In addition, practical nanotechnology necessarily represents the increasing ability to precisely manipulate material to previously impossible standards, offering a range of possibilities that others did not previously imagine - so it is not surprising that few areas of human technology are excluded from the benefits that result from the use and application of technology [35].

Applications of Nanotechnology in Medicine

Nano medicine

Biological and medical research groups have taken advantage of the unique properties of nanomaterials associated with various applications (e.g., contrast agents for cell imaging and cancer treatments). Hence, terms such as biomedical nanotechnology began to be used [36]. Bio-nanotechnology and nanomedicine aim to describe this broad field. Functions can also be added to nanomaterials through their communication and interaction with most biological molecules and structures. The size of nanomaterials is similar to the size of most molecules and biological formulations; Hence, nanomaterials may be useful for research, biological, and industrial applications. The integration of nanomaterials with biology for the development of diagnostic devices, contrast agents, natural drug delivery tools, analytical tools, and therapeutic applications was of great importance [37]. Uses of Nano-medicine include:

Diagnosis

Nanotechnology on a chip is one additional dimension of lab-on-a-chip technology. It uses nanoparticles that are attached to the body of an appropriate antigen for the classification of certain molecules, particles, and microorganisms. Gold particles can also be used. Nanoparticles are labeled with short segments of DNA in order to identify the genetic sequence of a sample. The inclusion process results in different-sized quantum dots within polymeric microspheres, which provide multi-color coding for bioassays, and the transformed nanopore technology for analyzing nucleic acids and nucleotide sequences directly into electronic signatures [38].

Medication delivery

Nanotechnology is a form of prosperity and progress in the medical field, with the possibility of delivering medicine to specific cells using nanoparticles. The overall drug consumption process, in addition to the side effects, can be significantly reduced by depositing the active agent in the diseased area only and without any doses higher than what is required. This method reduces the selectivity of cost and human suffering as well. One such example can be found in nanoporous materials. Another example is used through drug packaging. Micelles use micelles or block copolymers, which form a micellar compound. They are used to preserve small drug molecules to help transport them to their intended destination [39]. Other applications

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are based on small electromechanical systems, where research was conducted in the field of nano-electromechanical systems, which are a younger generation of active drug release systems. Some important applications include treating cancer using iron nanoparticles or gold shields. Targeted or personalized medication reduces the process of drug consumption and treatment expenses as well [40]. Nanotechnology also opens new opportunities in implantable drug delivery systems, which are often preferred for their use with injected drugs, as the latter often exhibit first-order action (as the blood concentration increases rapidly, but declines weakly over time). This rapid increase may cause difficulties with toxicity and drug efficacy. It may disappear as a result of the drug concentration falling below the required rate [41].

Tissue engineering

From the process of cell proliferation to tissue engineering, nanotechnology helps reproduce and repair damaged tissue. Technology takes advantage of the distribution of synthetically stimulated cells through the use of growth factors and appropriate nanomaterial-based scaffolds. Textile engineering technology may solve this problem. It replaces the traditional treatment methods used today, including organ transplantation or prosthetic limbs. Advanced engineering technology may result in tissues for prolonging life [42]. Patients who suffer from complete organ failure may not have enough healthy cells for the expansion and transplantation of extracellular tissue. In this need, there is a need for stem cells with multiple reproductive powers. One of the sources with potential for these cells is represented by induced stem cells with high reproductive potential. They are represented by normal cells from the body. The patient has been programmed to have multiple reproductive capabilities, in addition to providing the advantages of avoiding the expression "rejection" of the patient's body (the life-threatening complications of the patient resulting from the use of immunosuppressive treatments) [43].

Embryos are one of the sources of stem cells with multiple reproductive capacity, but this source has two clear drawbacks: it requires solving the problem of reproduction, which is technically very difficult (especially if distortions are avoided), and this process requires harvesting the embryos. As a result of the fact that one of us was only an embryo at the beginning of his life, this source is considered a source of ethical issues. Therefore, the medical applications of this technology are among the most promising applications of all, and it is possible to obtain nano compounds enter the human body, nanotechnology sites monitor diseases, inject medicines, and order cells by secreting appropriate hormones and repairing tissues, these smart compounds can also inject insulin into cells in appropriate doses, or they enter cancer cells to explode them from within, and they are then called nano-bombs, which It was able to extend the life of mice [44].

As for nano-sensors, they can be implanted in the brain to enable a quadriplegic to walk. As it was done by obtaining a silicone denture that is no larger than the size of a cell and is able to swallow and bite. They are released back into the blood at a rate of ten cells per second, and this denture can help introduce medications or genes that are transported into cells and thus enhance focused cellular therapy for many diseases [45].

Nanobiotics

Researchers expect this to lead to nanobiotics (new technology leads to an unprecedented revolution in dealing with microorganisms, where nanobiotics are relied upon. It is a new alternative to antibiotics that mechanically punctures pathogenic cells (germs or viruses). Nanobiotics is a synthesized self-assembling cyclic peptide that can assemble into nanotubes or tiny nanopins. When millions of these sticky tubes made up of nanotubes enter the cyclic peptides inside the gelatinous root of the bacteria, then they are chemically attracted to each other and assemble themselves into long growing, self-assembled tubes that perforate the cell membrane, and these adjacent groups of tubes function by opening larger pores in the bacterial cell wall, and within a few minutes the bacterial cell dies as a result of the dissipation of the voltage (the external electrode of its membrane, and this is what practically ends the life of the cell). This technology has shown remarkable success in eliminating both resistant *Staphylococcus aureus* bacteria and *bacilli* [46]. Therefore, we see that the principle of nanobiotics and nanotubes is completely different from the way antibiotics work. The first medical use of nanotechnology is currently proving its worth in experiments, after Tejal Desai from the University of Illinois, USA developed a device engineered with nanotechnology that is implanted in the body, so that people who suffering diabetes results from the use insulin injections. This device is implanted in their bodies without them needing insulin injections or showing any signs of rejection [47].

Developments like this promise to change the way we take medicine, and smart devices implanted in the body are on the verge of administering medications accurately when they are needed. They must come to the market, and electronic devices that command cells by secreting limited hormones when the human body needs them, generating electricity, and motors that assemble themselves inside the cell.

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Tissue Engineering Using Nanotechnology
Nanoscaffolds are used in conjunction with cell and growth factor signaling in tissue engineering applications. Tissue engineering applications are designed to overcome the obstacles associated with tissue transplantation, which include a lack of available non-transplant donors, complex surgical procedures, and postoperative care. In 2015, the global tissue engineering market was estimated at $23 billion, and is expected to reach $94.2 billion US Dollars by 2022 [48]. Rapid growth was expected due to increased bone and joint disorders, as muscle regenerative drugs formed, and orthopedic 26.4% of the regenerative medicine market. Nano scaffolding is a medical process used to regrow tissue and bone, including organs and limbs. A nanoscaffold is a three-dimensional structure composed of very small polymer fibers that are measured in the 9-10 nm scale [49]. A novel medical technology was developed by the US Army; it uses a microscopic device made of nano-polymer fibers, called scaffolding. The damaged cells adhere to the scaffold and begin rebuilding the bone and tissue lost through the small holes in the scaffold. As the tissue grows, the scaffold is absorbed into the body and disappears completely [50]. Nanoscaffolds have also been used to regrow burned skin. The process cannot grow complex organs such as hearts [51].
Historically, research on nanoscaffolds goes back to at least the late 1980s when Simon showed that it could use electrospinning to produce nano- and sub-micron fibrous polymeric scaffolds specifically designed for use in *in vitro* cells and tissue substrates. This demonstrated the early use of electrospun fibrous mesh for implanting cells and tissue. Engineering different types of cells that will adhere to and multiply on the polycarbonate fibers. It was noted that in contrast to the flat morphology typically seen in 2D culture, cells grown on spun fibers demonstrated electrical activity, creating a more rounded three-dimensional shape generally observed for tissues *in vivo* [52]. So, how does it work? Nanoscaffolds are very small, 100 times smaller than a human hair, and are made of biodegradable fibers. Let's use these scaffolds to make more effective use of stem cells, resulting in faster regeneration. Spun nanofibers are prepared through electrophoresis using microscopic tubes with a diameter between 100 and 200 nm. These are intertwined with each other to form a mesh during their production. Electrospinning allows control of the creation of these networks in terms of tube diameter, thickness, and material used. Nano-scaffolds are placed in the body at the site where the regeneration process will occur.
Once injected, the cells stem from the scaffolding. Stem cells attached to a scaffold have been shown to be more successful at adapting to their environment and performing the task of renewal. Nerve endings in the body attach to the scaffolding by weaving between the openings. This will do their job as a bridge to connect the cut sections. Over time, the scaffolds will dissolve and exit the body safely, leaving healthy nerves in the body [53]. This technology is a combination of stem cell research and nanotechnology. The ability to repair damaged nerves is the greatest challenge and reward for many researchers, as well as a major step in the medical field. This will allow doctors to fix nerves damaged in severe accidents, such as third-degree burns. However, this technology is still in its infancy and has not yet been fully developed. It is still unable to regenerate complex organs such as the heart, although it can indeed be used to create skin, bones, and nails. Nanoscaffolds have been shown to be four to seven times more effective in preserving stem cells, allowing them to perform their function more effectively. This technique can be used to save limbs, which might otherwise need amputation.
Nanoscale scaffolds provide a large surface area for the materials being produced, besides variable chemical and physical properties. This allows them to apply in many different types of technological fields [54]. For the extracellular matrix [ECM], most human cells within tissues are attached to the solid extracellular matrix. Its ECM acts as a natural "scaffolding" [55]. The ECM works five main functions: providing the cellular support and microenvironment necessary to enable cell growth, migration, and signal response. Providing the mechanical properties of tissues, such as stiffness and elasticity. These properties vary to provide specific tissue functions, provide bioactive regulators to stimulate cell responses, provide a reservoir of cellular growth factors to enhance cell responses to developmental, physiological, and pathological ECM inputs, and provide a biodegradable physical environment to accommodate ECM remodeling. During tissue operations: to encourage tissue recovery, replacement, and regeneration. Both ECM and nanoscale scaffolds are intended to mimic functions, making imitation of the nanoscale scaffold difficult. Nano scaffold roles to mimic a motor control unit, the nanoscaffold follows four main features and functions: architecture; empty space must be provided to form a new texture.
Nano biomaterials must be a porous scaffold to allow nutrients to be transported to tissues within the construct. Nanoparticles are mechanically strong enough to withstand physiological loads. Cell and tissue compatibility: nanoscaffolds must support cell attachment, growth, and differentiation before *in vitro* implantation and after transplantation *in vivo*. Bioactivity: biomaterials within the nanoscaffold should facilitate and regulate cell and tissue activity, as well as in normal host tissues. Mechanical property: It must provide shape and stability to damaged tissue, determine the mechanical properties of the nanoscale scaffold, cell differentiation, morphology, and properties due to the ability of the cell to sense the rigidity of

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the substrate. There are four main approaches to nanoscaffolds, which include prefabricated porous scaffolds for cell seeding, autologous secreted, decellularized ECM from allogeneic tissue for cell seeding, and cell sheets where the cells are encapsulated in a self-assembled hydrogel matrix. Each method contains different materials and manufacturing methods, resulting in different mechanical properties. In addition to these four approaches, metal nanoparticles have been researched to improve the mechanical properties of nanoscale scaffolds [55]. A wide range of nanoscaffold biomaterials have been used in prefabricated porous scaffolds for cell culturing. These biomaterials can be classified as either natural or artificial. Biomaterials are obtained from allografts or ECM, or from natural sources, which include but are not limited to calcium phosphate, and organic polymers, such as proteins, polysaccharides, lipids, and xenografts and polynucleotides.

Natural biomaterials increase the biocompatibility of nanoscaffolds, but limit physical and mechanical stability. Natural biomaterials risk an adverse immune response in the implantation host due to an allogeneic or heterogeneous source. Synthetic biomaterials can be classified as organic or inorganic. Compared with natural synthetic biomaterials, they are more easily tailored to suit different tissue hardness, it is therefore applicable to a variety of tissues. Synthetic biomaterials are less biocompatible, which leads to decreased cell attachment and growth. Surface and bulk properties within biomaterials can be changed synthetically in an attempt to increase the biocompatibility of the surface. Various fabrication techniques have been used to fabricate a porous scaffold, such as porogens within biomaterials, or shaped solid steel, or with the use of woven or non-woven fibers. To use a porogen in nano-scaffold biomaterials, solids are incorporated into a medium or dissolved in solvents with the porogen. Porogenic materials include carbon dioxide, water, and paraffin. One of the fabricated biomaterials is done by the removal of porogens by methods such as sublimation, evaporation, and dissolution. Therefore, when the porogens are removed, a porous scaffold is left behind. For manufacturing, free or rapid solid prototyping methods were used, such as laser sintering and lithography, with the incorporation of 3D printing. These methods use light or heat transfer to bond or bind the biomaterial being used. It provides cross-linking, which improved physical strength. Manufacturing technology using woven and non-woven fiber structures provides porosity structure when fibers are bonded with thermal energy. Electrospinning is used by applying high voltages to a polymer solution. A rotating fiber jet is formed when electrostatic forces exceed those within a solution polymer.

The method of prefabricated porous scaffolds allows the formation of a specific structure. With manufacturing that allows the formation of a complex structure. For specific tissues. ECM spinning is used. Nanoparticle scaffolds using this method can be tuned to resemble fixed modules, then its applicable to use electrophoresis by applying high voltages to the polymer solution. A rotating fiber jet is formed when forces exceed electrostatic forces present within a polymer solution. The method of prefabricated porous scaffolds allows the formation of a specific structure. With fabrication allowing the formation of a complex structure, nanoscale scaffolds using this method can be tuned to resemble fixed shapes [56]. ECM of decellularized tissues and xenogeneic tissue culturing: In tissue engineering of xenogeneic heart valves, decellularized allogeneic tissue, the ECM has been used. Allogeneic tissue or ECM, vessels, nerves, tendons, and ligaments must be removed. To take advantage of cellular antigens due to the transplant recipient's immune response, the decellularization process is performed by a set of physical, chemical, and enzymatic processes. Freeze-thaw cycles or ionic solutions have been used. ECM detergents separate cellular components/EDTA to analyze cell membranes. Trypsin treatments are then used with preserved growth factors as a decellularized ECM scaffold by dissolving and removing cell cytoplasm and nuclei. Decellularized mechanical properties are closer to natural values than nanoscale ECM methods [57].

Cellular sheets with self-secreting ECM: For cellular scaffolding. Cells are cultured until they confluence with the ECM polymer, which is heat-responsive. Hydrophobicity is thermally regulated repeatedly to separate multiple layers of cell sheets. The possibilities for the secreted ECM loading for this approach are limited due to the use of thin cell sheets. Cell sheets provide self-induced high cell density and tight cell interconnection within the nanoscaffold [58]. Encapsulating the cell in a self-assembling hydrogel matrix: The hydrogel structure consists of cross-linked hydrophilic polymer chains. A semi-permeable membrane or a solid, homogeneous encasing mass encases cells. Natural and synthetic hydrogels are used to encapsulate cells. Algae and alginates provide sodium, which is commonly used as a source of polysaccharides. Other natural biomaterials used include agarose and chitosan. The synthetic biomaterials include polyvinyl alcohol (PVA) and polyethylene glycol (PEG). Before starting, the biomaterial exists as a liquid monomer. Biomaterials are mixed with cells. Once you start exponentiation, depending on pH, temperature, ionic strength, or light control, biomaterials self-assemble and combine into a polymer network. Because the cells are mixed before initiation, this allows the fabrication of the nanoscale scaffold structure and cell seeding in a single step one. This method has low mechanical properties due to the highly moldable structure of the nanoscaffold; it's not ideal for currently used applications [59].

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Nanometallic scaffolds: Metal nanoparticles within polymers increased the mechanical strength and biocompatibility of nanoscale scaffolds. Copper, gold, iron oxide, platinum, palladium, strontium, titanium, zinc, and their oxides were used in regeneration applications of bone tissue. These nanoparticles are incorporated into polymers such as poly-lactic-co-glycolic acid (PLDA), poly-capro-lactone (PCL), collagen, hyaluronic acid, poly-lactic acid (PLLA), silk, alginate, and fibrin. Nanoparticles within the nanoscaffolds enhance antioxidant activities and anti-diabetes effects. Copper nanoparticles within nanoscale scaffolds can catalyze the formation of angiogenesis, cell migration, and endothelial cell proliferation. Gold nanoparticles are catalyzed within nanoscale scaffolds, enhance osteogenic differentiation due to signal transduction from mechanical stimuli, reducing platinum nanoparticles and palladium particles. Nanoparticles within nanoscale scaffolds protect against oxidative stress that reduces disease progression. Silver nanoparticles of the nanoscaffolds are antimicrobial and help prevent post-pathogenic infections, especially in surgery. Silver nanoparticles were used within nanoscale scaffolds to develop an antimicrobial coating. Particles of the titanium nanoparticles within the nanoscaffolds are highly porous, making them ideal for cell proliferation. Zinc molecule nanoparticles within nanoscale scaffolds decrease the number of reactive oxygen species, which is associated with implant failure due to bacterial infection. The silver nanoparticles inside the nanoscaffolds are antimicrobial and help in preventing pathogenic infections after surgery. Silver nanoparticles were used within nanoscale scaffolds to develop an antimicrobial coating. Titanium nanoparticles within nanoscale scaffolds are highly porous, making them ideal for cell proliferation [60].

Applications of nano-scaffolds include: Bone scaffolds: By 2012, more than half a million people in the United States received repairs for bone defects annually at an estimated cost of $2.5 million, it has doubled in recent years [61]. In the United States, bone is one of the most common implant in which the growing demand for bone grafts and bone substitutes has been estimated at $3.3 billion [62]. Investing in research into tissue engineering solutions is a huge market, especially for bones. As a scaffolding tissue, bone is responsible for the functions of support, protection, load bearing, and blood formation. With regard to small defects, human bones have the ability to constantly remodel and rebuild themselves. However, extensive defects and infections caused by accidents, infections, and tumors make it difficult for the bones to function normally, to heal, and require external interventions. A growing shortage of donors, transplant rejections, and failures have resulted mechanically; it is difficult to obtain permanent solutions.

Advances in nanotechnology have enabled 3D printing applications in tissue engineering for developing bone scaffolds. Orthopedic scaffolds are typically made of biodegradable porous materials that provide mechanical support during the repair and regeneration of damaged and diseased bones. The scaffold design offers a surface that promotes cell attachments, growth, and differentiation, while providing a network that is porous for tissue growth. For continuous growth of a bone scaffold, interconnected porosity is important because it can allow nutrients and molecules to be transported to the inner parts of the scaffold to facilitate cell growth, blood vessels, and waste removal. The 3D bioprinting method has been used to fabricate more optimal structural scaffolds with better shape control of pores, pore size, and porosity. 3D printing can be essential for orthopedic scaffolds because it considers the high degree of porosity combined with high mechanical strength, which is crucial to scaffold performance [63]. Scaffolding of cardiac muscles: On the other hand, cardiac muscle has a degree of elasticity of only about 10 Mega Pascal, i.e. 3 times that of the size is smaller than the bone. However, it is subjected to constant cyclic loading as the heart pumps. This means scaffolding must be rigid and flexible, a property achieved using polymeric materials [64].

Spinal cord nano-engineering: A spinal cord injury can be seriously detrimental to the lives and function of the human body; it often leads to a significant loss of motor and sensory functions that can even affect the entire body below the level of injury. The number of global cases of spinal cord injury rose to 27.04 million in 2016, which costs an economy 1-5 million USD for a specific case. As a result, new solutions are urgently needed to address the problem [65]. New tissue engineering and biomaterials strategies have recently been developed to address the need, and are mainly focused on formulating nanoscale scaffolds that fill the gap created at the site of injury and promote a pro-regenerative environment that helps in facilitating the restoration of the structure and function of the spinal cord. This is achieved by physically connecting the exposed areas in the spinal cord via cross-scaffold, which additionally provides a favorable environment for regenerative cell types such as mesenchymal stem cells and Schwann cells to promote axonal recovery and remyelination. Olfactory epithelial cells, dendritic cells, and others play a major role in creating a stimulating environment for regenerative purposes [66, 67]. In order to make these nanoscale scaffolds, natural and synthetic polymers are used in their synthesis. With regard to natural polymers, hyaluronic acid and collagen are the most important candidates used in industry today. Hyaluronic acid is a major component of the extracellular matrix and has variable properties depending on its molecular weight, which is useful in compensating for the properties needed for a good scaffold. Collagen is also a key ingredient for the extracellular matrix, most importantly in the central nervous tissue, where it has good histocompatibility

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and supports adhesion and growth [68]. In summary, nanotechnology has a bright future in daily life applications, it puts a foot on the science map to participate in different fields, especially medicine. It's applied in drug delivery for pharmaceuticals, and it provides diagnostic techniques such as nanoimprint lithography that can be used to detect viruses. Nanotechnology promises to substitute conventional antibiotics by using gold nanoparticles. Moreover, it showed satisfying results in treating wounds. Nowadays, many disease treatments are under trial of nanotechnology, especially for cancer, heart diseases, diabetes, and kidney diseases [69, 70].

Conclusion

At the end of this review, it was concluded that nanotechnology is one of the most important technologies these days and in the future and has become at the forefront of the most fields of science, because of their importance in improving products, treating diseases, and serving humanity in all areas of life, in addition to giving great hope for future scientific revolutions in physics, chemistry, biology, and engineering, etc. Therefore, we must work to take advantage of the distinct properties of nanomaterials to create useful innovations and inventions that serve humanity in the fields of peace, accelerating and facilitating life, in addition to getting rid of malignant diseases that science has not yet reached today. Since nanotechnology is the focus of science today, the hope is that interest in it will increase in Libya, and the country will become one of the most competitive countries around the world with the most effort in research.

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The authors have no disclosures to declare.

Compliance With Ethical Standards

The work is compliant with ethical standards.

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