



The Impact of Using Nanotechnology in The Field of Medical Laboratories

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Abstract:

Scientists are attempting to utilize nanotechnology in the diagnosis, treatment, and prevention of diseases since they are aware of such benefits. Additionally, there may be applications in the development of medical instruments and procedures for the upcoming generation of medical scientists. Highlighting conventional research techniques in the medical profession and bringing together the many facets of nano-medicine under one category are the primary goals of this study review. The most recent information on nanotechnology in medicine and treatments from reputable scientific platforms has been incorporated through extensive investigation. With nanotechnology, delicate medical operations can be carried out. The domains of diagnostics, disease treatment, regenerative medicine, gene therapy, dentistry, oncology, the cosmetics industry, medication delivery, and therapeutics are all making good use of nanotechnology.

Keywords: Nanotechnology, Medical Laboratories, medicines, drug delivery, application.



Introduction:

All generations of clinical laboratory scientists must comprehend and value the vast potential of nanotechnology to solve issues and enhance the lives of individuals undergoing medical care as well as our own. **Nikalje et al (2015); Thakur et al (2022)** These consist of diagnosing, treating, and managing a variety of illnesses, among other things. It could lead to new understanding of genetic mistakes, infections, cancers, and improved, tailored drug delivery systems. **Modi et al (2022); Das et al (2022)** Communications, materials engineering, energy generation, and environmental challenges are already being revolutionized by nanotechnology. We need to comprehend how this "must know" technology will contribute to revolutionary developments in clinical laboratories. One of the first to propose that atoms may be controlled was Dr. R. Feynman, in his now-famous 1959 speech, "There is Plenty of Room at the Bottom." According to K. Eric Drexler, "molecular engineering and nano-systems that could potentially produce them" began with his 1981 publication, "Molecular engineering: an approach to the development of general capabilities for molecular manipulation." Osawa from Tokyo University of Technology predicted that three-dimensional sixty-carbon (C₆₀) structures in the shape of soccer balls might be created, and in fact, they were initially created in 1991. Nearly 25 years prior, in the field of architecture, the renowned and inventive Buckminster Fuller, a futurist and renowned scientific thinker, created the Montreal geodesic dome (the U.S. pavilion at Expo 67). **Erkoc et al (2021)**, In honor of Dr. Fuller, the basic sixty-carbon soccer ball-shaped constructions were called "fullerenes" or "buckyballs" since these geodesic domes he designed essentially had the same proportions as the C₆₀. The discovery of this extraordinary family of compounds, which can be produced into single, double, triple, etc. nanotubular structures with the addition of additional atoms and manipulation, earned Kroto, Curl, and Smalley the 1996 Nobel Prize in Chemistry. **Hulla et al (2015); Misra et al (2010); Bhushan (2017)** These structures, known as graphene nanotubes (an allotrope of carbon), look similar to a roll of chicken wire, except they are formed of carbon atoms arranged in a hexagonal lattice structure rather than metal. Nanocomp Technologies, Inc. manufactures nanotubes with diameters ranging from 0.4 nanometers to millimeters. Nanocomp has developed a technique to create longer nanotubes that are 100 times stronger than steel, lighter than aluminum, and capable of conducting electrical and heat transfer. "A sheet of graphene as thick as Saran-Wrap would require an elephant balanced on a pencil to pierce it." Products with these qualities seem to have countless uses. Along with the US Navy Office of Naval Research, Nanocomp Technologies has partnered with the US Army Natick Soldier Center to enhance military body armor and create interference barriers. **Chakravarthi et al (2010); Pramanik et al (2020)**



Scientific Principles:

The atomic force (scanning-tunneling) microscope can pierce samples that are just a few nm deep thanks to tiny carbon, silicon, or silicon nitride nanotubes employed as a tip. We can finally "see" a single atom thanks to the atomic force microscope (AFM), which has a resolution that is almost a thousand times higher than optical diffraction microscopes. **Badrunnisa et al (2023); Anselmo et al (2019)** To illustrate, International Business Machines (IBM) created the tiniest corporate logo in history in the mid-1990s by picking up and arranging 35 xenon atoms in the correct order. A little dive into the realm of piezoelectricity is required to comprehend how this is feasible. It has to do with the phenomenon of manipulating individual atoms. High-purity crystals arranged end-to-end will generate a piezoelectric current, or flow of electrons, when tapped. **Vaishampayan et al (2023)** The probing tip of the AFM may use "tweezers"—twin laser beams—to place individual atoms in a chilled cesium cloud thanks to this and other physicochemical forces, such as magnetism, Van der Waal's forces, and manipulation of regular chemical bonds. Atoms are pulsed along a beam to the intended location by the "standing wave" sequence of peaks and troughs produced by the twin lasers, also known as the "prongs" of the tweezers. One by one, single atoms are moved into place in three dimensions. This is enabled by a "cantilever" arm, often composed of silicon or silicon nitride nanotubes, which are fixed at one end and can be "focused" or diverted at the atomic level by piezoelectric forces and other phenomena that have been previously described. **Dessale et al (2022); Mbunge et al (2021)**, to better understand this, consider a phonograph, where music is produced by the "arm" holding the needle making contact with the record grooves. The tiny carbon (or other material) nanotubular probe serves as the "needle" in the AFM, while the cantilever, which dips up and down at the operator's discretion, serves as the "arm." **Fox et al (2019)** On a monitor that resembles a television, the technician can physically see atoms being picked up and repositioned while viewing the greatly increased and magnified field of focus. **Singh et al (2022); Xu et al (2022)**

The new ultra-high resolution microscope, whose research is presently underway in Germany, is another advancement that will increase our understanding of nanotechnology. It will be capable of detecting atomic distances, have a resolution of 50 billionths of a millimeter, and help with the research of chemical bonds. Although these achievements are outstanding, how will they be translated into clinical laboratory diagnostic capabilities? **Sadeghi et al (2023); Rajput et al (2023)** Multiple antibody-bearing cantilever arms (small moveable platforms) are already being created for use in environmental monitoring, clinical laboratories, and a variety of other cutting-edge settings. When these cantilevered projections covered with particular antibodies come into contact with corresponding pathogens or other targets, they physically "dip" or bend, changing the resonance frequency. Toxins, bacteria, viruses, illegal narcotics, and tainted food and water are just a few of the substances that can be identified



(quantitatively) thanks to the signals' high sensitivity and precision and specificity. **Wang et al (2021); Malik et al (2023)**, Self-replicating machines are on the horizon. Mechanical or electromechanical devices that function in the nanoscale range are known as nanomachines, or nanites. Some relatively simple devices have been tried, however they are still in the development stage. **Jhou et al (2017); Welch et al (2021); Patel et al (2023)** A sensor with a 1.5 nm-diameter switch that can count particular molecules in a specimen containing analytes has been created. Nanites will probably be used most immediately in clinical laboratories to identify poisons, infections, and diagnostic compounds in patient specimens. To build bigger devices, self-replicating nanites, or nanorobots, could be created. Certain specialized nanoparticles may be made to "search and destroy" microbiological invaders, while others may be specifically made to transport medications to specific tissues. While Parts 3 and 4 of this issue will cover environmental, societal, and safety concerns, Part 2 will go into detail on many of these clinical and technical applications. **Thwala et al (2023)**.

Nanotechnology in Medical Laboratories:

Nanotechnology and Lab-on-Chip Technology

By providing cutting-edge approaches to drug delivery, individualized treatment, and disease diagnostics, nanotechnology and lab-on-a-chip technologies have completely transformed the healthcare industry. **Kumari et al (2022); Shen et al (2021); Babu et al (2019)** By combining these two technologies, sophisticated diagnostic instruments that are quicker, more accurate, and more economical than conventional diagnostic techniques have been created. In a variety of scientific domains, lab-on-a-chip technology is advancing; for instance, it is being explored for potential applications in the fight against cancer and viruses. **Souri et al (2022)** The analysis of genetic data at the cellular level is important to the entire procedure. Cutting-edge techniques for gene sequencing and bodily fluid collection have also contributed to the revolution of nanotechnology in the search for previously unthinkable disease solutions. **Crommelin et al (2020); Kang et al (2021); Park et al (2013)** These two technologies have combined to create Lab-on-Nanoparticles, which are tiny devices with a variety of uses, such as medicine administration, diagnostics, and condition monitoring. The nanoscale materials used to make these devices have the ability to recognize and react to changes in the body, enabling real-time monitoring and individualized care. The diagnosis of cancer is one of the major uses of lab-on-a-chip technology and nanotechnology in healthcare. **Adir et al (2020)**, it is possible to create nanoparticles that specifically target cancer cells, enabling early diagnosis and treatment. Additionally, a variety of medical illnesses, including as infectious diseases, genetic disorders, and metabolic disorders, can be diagnosed using lab-on-a-chip devices. **Buya et al (2020); Amna et al (2022)** Advanced medication delivery systems have also been developed as a result of the application of nanotechnology and lab-on-a-chip technologies in healthcare. By targeting particular cells or tissues in the body,



nanotech systems like nano-liposomes might improve medication efficacy and lessen unwanted effects. Furthermore, it is thought that future generations of nanoscale diagnostic equipment will have the ability to identify viruses. It is anticipated that these gadgets will make it possible to identify drug releases in the body's organs, which will aid in determining treatment effectiveness and efficiency rates. To put it simply, nanotechnology aims to improve the pharmacokinetic and pharmacodynamic characteristics of medications so they remain in the body longer, function more quickly and effectively, and reach vital locations. **Baroud et al (2021); Dong et al (2019).**

Nanotechnology in Pharmaceutical Science:

Nanotechnology systems, such as nano-liposomes, may enhance drug effectiveness and reduce side effects by specifically targeting specific cells or tissues in the body. Moreover, it is believed that viruses will be detectable by upcoming generations of nanoscale diagnostic devices. **Sahu et al (2021); Oroojalian et al (2020)** These devices are expected to enable the detection of drug releases in the body's organs, which will help determine the efficacy and efficiency rates of treatment. In a nutshell, nanotechnology seeks to enhance the pharmacokinetic and pharmacodynamic properties of drugs so they reach key sites, work more rapidly and efficiently, and stay in the body longer. Furthermore, the dosing regimen for nanoparticles needs to be carefully considered due to their complex pharmacokinetics and dynamic behavior in vivo. To accomplish their therapeutic objectives while reducing side effects, researchers must ascertain the ideal range of doses, frequency, and duration of nanoparticles. **Enrico et al (2019); Suhail et al (2022)** Medical research has produced very sophisticated treatment solutions in the past, but there is still a need to successfully neutralize drug overdoses. One aspect being considered to develop a rich way of medication absorption in the medical sciences is the utilization of nanoparticles as absorbents of dangerous substances. In order to treat illnesses from bodily fluids and lessen the negative effects of drug overdoses, materials resembling nanosponge are being developed to absorb hazardous amounts of pharmaceuticals in blood. **Chouhan et al (2023); DeLuca et al (2020)** Researchers who work as nanoscale molecules to create antiviral and anticancer nucleoside analogs by linking with squalene have introduced such antiviral drug absorbents. For the treatment of human cancer cells that have not yet progressed past in vitro research, these nano-assemblies function as superior anti-cancerous chemicals. In conclusion, careful evaluation of the dosage and mode of administration of nanoparticles is necessary for the development of nanomedical products in order to guarantee their safety and effectiveness. To guarantee the safety and effectiveness of nanomedicines, the nanoscience community and regulatory bodies must work together to create testing protocols. **Jiang et al (2022); Idrees et al (2020).**



Nanotechnology and Drug Delivery System:

Modifications to drug delivery systems in accordance with the new nanoscaling guidelines are also being carefully considered. It is anticipated that some types of medical nanorobots would be employed to distribute medications. These substances transport medications to particular locations by swimming through veins. These features are applied to medications' antitumoral effects. **Salameh et al (2020)** Researchers are even attempting to do intranuclear and wireless intracellular nanoscale operations to treat a variety of illnesses and cancers. The production and testing of mechanical red blood cell technologies known as respirocytes is an example of amazing scientific arrangements. Compared to natural red blood cells, nanorobotics has the ability to supply 200+ times more oxygen to bodily tissues. This may cause one to consider the possibility of using nanotechnology in the future to diagnose, treat, and cure a variety of blood-linked illnesses. In summary, the use of nanotechnology in medication delivery has completely transformed the medical industry. Drugs have been delivered more efficiently and precisely, side effects have been reduced, and the therapeutic efficacy of medications has grown. Future drug delivery depends on the ongoing development of drug delivery methods based on nanotechnology. **Uchida et al (2019); Tockary et al (2019).**

Nanotechnology and Drug Delivery Assemblies:

The majority of nanomedicines are made by degrading particles to the micro- and nanoscales using physical and chemical processes. Nonetheless, nanomedicine is now incorporating the ideas of green chemistry and green engineering into the production of nanobiomedicine due to worries about harmful health effects and environmental effects. **Jahangirian et al (2017); Kanwar et al (2019); Nasrollahzadeh et al (2020)** This green technology aims to produce environmentally benign nanoassemblies that have fewer detrimental effects on the environment and human health. The next stage to advance the science of green nanomedicine will be the mixing of green nanoassemblies with medications, vaccinations, or diagnostic markers. Using the concepts of nanotechnology and green engineering, numerous inorganic nanoassemblies have been produced and released onto the market. Solid lipid nanoparticles, dendrimers, organic polymeric nanoparticles, mesoporous silica nanoparticles, quantum dots, gold and silver nanoparticles, and nanostructured lipid carriers are a few possible examples. To facilitate further handling in nanomedicine, these nanoassemblies are bonded with medications, DNA molecules, or certain enzymes, proteins, or peptides. However, it is necessary to set up experiments that show how making nanomedicines using conventional bioengineering differs from making them using the elaborate principles of green bioengineering, as well as how effective the former is. This will enable researchers to select the optimal circumstances for producing nanoassemblies in the future. **Amiri et al (2022).**



Nanotechnology and Antibacterial Usages:

Since the agents responsible for bacterial, viral, and other microscopic illnesses operate at the microscopic level, controlling them at the nanoscale is the most effective strategy. **Salleh et al (2020); Husain et al (2023)** To cure and diagnose a variety of bacterial, fungal, and viral infections, nanotechnology is the key. A modernized kind of nanoscale-based material conversion has been demonstrated to increase the effectiveness of both conventional and contemporary treatment alternatives, even though traditional Greek medical methods have long used metals like silver to treat illnesses. **Saunders et al (2020)** According to a study conducted by Nycryst Pharmaceuticals (Canada), nanosized silver particles are more effective at curing burns and wounds because they can easily penetrate the skin on a microscopic scale. **Kubinová et al (2010)** The best way to regulate the agents that cause bacterial, viral, and other microscopic ailments is at the nanoscale since they function at the minuscule level. Nanotechnology holds the key to diagnosing and treating a wide range of bacterial, fungal, and viral infections. Although metals like silver have long been utilized in traditional Greek medicine to heal ailments, a modernized form of nanoscale-based material conversion has been shown to boost the effectiveness of both conventional and contemporary treatment choices. According to a study by Nycryst Pharmaceuticals (Canada), because nanosized silver particles can easily penetrate the skin on a microscopic scale, they are more successful at healing burns and wounds. **Hajiali et al (2021)**.

Nanotechnology in Regenerative Medical Labs:

Additionally, scaffolds that resemble the structure of bone can be made with nanoparticles to help guide the formation of new bone and promote bone regeneration. Furthermore, very accurate and personalized implants for bone regeneration can be made using developments in 3D printing technology that employ nanoscale materials. A common concern is bone weakening and malfunction, which nanotechnologists have identified as being of the highest significance when relating nanotechnology to medicine. With the aid of nanotechnology, some research is being done on the structure and production of bones. In order for body and organ tissues to accept bone graft alternatives, scientists are working to create nanostructured materials with comparable qualities. Should these investigations be successful, a new generation of regenerative technologies will be able to repair shattered muscle segments and damaged bones.

Nanotechnology and Regenerative Medicine:

In the multidisciplinary field of regenerative medicine, the advantages of tissue engineering and cell therapy techniques are effectively combined to provide mechanisms for the repair, preservation, enhancement, and restoration of damaged and dead cells, tissues, and organs. It was previously challenging to treat the body at the cellular level, but the advent of nanoscale



technology has created a tremendous opportunity in regenerative medicine to work with cells and their constituent parts in order to regulate the interconnected cellular responses and the production of extracellular material. Nanoassemblies' potent tissue regeneration capabilities have significantly improved tissue repair. These technologies are focused on mechanical processes that start tissue regeneration, such as cellular adhesion, migration, and differentiation. The production of nanoscale materials, including gold and silver nanoparticles, dendrimers, nanorods, carbon buckyballs, nanoshells, nanocubes, and numerous other types of nanoparticles, is being investigated in the subject of nanomedicine. Each is unique to its associated qualities, which can be used directly in the organs and tissues that are being targeted. The diagnostic, therapeutic, antiviral, antifungal, and—most importantly—anticancer capabilities of these nano-agents are being investigated by numerous research groups across the globe. To support the results of this study, a questionnaire was prepared consisting of 10 open questions (yes, no, and I don't know) and distributed to workers and specialists in the field of medical laboratories from all categories (technician, specialist, senior specialist, and laboratory consultant) to know their opinions regarding the impact of using nanotechnology in the field of medical laboratories. The results will be monitored later.

Results and dissections:

The age distribution of participants was as follows: 20.7% were aged 25-34, 74.1% were aged 35-44, and 5.2% were aged 45-60. The gender distribution of laboratory workers was as follows: laboratory technicians and senior laboratory specialists were equally divided at 8.5%, laboratory specialists at 79.7%, and laboratory consultants at 3.3%. The male population was high at 83.1%, while the female population was low at 16.9%. The majority of the participants were Saudis, both male and female, at 94.8%, and non-Saudis, both male and female, at 5.2%. Their qualifications were distributed according to the questionnaire as follows: the percentage of those who hold a bachelor's degree in the field of medical laboratories - medical sciences is 81%, the percentage of those who hold a diploma in laboratories and a master's degree in the field of laboratories (equal) is 7%, while those who hold a doctorate are 5%, and regarding their responses (opinions and attitudes) to the questionnaire questions, they were as follows:

Questions	Yes	No	I don't know
By using nanotechnology, it is possible to image the infected body cells (the site of infection) and thus facilitate taking samples from it	87.9%	3.5%	8.6%
the development of nanotechnology contributed to changing the	91.2%	7%	1.8%



medical rules followed in preventing, diagnosing and treating diseases			
Can nanotechnology be used to develop accurate diagnostic devices to detect diseases such as cancer and infectious diseases	91.2%	0%	8.8%
Nanotechnology is changing healthcare by making diagnosis and treatment more accurate and effective	91.4%	2%	6.6%
Nanotechnology (biosensors) helps in detecting diseases early?	80.4%	7.1%	12.5%
The imaging tools provided by nanotechnology will help in early diagnosis, and at what therapeutic point is the treatment success rate high	89.5%	0%	10.5%
Nanotechnology has brought about a major and wide development in the field of medicine and diagnosis?	96.6%	0%	3.4%
Nanotechnology enables the development of highly sensitive diagnostic tools, which enhances the accuracy of tests	84.2%	3.5%	12.3%
Nanotechnology enables diagnosis at the single cell and molecular level	93%	0%	7%
How does nanotechnology have significant impacts on analytical laboratory tests	87.5%	1.8%	10.7%
Analytical laboratories can now identify and measure the presence of trace elements and potential contaminants with unprecedented accuracy, ensuring the highest quality of final products due to nanotechnology	81%	3.5%	15.5%
In tissue engineering, nanomaterials improve cellular interactions and promote tissue regeneration. This application is particularly promising in areas such as nerve, dental, and skin repair ⁸	70.7%	6.9%	22.4%

We find that nanotechnology has contributed to the accuracy and enhancement of medical laboratories by 84.2%, and has contributed to the development of accurate diagnostic devices for detecting diseases such as cancer and infectious diseases by 91.2%, as well as imaging infected body cells (the site of infection) and thus facilitating the collection of samples from



it by 87.9%, and has had a significant impact on analytical laboratory tests by 87.5%. Therefore, according to their opinions, we find that nanotechnology has contributed to shortening the detection of diseases for the sake of human health.

Conclusion:

Nanotechnology in healthcare and medicine has enormous promise to transform how we identify, cure, and prevent illnesses in the future. In order to precisely regulate a material's physical, chemical, and biological properties, nanotechnology manipulates materials at a scale so small that their properties differ greatly from those of their bulk counterparts. This creates new possibilities for the development of sensitive diagnostic instruments, targeted medication delivery systems, and innovative therapeutics. By increasing the solubility, stability, and bioavailability of current medications, nanoparticles can be utilized to improve their efficacy in addition to drug delivery, targeted administration, better medications, restricted dosages, and decreased systematic side effects. Furthermore, real-time patient health monitoring is made possible by sensors and gadgets based on nanotechnology, which allows for early detection and individualized treatment regimens. Nanotechnology may even make it possible in the future to create nanorobots that can move through the bloodstream to target and eliminate cancer cells or deliver medication payloads to specific areas.

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